

UNIT – I

CONSTITUENT MATERIALS

SYLLABUS

Cement - Different types - Chemical composition and Properties – Hydration of cement - Tests on cement - IS Specifications - Aggregates – Classification - Mechanical properties and tests as per BIS - Grading requirements – Water - Quality of water for use in concrete

1.1 CEMENT

Cement is the binding material, obtained by burning and crushing of clay stones containing Calcium Carbonate and Magnesium Carbonate.

- Silica, SiO_2 : from sand, old bottles, clay or argillaceous rock
- Alumina, Al_2O_3 : from bauxite, recycled aluminum, clay
- Iron, Fe_2O_3 : from clay, iron ore, scrap iron and fly ash

Manufacture of cement

The main raw material for the production of cement is clinker. Clinker is an artificial rock made by heating limestone and other raw materials in specific quantities to a very high temperature in a specially made klin.

Portland cement gets its strength from chemical reactions between the cement and water. The process is known as hydration. This is a complex process that is best understood by first understanding the chemical composition of cement.

Portland cement is manufactured by crushing, milling and proportioning the following materials:

- Lime or calcium oxide, CaO : from limestone, chalk, shells, shale or calcareous rock
- Gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$: found together with limestone

The materials, without the gypsum, are proportioned to produce a mixture with the desired chemical composition and then ground and blended by one of two processes - dry process or wet process. The materials are then fed through a kiln at 2,600° F to produce grayish-black pellets known as clinker. The alumina and iron act as fluxing agents which lower the melting point of silica from 3,000 to 2600° F. After this stage, the clinker is cooled, pulverized and gypsum added to regulate setting time. It is then ground extremely fine to produce cement.

1.1.1 TYPES OF CEMENT

By altering the chemical compositions of the ordinary Portland cement (OPC), many types of cement can be obtained as follows;

- ❖ Ordinary Portland cement (OPC)
- ❖ Sulphate resistance cement
- ❖ Low heat cement
- ❖ Quick setting cement
- ❖ Portland Pozzolana cement (PPC)
- ❖ High alumina cement
- ❖ Colored cement
- ❖ White cement
- ❖ Air entraining cement
- ❖ Hydrophobic cement
- ❖ Expansion cement
- ❖ Rapid hardening Portland cement

Ordinary Portland cement:

This is the most commonly used cement for all types of engineering works. Ordinary

Portland cement (OPC) is manufactured in different grades; the most common grades in India are 33, 43 and 53 grade. OPC is manufactured by burning lime stone and clay at very high temperature range of 1400° C to 1700°C and thereafter grinding (or) pulverizing it with gypsum to retard the setting time.

Uses / Advantages:

- Normally used for all kind of construction works
- Widely used in residential construction where special type of cement properties is not required

Sulphate resistance cement

Sulphate resisting cement is a type of Portland cement in which the amount of tri-calcium aluminates (C_3A) is restricted to 5 %. The use of sulphate resistance cement is particularly beneficial in such conditions where the concrete is exposed to the risk of deterioration due to sulphate attack or directly exposure to the soil.

Uses / Advantages:

- ✓ It is used in the construction of foundations and piles.
- ✓ Basements and underground structures.
- ✓ Sewage and Water treatment plants.
- ✓ Chemical, Fertilizers and Sugar factories.
- ✓ Food processing industries and Petrochemical projects.
- ✓ Coastal works.
- ✓ Also for normal construction works where OPC is used.

- ✓ Construction of building along the coastal area within 50 km from sea.

Low heat cement

Low heat cement is produced by reducing the amount of tri-calcium aluminates (C_3A) & di-calcium silicate (C_2S). This type of cement is used in mass constructions (like dams) and in high wear resistance required area. In general, this type of cement is producing very minimum amount of CO_2 emission than OPC.

Uses / Advantages:

- It is very much used in the mass Construction of dams,
- Mass construction of marine structures
- Hydraulic Engineering Concrete
- Retaining wall construction

Quick setting cement

This type of cement is manufactured by reducing the amount of gypsum and adding small amount of aluminium sulphate to accelerate setting time of cement. As the name suggests, it is used where the works needs to be done quickly and when mixed with water starts to set in five minutes and become hard like stone in just 30 minutes.

