B. Architecture

Building Material – III (AR6304)

Requirements of Ingredients for Mortar/Concrete

Lecture - 1

Brief about Cement:

Let us start with the cement it is always very interesting to start with the history of any matter. Cement is the Assyrians and Babylonians were perhaps the first to use clay as cementing material. In ancient monuments for example forts, places of worship and defense structures, stones have been invariably used as a construction material with lime as the binder. If you looked at it the basic small domestic buildings could be built without binders but as you go bigger and bigger one should use a composite set of materials and a binder was an important aspect in it.

Records show that Egyptians have used lime and gypsum as cementing material in the famous pyramids. Vitruvius, a Roman is believed to be the first to have the knowhow about the chemistry of the cementious lime. Lime was an important material those days. One of the most notable examples of Roman work is the Pantheon. It consists of a concrete dome 43.43m span.

The calcareous cements used by the romans were either composed of suitable limestone burned in kilns or were mixtures of lime and puzzolanic materials (volcanic ash, tuff) combining into a hard concrete. Joseph Aspedin of Yorkshire (U.K) was the first to introduce Portland cement in 1824 formed by heating a mixture of limestone and finely divided clay in a furnace to a temperature high enough.

In 1845, Issac C. Johnson invented the cement by increasing the temperature at which the mixture of limestone and clay were burned to form clinker. This cement was the prototype of the modern Portland cement.

Cement – Definition:

Let’s go into the definition of cement, Cement in a general sense are adhesive and cohesive materials which are capable of bonding together particles of solid matter into a compact durable mass. Cement used in Construction industry may be classified as hydraulic and non-hydraulic.

The latter does not set and harden in water such as non-hydraulic lime or which are unstable in water, e.g., Plaster of Paris. The hydraulic cement set and then hardens in water and gives a product which is stable. Portland cement is one such. It is a cementing material resembling a natural stone quarried from Portland in U.K. Portland cement may be defined as a product obtained by finely pulverizing clinker produced by calcining to incipient fusion, an intimate and properly proportioned mixture of argillaceous and calcareous materials.

Cement can be manufactured either from natural cement stones or artificially by using calcareous and argillaceous materials. The examples of natural cements are Roman cement, Puzzolana cement and Medina cement and those of artificial cement are Portland cement and special cements.

Cement – Composition:

We now move on to the composition of the cement. It is very important for any of the building material because when we look at the composition the various properties give you the characteristics of what makes it that particular building material and how it has be used. The three constituents of hydraulic cements are lime, silica and alumina. In addition most cement contains small proportions of iron oxide, magnesia, sulphur trioxide and alkalis. There has been a change in the composition of Portland cement over the years mainly reflected in the increase in lime content and in a slight decrease in silica content another raw material is blast-furnace slag which consists mainly of lime, silica and alumina and is mixed with a calcareous material of high lime content. The proportions of the above compounds vary in the various Portland cements. These various constituents combine in burning and form cement clinker. The compounds formed in the burning process have the properties of setting and hardening in the presence of water. They are known as Bogue compounds after the name of Bogue who identified them. The ordinary Portland cement has been classified as 33 Grade (IS269:1989), 43 Grade (IS 8112:1989), and 53 Grade (IS 12669-1987).

Cement – Strength:

Here will see about the strength of the cement which is the most important property. Strength of cement is primarily defined in three ways as,

1. Compression
2. Tension
3. Flexural strength

The compressive strength of cement is tested by making cubes of cement and testing it for compression using a vibrating means. Tensile strength also yields an indication of the compressive strength.

Cement – Properties:

It is always desirable to use the best cement in constructions. Therefore the properties of good cement must be investigated. Although desirable cement properties may vary depending on the type of construction, generally a good possesses following properties.

- Provides strength to masonry.
- Stiffens or hardens early.
- Possesses good plasticity.
- An excellent building material.
- Good moisture-resistant.

Application of Cement:

Cements may be used alone that is "neat" as grouting materials but normal use is in mortar and concrete in which the cement is mixed with inert material known as aggregate.

Mortar is cement mixed with sand or crushed stone. Concrete is a mixture of cement, sand or other fine aggregate and a coarse. Mortars are used for building bricks, blocks and stone in walls or as surface renderings where the Concrete is used for a large variety of constructional purposes. Mixtures of soil and Portland cement are used as a base for roads. Portland cement also is used in the manufacture of bricks, tiles, shingles, pipes, beams, railroad ties and various extruded products. These products are prefabricated in factories and supplied ready for installation. It is also used for making joints for drains and pipes. It is used for water tightness of structure.

It is used where hard surface is required for the protection of exposed surfaces of structures against the destructive agents of the weather and certain organic or inorganic chemicals. It is also used for precast pipes manufacturing, piles, fencing posts etc. It is used in the construction of important engineering structures such as bridges, culverts, dams, tunnels, light houses etc. It is used in the preparation of foundations, water tight floors, footpaths etc., and is also employed for the construction of wells, water tanks, tennis courts, lamp posts, telephone cabins, roads etc.

Manufacture of Cement:

So understanding the manufacture of cement we can know how the characteristics are particularly formed. Here you can see the illustrative diagram for the manufacture of cement. If you look at it we have a dump truck which deposits the main form of the material used for making cement. It goes further and there is a first crush where the calcite materials add just sand, silica and clay.

