Concrete Ingredients

**carbon footprint**

**Definition:** The amount of carbon dioxide let in to the atmosphere/environment by an individual, event or organisation.

* Carbon Rating

→ First cement industry in India was started in the year 1914 in Porbandar, Gujarat.

→ India cement company Limited is the name of the company.

upto 28

1. Tricalcium Silicate $\rightarrow C_3S \rightarrow 50-60\%$

after 28

2. Dicalcium Silicate $\rightarrow C_2S \rightarrow 10-30\%$

3. Tricalcium Aluminate $\rightarrow C_3A \rightarrow 5-7\%$

4. Tetra calcium Aluminoferite $\rightarrow C_4AF \rightarrow 2-5\%$

**Types of cement**

* Ordinary portland cement

  $\text{	ext{OPC}}_3_5 \rightarrow \text{	ext{OPC}}_5_4$

  $\text{	ext{OPC}}_4_3$
2 Rapid hardening cement
3 Extra Rapid hardening cement
4 Sulphate resisting cement
5 Portland slag cement
6 Quick setting cement
7 Super sulphated cement
8 Low heat cement
9 Portland pozzolana cement
10 Air entraining cement
11 Coloured cement / white cement
12 Hydrophobic cement
13 Masonry cement
14 Expansive cement
15 Oil well cement
16 Readiset cement
17 Concrete sleeper grade cement
18 High alumina cement
19 Very high strength cement

Use of Rapid hardening cement:
* It is prefabricated concrete construction
* If the form work has to be removed early
* Road repair works
* In cold weather concreting

Extra Rapid Hardening cement

BHC + CaCl₂

**Concrete Technology**

- Cement
  - Fine aggregates
    - Gradation
    - Specific gravity
  - Coarse aggregate
    - Shape test
    -Abrasion test
    - Crushing strength
    - Impact strength

Field test
  - Fineness
  - Standard consistency
  - Setting time
  - Mortar strength
  - Specific gravity

**Types of cement:**

1. Ordinary Portland cement:

* Ordinary Portland cement (OPC) is by far the most important type of cement.
* The 6PC was classified into 3 grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4021 - 1988.
* If the 28 days strength is not less than 33 N/mm² it is called 33 grade cement.
* If the strength is not less than 43 N/mm² it is called 43 grade cement.
* If the strength is not less than 53 N/mm² it is called 53 grade cement.

2. **Rapid Hardening cement**:  
   * 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.

3. **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.

Sulphate Resisting cement:

- Ordinary portland cement is susceptible to the attack of sulphates in particular to the action of magnesium sulphate.
- Sulphate react both with the free calcium hydroxide in set cement to form calcium sulphate and with hydrate of calcium aluminate to form calcium sulphaaluminate, the volume of which is approx. 227% of the volume of the original aluminates.
- Their expansion within the framework of hardened cement paste results in cracks and subsequent disruption.

In many of physical properties sulphate resisting cement is similar to ordinary portland cement. The use of sulphate resisting cement is recommended under the following conditions.
1. Concrete to be used in marine condition.
2. Concrete to be used in the construction of sewage treatment works.

5. **Portland slag cement** :-

* Portland slag cement is obtained by mixing Portland cement clinker, gypsum and granulated blast furnace slag in suitable proportions and grinding the mixture to get a thorough and intimate mixture between the constituents.

* It may also be manufactured by separately grinding Portland cement clinker, gypsum and ground granulated blast furnace slag and later mixing them intimately.

6. **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 underwater construction where pumping is involved.

**Super Sulphated cement**

* Super Sulphated cement is manufactured by grinding together a mixture of 80-85% granulated slag, 10-15% hard burnt gypsum, and about 5% Portland cement clinker.
* The product is ground finer than that of Portland cement.
* Specific surface must not be less than 4000 cm² per gm.

