Admixtures

Lecture No. 11
Admixtures

- The term admixture as “a material other than water, aggregates, hydraulic cement, and fiber reinforcement, used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing.

- Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations.
History

- The use of natural admixtures in concrete was a logical progression.

- Materials used as admixtures included milk and lard by the Romans; eggs during the middle ages in Europe; polished glutinous rice paste, lacquer, tung oil, blackstrap molasses,

- Extracts from elm soaked in water and boiled bananas by the Chinese; and in Mesoamerica and Peru, cactus juice and latex from rubber plants.

- The Mayans also used bark extracts and other substances as set retarders to keep stucco workable for a long period of time.
Function

- Increase workability without increasing water content or decrease the water content at the same workability;
- Retard or accelerate time of initial setting;
- Reduce or prevent shrinkage or create slight expansion;
- Modify the rate or capacity for bleeding;
- Reduce segregation;
- Improve pumpability;
- Retard or reduce heat evolution during early hardening;
Function

- Accelerate the rate of strength development at early ages;
- Increase strength (compressive, tensile, or flexural);
- Increase durability or resistance to severe conditions of exposure, including application of deicing salts and other chemicals;
- Decrease permeability of concrete;
- Control expansion caused by the reaction of alkalies with potentially reactive aggregate constituents;
- Increase bond of concrete to steel reinforcement;
- Improve impact and abrasion resistance;
Chemical Admixtures

Chemical admixtures are added to concrete in very small amounts mainly for the entrainment of air, reduction of water or cement content, plasticization of fresh concrete mixtures, or control of setting time.

- Air-Entrainment
- Water-Reducing
- Set-Retarding
- Accelerating
- Superplasticizers
Mineral Admixtures

- Mineral admixtures (fly ash, silica fume [SF], and slags) are usually added to concrete in larger amounts to enhance the workability of fresh concrete; to improve resistance of concrete to thermal cracking, alkali-aggregate expansion, and sulfate attack; and to enable a reduction in cement content.

- Fly Ash

- Silica Fume

- Ground Granulated Blast Furnace Slag
Air-Entrainment

- An air-entraining agent introduces air in the form of minute bubbles distributed uniformly throughout the cement paste.

- The main types include salts of wood resins, animal or vegetable fats and oils and sulphonated hydrocarbons.

- Entrained air is intentionally incorporated, minute spherical bubbles of size ranging from 5 microns to 80 microns distributed evenly in the entire mass of concrete.
Air-Entrainment

The major proportion of commercial products is based on the following chemical materials, set out in order of probable decreasing use:

- Abietic and pimeric acid salts
- Fatty Acid salts
- Alkyl - aryl sulphonates
- Alkyl sulphonates
- Phenol ethoxylates
Air-Entrainment: Advantages

- Durability

- Reduced bleeding and segregation because of:
  - Attachment of air bubbles with cement particle and linking them.
  - Increase in inter particle attraction caused by adsorption of air entrainer.
  - Bubble acting as extra fine filler and increased total surface area of constituents relative to water volume.
  - Water flow between cement particles is restricted.

- Workability increased due to action of air bubbles as ball bearing which assist movement of particles each other.
Air-Entrainment: Advantages

![Graph showing compressive strength vs. percent entrained air](image)

- Significant Water-cement Ratio = 0.55 by weight
- Percent Sand = 38 by weight
- Maximum size aggregate = 40 mm

This photomicrograph of air entrained plastic concrete suggests how minute bubbles of air function as very small ball bearings which make the concrete more workable than a non-air entrained mix.
**Water-Reducing (Plasticizers)**

- A material, which either increases workability of freshly mixed concrete without increasing water cement ratio or maintains workability with a reduced amount of water, is termed as water reducing admixture.

- As their name implies, the function of water reducing admixture is to reduce the water content of the mix, usually by 5 to 10%, sometimes (in concrete of very high workability) upto 15%.

- Thus, the purpose of using a water reducing admixture in a concrete mix is to allow a reduction in the water cement ratio while retaining the desired workability or, alternatively, to improve its workability at a given water cement ratio.
Water-Reducing (Plasticizers)

- The actual reduction in water depends on dose of admixtures, cement content, type of aggregate used, ratio of cement, fine and coarse aggregate etc.

- The chemicals used as plasticizer (water reducing admixtures) are as follows:
  - Lignosulfonic acids, derivatives and their salts.
  - Hydroxylated carboxylic acids, their salts and derivatives.
  - Nepthalene sulphonic acid based
  - Sulfonated melamine polycondensation products
Water-Reducing (Plasticizers)
Water-Reducing (Plasticizers)

- **Dispersion Effect:** Portland cement will have a tendency to flocculate in wet concrete. These flocculation entraps certain amount of water used in the mix and thereby all the water is not freely available to fluidify the mix. When cement particles are deflocculated, the water trapped inside the flocs gets released and now available to fluidify the mix.

- **Retarding Effect:** It is mentioned earlier that plasticizer gets adsorbed on the surface of cement particles and form a thin sheath. This thin sheath inhibits the surface hydration reaction between water and cement as long as sufficient plasticizer molecules are available at the particle/solution interface.
Water-Reducing (Plasticizers)

- **Dispersion Effect:** Portland cement will have a tendency to flocculate in wet concrete. These flocculation entraps certain amount of water used in the mix and thereby all the water is not freely available to fluidify the mix. When cement particles are deflocculated, the water trapped inside the flocs gets released and now available to fluidify the mix.