This material then crushed and ground together and put to certain temperature of heat so it goes through a kiln and then clinks as clinkers. Clinker is the main base unit of cement these further put to heat and cool down and then broken down with the help of the catalyst for example gypsum and at the end we get the cement.

Cement is usually manufactured by two processes.

- Wet process
- Dry process

These two processes differ in operation but fundamentals of both these processes are same. There are five stages in manufacturing of cement by wet process.

i. Crushing and grinding of raw material
ii. Mixing the material in proportion
iii. Heating the prepared mixture in rotary kiln
iv. Grinding the heated product known as clinker
v. Mixing and grinding of cement clinker with gypsum

Crushing and Grinding:

In this phase, soft raw materials are first crushed into suitable size. This is done usually in cylindrical ball or tube mills containing the charge of steel balls.

Mixing the Materials:

In this part, the powdered limestone is mixed with the clay paste in proper proportion (75% is equal to lime stone; clay is equal to 25%). The mixture is then grounded and made homogeneous by mean of compressed gas. The resulting material is known as slurry having 35-40% water.

Heating the slurry in rotary kiln:

Slurry is then introduced in rotary kiln with help of conveyor. The rotary kiln consists of large cylinders 8 to 15 feet in diameter & height of 300-500 feet. It is made with steel and is usually lined inside with firebricks. Kiln rotates at the rate of 1 to 2 revolutions per minute. In rotary kiln, slurry is passed through different zones of temperature. This whole process in kiln usually covers 2 to 3 hours.

Clinker Formation:

The product which is obtained from the rotary kiln is known as the cement Clinker. Clinker is usually in the form of greenish black or grey colored balls.

Grinding the Clinker with Gypsum:

The Cement Clinker is then air cooled. The required amount of Gypsum (5%) is ground to the fine powder and then mixture with the Clinker. Finally cement is packed in bags and then transported to the required site.

The chief advantages of the wet process are the low cost of excavating and grinding raw materials the accurate control of composition and homogeneity of the slurry and the economical utilization of fuel through the elimination of separated drying operations. On the other hand the longer kilns essential in the wet process cost more and are less responsive to a variable clinker demand than the short kilns which can be used in the dry process.

Cement Test:

The various tests that shall be conducted to maintain fine cement is,

- Fineness test

- Soundness test
- Setting time test
- Strength tests
    i. Compressive strength test
    ii. Tensile strength test
    iii. Flexural strength test
- Specific gravity test
- Consistency test
- Heat of hydration test
- Loss of ignition test

Cement – Fineness Test:

The degree of fineness of cement is the measure of the mean size of the grains in it. There are three methods for testing fineness, the sieve method, the air permeability method and the sedimentation method.

The last two methods measure the surface area, whereas the first measures grain size. Since cement grains are finer than 90 micron, the sieve analysis method does not represent true mean size of cement grains. Also the tiny cement grains tend to conglomerate into lumps resulting in distortion in the final grain size distribution curves. Considering these demerits, fineness is generally expressed in terms of specific area, which is the total surface area of the particles in unit weight of material.

Cement – Consistency test:

This is a test to estimate the quantity of mixing water to form a paste of normal consistency defined as that percentage water requirement of the cement paste. The viscosity of which will be such that the Vicat's plunger penetrates up to a point 5 to 7 mm from the bottom of the Vicat's mould. The cube mould is most common mode of testing the consistency of the cement of different batches.

Cement – Rapid Hardening Cement:

RHC has high lime content and can be obtained by increasing the C3S content but is normally obtained from OPC clinker by finer grinding. The basis of application of rapid hardening cement (RHC) is hardening properties and heat emission rather than setting rate.

RHC attains same strength in one day which an ordinary cement may attain is 3 days. The cost of rapid hardening cement is about 10% more than the ordinary cement. Concrete made with RHC can be safely exposed to frost, since it matures more quickly. It is suitable for repair of roads and bridges and when load is applied in a short period of time.

Cement – White and colored Cement:

It is manufactured from pure white chalk and clay free from iron oxide. Grayish color of cement is due to iron oxide. So, the iron oxide is reduced and limited below 1 per cent. Colored cements are made by adding 5 to 10 per cent coloring pigments before grinding. These cements have same properties as that of ordinary Portland cement and are non-staining because of low amount of soluble alkalis. Sodium alumino fluoride is added during burning which acts as a catalyst in place of iron. These cements are used for making terrazzo flooring, face plaster of walls (stucco), ornamental work and casting stones.

Cement – Water proof cement:

It is manufactured by adding stearates of Ca and Al and gypsum treated with tannic acid etc., at the time of grinding.

Property - It is resistant to penetration of water.

Uses – Water retaining structures like tanks, reservoirs, retaining walls, swimming pools, bridge piers etc.

Cement – Water repellant Cement:

It is also called hydrophobic cement. A small amount of hydrophobic surfactants such as stearic acid, boric acid or oleic acid is mixed with the ordinary Portland cement during grinding of clinker. When concrete is being prepared, hydrophobic admixtures plasticize the mix and contribute to the formation of uniformly distributed fine pores in concrete as it hardens and thus enhance its frost resistance. Hydrophobic cement also features greater water resistance and water impermeability.

Uses – It is most suitable for basements and for making water tight concrete.