CONCRETE TECHNOLOGY (IV sem)

UNIT-1

(Part-3 Admixtures- (iii) Mineral Additives or Supplementary Additives)

Pozzolana Admixtures (Mineral additives):

Pozzolanic materials are finely ground siliceous and aluminous materials, which do not possess cementing property in themselves, but in the presence of moisture, chemically react with calcium hydroxide released from the hydration of Portland cement at normal temperature to form compounds of low solubility having cementing properties. The action is termed ***Pozzolanic Action***. The suitable pozzolanas used in appropriate amount can modify certain properties of fresh and hardened mortars and concrete.

Pozzolanic materials can be grouped into two groups:

1. Natural Pozzolanas- Clay, shale, opaline cherts, diatomaceous earth, volcanic tuffs and pumicites.

2. Artificial Pozzolanas- Fly-ash, surkhi, blast-furnace slag, silica fumes, rice husk ash.

Other mineral additives are finely ground marble, quartz, granite powder. They neither possess pozzolanic property nor the cementing properties, they just act as *Inert fillers*.

Effects of Pozzolanas on the Properties of Concrete:

- Lower the heat of hydration and thermal shrinkage
- Reduced permeability
- Improved work-ability with lesser amount of water
- Reduced susceptibility to dissolution and leaching of calcium hydroxide
- Reduced alkali-aggregate reaction
- Increased resistance to freezing and thawing
- Improved resistance to attack by sulphate soils and sea water.
- Improve extensibility
- Lower costs

Strength

The rate of development of strength and ultimate strength differs from pozzolana to pozzolana. It is seen that Portland pozzolana cements consistently develop higher tensile strength than Portland cement. Pozzolanas do not contribute to the development of compressive strength. No pozzolanic action is evident at 7 days of curing, but it is apparent at 28 days and more pronounced when the concrete is 90 days old.

When used in smaller quantities, it is even more efficient than Portland cement, but beyond 20%, its effectiveness is decreased.

Permeability

It is used as a replacement for cement is there ability to reduce the permeability of concrete. Pozzolanas of opaline character are more effective in reducing permeability at the early stages than the glassy pozzolana are such as pumicites and fly ash. The leaner the concrete, the more beneficial is the effect of pozzolana in reducing the permeability. It is estimated that at 28 days, concrete may be fly ash concrete may be 3 times as permeable ordinary concrete but thereafter 6 months it may be less than one quarter as permeable.

Heat of Hydration

The heat of hydration is always greater for a are given Portland cement. The heat generation and resultant temperature rise in concrete made with the combination of pozzolana and ordinary Portland cement is almost similar to concrete made with low heat cement. This is an important and desirable characteristic in mass concrete structures. Pozzolanic admixtures are used in mass concrete for achieving economy also.

Volume Change

In general, mortars in cement containing pozzolana as cement replacement expand slightly more under continuously wet conditions and shrink substantially more under continuously dry conditions than the corresponding mortars and concretes containing only Portland cement.

Alkali-Aggregate Reaction

Pozzolanas are effective in reducing the excessive expansion of concrete, due to alkali aggregate reaction. It is observed that when an aggregate contains silica in a particular percentage and in particular size, alkali aggregate reaction takes place. It is possible that use of pozzolanic material imbalances the optimum condition that is required for alkali aggregate reaction, and hence reduce alkali aggregate reaction.

Resistance to Sulphate Attack

The sulphate resistance of ordinary Portland cement was greatly increased when certain pozzolanic materials were used as replacement of cement. The reason is that the addition of pozzolanic material converts calcium hydroxide formed in the process of hydration, into insoluble cementitious compound. The improvement in the permeability characteristic of concrete is the important factor responsible for the improve resistance to sulphate attack.

Workability

Additions of some pozzolanic material is found to increase the workability without necessitating the increase in water-cement ratio. Since, their surface is very smooth and particle will act as a ball bearing for the aggregate to slide past over each other.

Bleeding

Bleeding or water-gain is very undesirable since it makes the concrete porous and inferior. Use of pozzolanic material is found to be very effective in reducing bleeding.

Segregation

Concrete material often segregates during transporting, placing and compacting. This tendency is more when the concrete is to wet. The tendency for segregation can be greatly reduced by the addition of a moderate percentage of pozzolana as cement replacement.

Fly-ash:

The fly ash or *pulverized fuel ash* (PSA) is the residue from the combustion of pulverized coal collected by the mechanical dust collectors or electrostatic precipitators or separators from the fuel gas of thermal power plants. The fly ash contains oxides of calcium, aluminium and silicon, but the amount of calcium oxide is considerably less. The carbon content in fly ash should be as low as possible, whereas silica content should be as high as possible.

The material, once considered a waste by-product, finding difficult to be disposed off, has now become a material of considerable value. Indian Standard 3812 Parts I, II and III gives the various specifications for fly ash.

The fly ash obtained from electrostatic precipitators higher fineness than the Portland cement. The fly ash obtained from cyclone separators is comparatively coarser and may contain larger amounts of unburnt fuel.

Surkhi:

Surkhi is the most common pozzolanic materials used in India. Surkhi is an artificial pozzolana made by powdering burnt bricks. In some major works, for large scale production of surkhi, clay brick or clay balls are specially burnt for this purpose and then powdered.

By its nature, it is very complex material differing widely in qualities and performances. Being derived from the soil, its characteristics are greatly influenced by the nature of soil, degree of burning and fineness of grinding. this is also used for the reason of economy.

'Burnt Clay Pozzolana' is used instead of the word surkhi giving specific property and composition to this improved construction material. The specification of this material is covered by IS:1344-1968.

Surkhi is used as an admixture in the construction of Krishnaraja Sagar dam, Thungabhadra, Chambal, Kakrapara and in Bhakra Dam.

Granulated Blast-Furnace Slag:

It is a waste industrial by-product obtained during the production of iron. The blast-furnace slag is non-metallic product having oxide composition similar to that of Portland cement clinker, i.e., it consists essentially of silicates and aluminates of calcium and other bases but it contains lesser but it contains lesser calcium oxide.

Air cooled crystalline slag has no commenting properties. However, when cooled rapidly it solidifies in a granulated (Glassy) form, which is reactive with water having alkaline medium. Alkaline medium required to initiate the hydration can be provided by lime, sodium hydroxide or gypsum. Like Portland cement, the growth and interlocking of calcium-silicate-hydrate gives mechanical strength.

The main advantage in using blast-furnace slag is the lower rate of heat evolution, refined pore structure, reduced permeability and improved resistance to sulphate attack. The performance of slag largely depends on chemical composition, glass content and fineness of grinding.

Silica Fumes:

Silica fume, also called micro-silica, is a light to dark grey or pink or white cementing material, composed of at least 85% ultra-fine, amorphous non-crystalline glassy spherical silicon dioxide particles. It is produced as a product during the manufacture of Silicon metal or ferrosilicon alloys by reduction of high purity quartz in a submerged-arc electric furnace heated to 2000^{o}C with coal coke and wood chips as fuel.

The silica fume is not chemical admixture because it has no formulated chemical composition, nor does it have a chemical action distinct from pozzolanas.

The extremely fine particle size, large surface area and high content of highly reactive amorphous silicon dioxide give silica fume pozzolanic properties.

The various advantages in using silica fume such as reduction in bleeding and segregation of fresh concrete, improvements in the strength and durability characteristics of hardened concrete. The combination of high reactivity and extreme fineness results in the possibility of producing more dense concrete with a very low porosity, the pores being small and discontinuous, and therefore, with a high strength and a low penetrability.