Uses / Advantages:

- It is used in under water construction.
- It is also used in rainy & cold weather conditions.
- Where, quick strength is needed in short span of time.

Portland Pozzolana cement (PPC)

PPC is manufactured by adding pozzolanic materials such as fly ash, shales, clays etc. It gains high compressive strength with age and it is affordable than other type of concrete.

Uses / Advantages:

- ✓ Used in the hydraulic structures such as dam, canals, lining etc.
- ✓ Mass concreting works such as foundation, tall building etc.
- ✓ Construction of marine structures.
- ✓ This cement has higher resistance to chemical attacks. Hence it can be used in construction of industrial buildings
- ✓ Used in the construction of water tighted structures (Water tank, retaining wall etc.)

High alumina cement

High-alumina cement is rapid hardening cement made by fusing at 1500 to 1600 °C a mixture of bauxite and limestone in an electric furnace or in a rotary kiln. It also can be made by sintering at about 1250 °C.

[*Sintering: Process of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquification]

Uses / Advantages:

- This cement is used in construction of refineries, factory or other workshop type structure
- Used in Sewage structures
- Used where acid resistance structures are needed

Colored cement

Colored cement is manufactured by mixing color pigments (5 - 10%) with OPC. As the name suggests, it is used where colored cements required for any aesthetic purpose. Chromium Oxide gives Green color. Cobalt gives blue color. Iron oxide gives brown color.

Uses / Advantages:

- These are widely used for finishing of floor, external surface, plastering wall, colored tiles.
- Used in construction of swimming pool, garden path, tennis courts etc.
- Used in the construction of artificial marble

White cement

This cement is white in color. This cement is free from coloring ingredients such as iron oxide, magnesium oxide, chromium oxide. This cement is burned by oil, and is very costlier than other type of cements.

Uses / Advantages:

- It is used for floor finishes, plaster works, pointing of brick and stone works
- Used in the manufacturing of precast stone and tiles, aerodromes marking, traffic kerb and bridge rails.
- Used as a base coat before painting
- Used to cover the hairline cracks on concrete surface to give smooth finish

Air Entrained Cement

Air Entrained cement produced by mixing small amount of air entraining agent (Polymer based chemicals). Generally, this air entraining agents are used to introduce a tiny bubbles

in the concrete. It is used to fill up the gap in concrete which are produced by excessive amount of water during casting.

Uses / Advantages:

- Used in frost resistance concrete (resistance to freezing and thawing)
- Air entrained concrete has less tendency to bleed, it is considerably more plastic than ordinary concrete, and it generally shows less segregation.

Hydrophobic cement

This type of cement is manufactured by mixing admixtures like petrolatum, naphthalene soap which forms layer and act as water repellent. It is useful in wet climatic conditions and Useful when cement is stored for longer duration in wet climatic conditions.

Expansion cement

Expansive Cement is formed from the reaction of tri calcium aluminate (C_3A) with Calcium Sulphate (C_2SO_4). As the name suggests, it expands and increases in volume while settled. Used to avoid the shrinkage of concrete.

Uses / Advantages:

- ✓ Used in repair works (to create a bond with old concrete surface)
- ✓ Used in Hydraulic Structures

Rapid hardening Portland cement (RHPC)

RHPC manufactured by combining lime stone (finely ground) and shale at high temperature. This type of cement is used where high strength is needed to be achieved quickly.

Uses / Advantages:

- ❖ It is used where formwork has to be removed as early as possible in order to reuse it.
- ❖ It is used where high early strength is required.

- ❖ It is generally used for constructing road pavements, where it is important to open the road to traffic quickly.
- ❖ It is used in industries which manufacture concrete products like slabs, posts, electric poles, block fence, etc.
- ❖ It is used for cold weather concreting

[The main disadvantage of the rapid hardening cement is costlier than other type of cement]

