Chapter 6: Admixtures for Concrete

Definition
A material other than water, aggregates and hydraulic cement that is used as an ingredient in concrete or mortar and is added to the batch immediately before or during its mixing (ASTM C125).

Reasons for using Admixtures

- reduce cost of concrete construction.
- Achieve certain properties more effectively than by other means.
- Ensure quality of concrete during stages of mixing, transporting, placing and curing in adverse conditions.
- Overcome certain emergencies during concreting.
- Improve or modify some or several properties of portland cement concrete.
- Compensate for some deficiencies.
  - Increase workability without increasing water content or to decrease water content at the same workability
  - Retard or accelerate the time of initial setting
  - Create slight expansion
Modification of Fresh Concrete

- To modify the rate, or capacity for bleeding or both
- to improve segregation
- to improve penetration and increase pumpability
- reduce the rate of slump loss

Modify Hardened Concrete Properties

- Accelerate the rate of strength gain
- increase ultimate strength
- increase durability
- reduce permeability
- compensate for shrinkage
- inhibit corrosion

Note: Admixtures are not a solution for poor mix design nor sloppy concrete practice. They are aimed at providing a more economical solution and enhanced concrete properties.
**General Groupings of admixtures**

**Chemical Admixtures:**
There are water soluble compounds added primarily to control setting and early hardening of fresh concrete or to reduce the water requirements.

**Chemical Admixture Classification**

1. Air entraining admixtures
2. Water reducing admixtures
3. Retarding admixtures
4. Accelerating admixtures

**Mineral admixtures:**
There are finely divided solids to improve workability, durability, or provide additional cementing properties. (i.e. slags, silica fume, fly ash, and pozzolans).

- Raw or calcined pozzolans
- Fly ash produced from burning bituminous coal
- Fly ash normally produced from burning lignite (subbituminous) coal. (both pozzolanic and cementitious).

**Chemical Admixtures**

**Air Entraining Admixtures**

Air entrainment refers to the introduction of large quantities of tiny air bubbles in the concrete matrix. The main reason for air entrainment is to improve the durability of the concrete to freeze-thaw degradation.

**The Air-Void System**

As un-reacted water freezes it expands 9 % by volume on phase change. This internal volume expansion causes internal stresses in the matrix. It can generate cracks in the concrete, which may allow water to infiltrate and the process can get progressively worse. It can lead to significant degradation of the concrete.
The formation of ice in the pore spaces generates pressure on any remaining unfrozen water. Introducing a large quantity of air bubbles provides a place for this water to move in to relieving the internal pressure. What is desired is to generate very many small air bubbles well distributed throughout the matrix rather than a smaller number of larger bubbles.

It's been determined that the optimum air content for frost protection is about 9% by volume of the mortar fraction. With respect to the concrete volume, the air content should be in the range of 4-8% by volume. The concrete normally has entrained air, the admixture increases the total volume of the air voids by 3-4% of the concrete volume.

Total air content is only a part of the formula for frost resistance. The nature of the entrained air is equally important. The critical parameter of the air-entrained paste is the spacing factor (max distance from any point in the paste to the edge of a void). It should not exceed 0.2 mm; the smaller the spacing factor the more durable the concrete.

The air bubbles themselves should be in the range of 0.05 – 1.25 mm in diameter.

**Air Entraining Materials**

What is needed is an agent that causes the water to foam into a very small matrix of very small bubbles. The admixtures are of the same family as household detergents, but these do not generate small enough bubbles and are not stable enough.

Air entraining agents contain surface-active agents or surfactants. These lower the water surface tension so bubbles can form, and stabilize the bubbles once they are formed.

Increasing the admixture dosage will increase air content, decrease bubble size, and decrease spacing factor. Thus decreasing the total strength of the concrete.

**Effect of Air on Other Concrete Properties**

- Increase workability and cohesiveness of fresh concrete.
- Considerable reduction in bleeding and segregation.
• Decreased strength (10-20% for most air entrained concrete)
• Increased durability (up to ~7% air; SEE FIG 7.6 Mindess)
• If a lower w/c ratio is used to account for the increased slump, some of the strength reduction will be offset.
• In addition, the lower w/c ratio that can be used and the better compaction
• characteristics results in more impermeable concrete and a better overall resistance to
• aggressive agents (i.e. sulfates).

**Water-Reducing Admixtures**

These admixtures lower the water required to attain a given slump, thus lowering the w/c ratio. This will:

- Improve the strength
- Improve the water tightness
- Improve durability.

Alternately it may be used to maintain the same w/c ratio but increase workability for difficult placement.

Typical reductions in water requirements are 5-10%.

There are admixtures called "superplasticizers" or "high-range water reducers" which can reduce water contents by 15-30%.

The water reducers reduce the electronegative charges on the fine cement particles allowing them to disperse more readily in the water. (Similar to the use of Calgon in hydrometer tests). This reduces the tendency for flocculation of the cement particles in the paste.

**Composition**

Three General Categories

1. salts and derivatives of lignosulfonates.
2. salts and derivatives of hydroxycarboxylic acids.
3. polymeric materials.
**Superplasticizers**

These are linear polymers containing sulfonic acid groups.

Two major commercial formulations
1. sulfonated melamine-formaldehyde condensate; and
2. naphthalene sulfonate-formaldehyde condensate

**Effect on Other Concrete Properties**

**Fresh Concrete**
- Improved workability of fresh concrete (flowing concrete with use of superplasticizers, SP)
- Some types may increase bleeding (hydroxycarboxylic acids).
- They tend to increase air entrainment (so less air entraining admixture can be used)
- Tend to retard set times.
- Rate of slump loss increases with normal-range water reducers about same for superplasticizers.

**Hardened Concrete**
- Increased compressive strength due to ability to reduce w/c ratio and better dispersion of cement in paste
- Increased durability due to lower w/c ratio.
- SP Rapid strength gain without increased heat generation.
- SP used for high strength concrete.