**Low Heat cement**

* It is well known that hydration of cement is an exothermic action which produces a large quantity of heat during hydration.
* Formation of cracks in large body of concrete due to heat of hydration has focused the attention of the concrete technologists to produce a kind of cement which produces less heat or the same amount of heat.
<9> Portland Pozzolana cement:

* The history of pozzolanic material goes back to Roman's time.
* The descriptions and details of pozzolanic material will be dealt separately under the chapter Admixtures.
* Portland Pozzolana cement is manufactured by the inter grinding of OPC clinker with 10 - 25% of pozzolanic material [as per the latest amendment it is 15 to 35%].
* A pozzolanic material is essentially a silicious or aluminious material which while in itself possessing no cementitious properties which will in finely divided form and in the presence of water, react with calcium hydroxide, liberated in the hydration process, at ordinary temperature to form compounds possessing cementitious properties.
Air Entraining cement:

- Air entraining cement is not covered by Indian Standard so far.
- This cement is made by mixing a small amount of an air-entraining agent with OPC clinker at the time of grinding.
- The following types of air-entraining agents could be used:
  1. Alkali salts of wood resins.
  2. Synthetic detergents of the alkyl-aryl sulphonate type.
  3. Calcium lignosulphate derived from the Sulphite process in paper making.

Coloured cement or white cement:

- For manufacturing various coloured cements, either white or grey Portland cement is used as a base.
- Coloured cement consists of Portland cement with 5-10% of pigment.
- The pigment cannot be satisfactorily distributed throughout the cement by mixing and hence it is usual to grind the cement and pigment together.
12) **Hydrophobic cement**:  
* Hydrophobic cement is obtained by grinding OPC clinker with water repellant film-forming substance such as oleic acid and stearic acid.  
* The water-repellant film formed around each grain of cement reduces the rate of deterioration of the cement during long storage, transport or under unfavourable conditions.

13) **Masonry cement**:  
Ordinary cement mortar, though good when compared to lime mortar with respect to strength and setting properties is inferior to lime mortar with respect to workability, water-retentivity, shrinkage property and extensibility.

14) **Expansive cement**:  
* Concrete made with OPC shrinks while setting due to loss of free water.  
* Concrete also shrinks continuously for long time. This is known as dry shrinkage.
* Cement used for grouting anchor bolts or grouting machine foundations or the cement used in grouting the prestress concrete ducts, if shrinks, the purpose for which the grout is used will be to some extent defeated.

15. **Oil well cement**:
* Oil well drilled through saturated sedimentary rocks through a great depth in search of oil.
* It is likely that if oil is struck, oil or gas may escape through the space between the steel casing and rock formation.
* Cement slurry is used to seal off the annular space between steel casing and rock strata and also to seal off any other fissures or cavities in the sedimentary rock layer.

16. **Rediset cement**:
* Accelerating the setting and hardening of concrete by the use of admixtures is a common knowledge.
* Calcium chloride, ligno-sulfonates and cellulose products form the base of some of admixtures.

* The limitations on the use of admixtures and the factors influencing the end properties are also fairly well known.

17. **High Alumina cement:**

* High alumina cement is obtained by fusing or sintering a mixture, in suitable proportions, of alumina and calcareous materials and grinding the resultant product to a fine powder.

* The raw materials used for the manufacture of high alumina cement are limestone and bauxite.

* These raw materials with the required proportion of coke were charged into the furnace.

18. **Very high strength cement:**

* The engineering of a new class of high strength cement called macro-defect-free (MDF) cements is an innovation.
MDF refers to the absence of relatively large voids or defects which are usually present in conventional mixed cement pastes because of entrapped air and inadequate dispersion.

Concrete sleeper grade cement:

It is a very finely ground cement with high C_3S content designed to develop high early strength required for manufacture of concrete sleeper for Indian railway. This cement can be used for prestressed concrete elements, high rise buildings, high strength concrete.
Tests on cement:

1. Fineness test
2. Setting time
3. Strength
4. Soundness

Test on coarse aggregates:

1. Sieve Analysis
2. Water Absorption
3. Aggregate Impact Value
4. Abrasion Value
5. Aggregate crushing Value
6. Specific Gravity
7. Elongation and Flakiness

1. Shape test
   - Flakiness index
   - Elongation index

2. Angularity Number
FLAKINESS INDEX:

Flakiness index of aggregate is the percentages by weight of particles whose least dimension [thickness] is less than $\frac{3}{5}$ or 0.6 of the mean dimension.

