Topic 9 Admixture

Admixtures are artificial or natural materials added to the concrete besides cement, water and aggregate to enhance the properties of concrete for applications in concrete works during casting or setting or service stage with special requirements.

To improve the properties of the concrete required. It can be divided in two groups that is:

1. Chemical Admixture
2. Mineral Admixture

Functions of Admixture

- To improve workability of fresh concrete
- To improve durability by entrainment of air
- To reduce the water required
- To accelerate setting & hardening, thus to produce high early strength
- To aid curing
- To impart water repellent / water proofing property
- To cause dispersion of the cement particles when mixed with water
- To retard setting • To improve wear resistance (hardness)
- To offset / reduce shrinkage during setting & hardening
- To cause expansion of concrete and automatic prestressing of steel
- To aerate mortar / concrete to produce a light-weight product
- To impart colour to concrete
- To offset or reduce some chemical reaction
- To reduce bleeding
- To reduce the evolution of heat

Types of chemical admixtures

- Water reducing Admixture
- Set-controlling chemicals
- Air Entraining
- Viscosity modifying agents
- Corrosion Inhibitors
- Alkali-Aggregate Reaction Inhibiting
- Shrinkage Reducing

Water reducing admixture

Types and Examples	Normal water reducers	High range water reducers	
	Lignosulphonates	Polysulphonates	polycarboxylates
	Hydroxycarboxylic acids	Sulphonated naphthalene formaldehyde	poly acrylates

	Carbohydrates	Sulphonated melamine formaldehyde	monovinyl alcohols
	Corn syrup, dextrin, Sugar		
Dosage Between	0.3 to 0.5 %	0.7 to 1 %	
Problems	High retardation and air entrainment	excessive retardation, lack of early strength	

Water reducing admixture

- Work on the principle of Dispersion
- Portland cement being in fine state will have a tendency to flocculate in wet concrete, these flocculation entraps certain amount of water used in the mix. When its used, they get adsorbed on the cement particles, creates particle to particle repulsive forces which overcome the attractive forces.
- This repulsive force is called Zeta Potential, which depends on the base, solid content, quantity of plasticizer used. When cement particles are deflocculated, the water trapped inside the flocs gets released & now available to fluidify the mix.

Set-controller admixtures

- Accelerator (It will increase the rate of dissolution of calcium ions and silicates.) • Retarder (It will impede the dissolution of calcium and aluminate)
- Added to increase/decrease the rate of hydration of concrete mix which then lead to the increases/decreases in the rate of development of strength and heat evolution.
- To shorten/longer the setting time,
- Disadvantages is possible cracking due to heat evolution & possibility of corrosion of embedded reinforcement and it may promote bleeding.

It is interesting to know, the same chemical acts as a retarder in the lowers dosages and an accelerator at higher dosages.

Examples: Calcium chloride, Calcium nitrate, Sodium silicate, Triethanol amine, Diethanol amine, Carboxylic acids, Lignosulphonates, Hydroxycarboxylic acids, Carbohydrate, Borates and Phosphates of zinc and copper, gluconic acid.

Air Entraining Admixture

- An entraining concrete containing air in a rather special form of a bubble that trapped in concrete,
- Used to improve workability, ease of placing, increased durability, better resistance to frost action.
- Able to reduce segregation tendency and control of bleeding.

- The common Air-Entraining agents are natural wood resins, neutralized vinsol resins, polyethelene oxide polymers and sulphonated compounds.
- Used to increase concrete durability by protecting it against freeze-thaw cycle damage.
- By entraining air in concrete to form a microscopic air-void system , the expansion is provided a relief valve system. The air void system in the hardened concrete paste allows water to freeze, with the empty air voids providing room for the expansion that occurs as water changes to ice.

Viscocity modifying admixtures Applications:

• To improve stability of the extremely flowable concretes like selfcompacting concrete (which maybe prone to segeration)

• To prevent the wash-out of concrete in underwater application. (also called as Anti-washout admixture) Examples: Xanthan gum, Diutan gum, Alginates, Hydroxypropyl methyl cellulose and Hydroxypropyl starch.