- **Retarding Effect:** It is mentioned earlier that plasticizer gets adsorbed on the surface of cement particles and form a thin sheath. This thin sheath inhibits the surface hydration reaction between water and cement as long as sufficient plasticizer molecules are available at the particle/solution interface.
Water-Reducing (Plasticizers)
Water-Reducing: Advantages

- They increase the workability of the concrete without reducing the compressive strength or without changing water-cement ratio. This is particularly useful when concrete pores are restricted either due to congested reinforcement or due to thin sections.

- High strength can be obtained with the same cement content by reducing water cement ratio.

- A saving in the quantity of cement (approx. upto 10%) can be achieved keeping the same water/cement ratio and workability.
## Water-Reducing: Advantages

<table>
<thead>
<tr>
<th>Description of mix</th>
<th>Dosage % cement wt.</th>
<th>Cement kg/m³</th>
<th>W/C Ratio</th>
<th>Slump cm</th>
<th>Compressive strength N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 day</td>
</tr>
<tr>
<td>Reference</td>
<td>--</td>
<td>300</td>
<td>0.6</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Plasticizes</td>
<td>0.2%</td>
<td>300</td>
<td>0.6</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>0.3%</td>
<td>300</td>
<td>0.6</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Strength increase</td>
<td>0.2%</td>
<td>300</td>
<td>0.56</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>0.3%</td>
<td>300</td>
<td>0.54</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Cement saving</td>
<td>0.2%</td>
<td>280</td>
<td>0.6</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>0.3%</td>
<td>270</td>
<td>0.6</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>
Superplasticizers

- The admixtures capable of reducing water content by about 30% are known as super plasticizers.

- At a given water /cement ratio and water content in the mix, the dispersing action of superplasticizer increases the workability of concrete, typically by raising the slump from 75mm to 200 mm, the mix remaining cohesive.

- The resulting concrete can be placed with little or no compaction and is not subject to excessive bleeding or segregation.
Superplasticizers

There exist four main categories of superplasticizers based on their chemical composition:

- Sulfonated melamine formaldehyde condensates
- Sulfonated naphthalene formaldehyde condensates
- Modified lignosulfonates
- Others such as sulfonic acid esters and carbohydrate esters
Superplasticizers

flocculated  deflocculated  dispersed in less water

Low fluidity  High fluidity  Intermediate fluidity

"Physical" effects operative in any slurry or paste
Superplasticizers: Advantages

- Cement content can be reduced to a greater extent keeping the same water/cement ratio. This will lead to economy.

- Water-cement ratio can be reduced significantly keeping same cement content and workability. This will lead to increase in strength.

- Higher workability at very low water cement ratio like casting concrete with heavy reinforcement..

- Reduction in permeability

- Where early strength development is required in prestressed concrete or casting of floor, where early access for finishing equipment is required
### Superplasticizers: Advantages

<table>
<thead>
<tr>
<th>SN</th>
<th>Dosage in Lt/50 kg of cement</th>
<th>W/C ration</th>
<th>Cement content kg/m³</th>
<th>Slump in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Control Mix</td>
<td>0.55</td>
<td>350</td>
<td>50</td>
</tr>
<tr>
<td>II</td>
<td>0.2</td>
<td>0.55</td>
<td>350</td>
<td>80</td>
</tr>
<tr>
<td>III</td>
<td>0.4</td>
<td>0.55</td>
<td>350</td>
<td>150</td>
</tr>
<tr>
<td>IV</td>
<td>0.6</td>
<td>0.55</td>
<td>350</td>
<td>200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SN</th>
<th>Dosage in Lt/50 kg of cement</th>
<th>W/C ration</th>
<th>Cement content kg/m³</th>
<th>Compressive strength in kg/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7 days</td>
</tr>
<tr>
<td>I</td>
<td>Control Mix</td>
<td>0.55</td>
<td>350</td>
<td>175</td>
</tr>
<tr>
<td>II</td>
<td>0.2</td>
<td>0.50</td>
<td>350</td>
<td>255</td>
</tr>
<tr>
<td>III</td>
<td>0.6</td>
<td>0.46</td>
<td>350</td>
<td>325</td>
</tr>
</tbody>
</table>
# Superplasticizers: Advantages

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Dosage in Lt/50 kg of cement</th>
<th>% of cement saving</th>
<th>Cement content in kg/m³</th>
<th>Compressive strength in kg/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 Days</td>
</tr>
<tr>
<td>I</td>
<td>Control mix</td>
<td>-</td>
<td>400</td>
<td>125</td>
</tr>
<tr>
<td>II</td>
<td>0.2</td>
<td>8.5%</td>
<td>366</td>
<td>130</td>
</tr>
<tr>
<td>III</td>
<td>0.6</td>
<td>14%</td>
<td>344</td>
<td>130</td>
</tr>
<tr>
<td>IV</td>
<td>1.0</td>
<td>20%</td>
<td>320</td>
<td>45</td>
</tr>
</tbody>
</table>