WATER:

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quality and quantity of water required is to be looked into very carefully.

Quality of water:

Generally, potable water should be used for construction purposes. But now-a-days as there is scarcity of water we consider that water suitable for making concrete may not necessarily be fit for drinking. However some conditions has to be satisfied. The pH of water should be between 6 and 8 and it should be free from organic materials.
The carbonates and bi-carbonates of sodium and potassium affect the setting time of concrete, while sodium carbonate causes quick setting and the bi-carbonates may either accelerate or retard the setting. In the higher concentration of these salts, they may reduce the strength.

Brackish water contains chlorides and sulphides. Tolerable limits of chlorides and sulphides are 12,000 ppm and 3000 ppm respectively. Salts of manganese (Mn), tin, zinc, copper, and lead cause a marked reduction in the strength of concrete.

Sodium iodide, sodium phosphate, and sodium boride reduce the initial strength of concrete to an extra ordinarily high degree. Another salt that is detrimental for concrete is sodium sulphide.

Sifts and suspended particles are undesirable as they interfere with setting, hardening and bond characteristics.

Turbidity limit of 2000 ppm is suggested.

The initial setting time of the block made
MINERAL ADMIXTURES / POZZOLONIC

The use of pozzolonic materials is as old as concrete construction. It was recognized long time ago that the suitable pozzolanas used in appropriate amounts modifies certain properties of fresh and hardened properties.

It has been demonstrated that the best pozzolonas if used in optimum dosages improves many qualities of concrete such as
(i) Lower the heat of hydration and thermal shrinkage
(ii) Encour Increase the watertightness
(iii) Reduce the alkali aggregate reaction
(iv) Improve resistance to attack of sulphate, soil and sea water
(v) Improve extensibility
(vi) Lower the risk of leaching
(vii) Improves workability
Pozzolonic materials:

Pozzolonic materials are siliceous and aluminous materials which in themselves possess little or no cementitious value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide liberated by hydration at ordinary temperature, to form compound possessing cementacious properties.

Generally amorphous silicate in its reaction much more rapidly than the crystalline form. It is described that calcium hydroxide is converted into insoluble cementacious materials by the reaction of pozollonic materials.

\[
\text{Pozzolona} + \text{Ca(OH)}_2 + \text{H}_2\text{O} \rightarrow \text{C-S-H} \quad \text{(gel)}
\]

Pozzolonic materials can be divided into 2 groups:

1. Natural pozollona
2. Artificial pozollona
Natural Pozzolana

(i) clay and shale 
(ii) Opaline cherts 
(iii) Diatomaceous earth 
(iv) Volcanic tuffs and Pumicites

Artificial Pozzolana

(i) Fly ash 
(ii) Blast furnace slag 
(iii) Silica fumes 
(iv) Rise hush ash 
(v) metakholine 
(vi) Surkhi

Fly ash:

Fly ash is finely divided residue from the combustion of powdered coal and transported by flue gases collected by electrostatic precipitator.

* Fly ash was first used in India in the construction of Rihand Dam with 150% replacement to cement.

* The use of fly ash as concrete admixture not only extends technical advantage to the properties of concrete but also contributes to the environmental condition.
There are two ways that the fly ash can be used:

(i) As an admixture
(ii) As a replacement to cement

**Silica fumes:**

* Silica fume also referred as micro silica or condensed silica fume is another material that is used as an artificial pozzolona admixture.
* It is a product resulting from high purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferro silicon alloy.
* Silica fume rises as an oxidised vapour.
* It cools, condenses and is collected in cloth bags.
* It is further processed to remove impurities and control particle size. Condensed silica fume is essentially silicon dioxide in non-crystalline form. Since it is air borne like fly ash.
* It has spherical shape. It is extremely fine particles of size less than 1 μm and size of 0.1 μm.
Silica fume has specific surface area of about 20,000 m²/kg, whereas cement has 230 - 300 m²/kg.

The use of silica fume with superplasticizers has given rise to high performance concrete.