Mineral Admixtures

- It optimize the particle size distribution of the cementitious materials that leads to homogeneous concrete.
- 3 major aspects of sustainability, social aspect, environmental aspect and economic aspect.
- They follow calcium oxide, aluminum oxide and silica ternary diagram.
- Types: Cementitious, Pozzolanic, Ground Granulated Blast Furance Slag (GGBFS), Fly ash, Silica Fume, Rice Husk, Calcined clay, Metakaolin,
- Fly-Ash Properties
- The fine particulate waste material produced by pulverized coal-based thermal power station, is an environmental pollutant, it has a potential to be a resource material.
- As per IS 3812: 2003, the generic name of the waste product due to burning of coal or lignite in the boiler of a thermal power plant is pulverized fuel ash. Pulverized fuel ash can be fly ash, bottom ash, pond ash or mound ash.
- Fly ash is the pulverized fuel ash extracted from the fuel gases by any suitable process like cyclone separation or electrostatic precipitation.
- Fly ash (also known as a pozzolan in PCC applications) are siliceous or siliceous and aluminous materials, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperatures to produce cementitious compounds.

Environmental benefits

Fly ash utilization, especially in concrete, has significant environmental benefits including:

- Increasing the life of concrete roads and structures by improving concrete durability,
- Net reduction in energy use and greenhouse gas and other adverse air emissions when fly ash is used to replace or displace manufactured cement, because production of cement 372 KJ/Kg energy is required for fly ash it is zero.
- Reduction in amount of coal combustion products that must be disposed in landfills,
- Conservation of other natural resources and materials.

Benefits to Concrete Fresh Concrete benefits:

- Improved workability
- Decreased water demand.
- Reduced heat of hydration Hardened Concrete benefits:
- Increased ultimate strength
- Reduced permeability
- Improved durability
- Improved resistance to corrosion

GGBFS in concrete & its advantages

- It is a by product of iron manufacturing which when added to concrete improves its properties such as workability, strength and durability.
- It is obtained by the heating of iron ore, limestone and coke at a temperature about 1500 degree Celsius.
- The main constituents of blast furnace slag are CaO, SiO2, Al2O3 and MgO. These are the minerals that are found in most of the cementitious substances.

Formation of GGBFS

The formation of GGBFS is not direct. The by-product of iron manufacturing is a molten slag and molten iron. The molten slag consists of alumina and silica, also with the certain amount of oxides. This slag is later granulated by cooling it. For this, it is allowed to pass through a high-pressure water get. This result in quenching of the particles which results in granules of size lesser than 5mm in diameter. The particles are further dried and ground in a rotating ball mill to form a fine powder, known as ground granulated blast furnace slag cement. Now different methods can be employed to perform the main process called as the quenching. Based on what method is

employed, it can be known as palletized slag, foamed or expanded slag, GGBFS or aircooled blast furnace slag (ACBFS).

Advantages of GGBFS in concrete

- GGBFS in concrete increases the strength and durability of the concrete structure.
- It reduces voids in concrete hence reducing permeability
- GGBFS gives a workable mix.
- It possesses good pumpable and compaction characteristics
- The structure made of GGBFS constituents help in increasing sulphate attack resistance.
- The penetration of chloride can be decreased.
- The heat of hydration is less compared to conventional mix hydration.
- The alkali-silica reaction is resisted highly.
- These make the concrete more chemically stable
- Gives good surface finish and improves aesthetics
- The colour is more even and light compare to OPC concrete.
- Lower chances of efflorescence.
- The maintenance and repair cost of structures are reduced thus increasing the life cycle of concrete structures.
- Unlike cement, GGBFS does not produce carbon dioxide, sulphur dioxide or nitrogen oxides.

GGBFS Properties

- Bleeding Characteristics of Fresh Concrete with GGBFS (A higher replacement with GGBFS leads to increase in the bleeding.)
- Workability Characteristics of Concrete with GGBFS (The reasons for higher workability is due to the spherical and glass texture of particles surface.)
- Glass Count of GGBFS (It is potentially reactive in nature hence greater the proportion of glass greater is the rate of reaction. It is recommended to have a glass count greater than 67 percent.)
- Stiffening Times (The GGBFS is slower in reaction with the water compared with the Portland cement.)

Chemical Reaction of GGBFS

The hydration mechanism is a combination of two reactions mention below.

$$CO_2 + 2OH- \leftrightarrow CO^{2-}_3 + H_2O, \quad (1)$$

$$Ca(OH)_2 \leftrightarrow Ca_2+ + 2OH^-, \quad (2)$$

$$CO_2 + Ca(OH)_2 \downarrow 2OH^- \leftrightarrow Ca_2+ + CO^{2-}_3 + H_2O,$$

$$\leftrightarrow CaCO_3 \downarrow + H_2O. \quad (3)$$

The rate of reaction undergone in a concrete mix with GGBFS mainly depends upon the following factors:

• Temperature: with the increase in temperature the reaction rate increases and vice versa

• The quantity of the components: The increase in the cement component proportion will increase the reaction

• The properties: The chemical composition and the fineness of the components have an influence on the rate of reaction

Highly Reactive Metakaolin Concrete

• It is produced from high purity kaolin clay by calcinations at temperatures ranging from 700 to 800^o C.

• Strength development of concrete (achieved greater strength than controlled concrete)

• Drying Shrinkage of Concrete (it is lowered than controlled concrete)

• Durability of Hardened Concrete (Metakaolin in concrete tend to reduce the size of pores which consequently lead to obtain more strength, higher density, and more resistance to acid).

Application of Concrete Containing Metakaolin

• Improving strength of lightweight concrete, decrease permeability, and releasing post tensioning earlier.

• Develop flexural strength early, increase both reflectability and durability factor • Increase strength and tackle alkali silicate reactions,

• Enhance chloride resistance, increase permeability, durability, and strength.

Microsilica in Concrete

• Microsilica, also known as silica fume or condensed silica fume, is a mineral admixture composed of very fine solid glassy spheres of silicon dioxide. It is usually found as a by-product in the industrial manufacture of ferrosilicon and metallic silicon in high-temperature electric arc furnaces.

• Microsilica reduces the rate of carbonation and decreases permeability to chloride. As a result, microsilica concrete is able to strongly protect reinforcement and embedments from aggressive agents.

Microsilica comes in 3 forms:

Powdered microsilica, Condensed microsilica, Slurry microsilica.

Effects of Microsilica on Concrete Effects on Fresh Concrete

• It reduces segregation possibilities, so it can be used as pumping aid.

• It almost eliminates bleeding, consequently finishing work shall begin early.

• Workability and consistency of concrete decreases.

Effects on Hardened Concrete

• Compressive strength, hence flexural and tensile strength are improved as well.

• Bond strength

• Abrasion resistance

• Reduces permeability; therefore, it helps in protecting reinforcement steel from corrosion.

• Impact and cavitations resistance.

• Sulphate Resistance

• Heat Reduction

• Chemical Resistance

Properties of Microsilica

• Microsilica is a grey; nearly white to nearly black powder.

• Spherical particles less than 1mm in diameter.

• The bulk density of microsilica is based on the degree of densification and varies from 130 to 600 kg/m3 .

• The specific gravity of microsilica ranges between 2.2 to 2.3

The practical use of Microsilica:

It uses in Silica Fume Waterproof Concrete, producing High Strength Concrete, Shotcrete, elastomeric, polymer, refractory, ceramic and rubber applications.

Advantages of Microsilica

• Reduces thermal cracking caused by the heat of cement hydration.

• Improves durability to attack by sulphate and acidic waters.

• Reduces the early age temperature rise.

• Silica fume is cheap; therefore, it is cost-effective.

• It reduces the overall slab weight and cost

• Addition of microsilica decreases efflorescence due to the refined pore structure and increased consumption of the calcium hydroxide.