Admixtures for Concrete

Course Number: CE-02-113

PDH: 2

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Module 1: Admixtures for Concrete

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** the operational constraints and prohibited applications of Calcium Chloride accelerators in reinforced and prestressed concrete.
- **Select** the appropriate water-reducing admixture (Normal, Mid-Range, or High-Range) based on required slump, strength, and placement conditions.
- **Identify** the specific primary functions and material compositions of standard concrete admixtures using ASTM classifications.

Executive Summary: Admixtures are powerful tools for modifying concrete properties to reduce costs or handle emergencies, but they are not a “fix-all.” The central tenet of this module is that **no admixture of any type or amount can be considered a substitute for good concreting practice**. Effectiveness depends heavily on compatibility with job materials, temperature, and mix proportions.

Design Fundamentals & Classification

You define admixtures as ingredients other than Portland cement, water, and aggregates that are added to the mixture immediately before or during mixing.

Fig. 1. Liquid admixtures, from left to right: antiwashout admixture, shrinkage reducer, water reducer, foaming agent, corrosion inhibitor, and air-entraining admixture. (69795)

While concrete qualities can often be obtained by selecting suitable materials, the major reasons you will use admixtures are:

- To **reduce the cost** of concrete construction.
- To **achieve specific properties** more effectively than by other means.

- To **maintain quality** during mixing, transporting, placing, and curing in adverse weather.
- To **overcome emergencies** during concreting operations.

💡 **Design Tip:** Always conduct trial mixtures with the specific admixture and job materials at the temperatures anticipated on the job to ensure compatibility and performance.

Admixture Classification Guide

Admixtures must meet applicable specifications (ASTM/AASHTO). The following table details the primary classifications, desired effects, and material compositions.

Table 1. Concrete Admixtures by Classification

Type of Admixture	Desired Effect	Material
Accelerators (ASTM C 494, Type C)	Accelerate setting and early-strength development	Calcium chloride, Triethanolamine, calcium nitrite, calcium nitrate, etc.
Air detrainers	Decrease air content	Tributyl phosphate, dibutyl phthalate, silicones, etc.
Air-entraining admixtures (ASTM C 260)	Improve durability (freeze-thaw, deicer, sulfate); Improve workability	Salts of wood resins (Vinsol), synthetic detergents, sulfonated lignin, etc.
Alkali-aggregate reactivity inhibitors	Reduce alkali-aggregate reactivity expansion	Barium salts, lithium nitrate, lithium carbonate, lithium hydroxide
Antiwashout admixtures	Cohesive concrete for underwater placements	Cellulose, acrylic polymer
Bonding admixtures	Increase bond strength	Polyvinyl chloride, polyvinyl acetate, acrylics, butadiene-styrene copolymers
Coloring admixtures (ASTM C 979)	Colored concrete	Modified carbon black, iron oxide, titanium oxide, cobalt blue, etc.
Corrosion inhibitors	Reduce steel corrosion in chloride-laden environments	Calcium nitrite, sodium nitrite, amines, phosphates, ester amines
Dampproofing admixtures	Retard moisture penetration into dry concrete	Soaps of calcium/ammonium stearate, butyl stearate, petroleum products
Foaming agents	Produce lightweight, foamed concrete (low density)	Cationic/anionic surfactants, hydrolized protein
Fungicides, germicides, insecticides	Inhibit bacterial/fungal growth	Polyhalogenated phenols, copper compounds, dieldrin emulsions
Gas formers	Cause expansion before setting	Aluminum powder
Grouting admixtures	Adjust grout properties	See Air-entraining, Accelerators, Retarders, Water reducers
Hydration control admixtures	Suspend and reactivate cement hydration	Carboxylic acids, phosphorus-containing organic acid salts
Permeability reducers	Decrease permeability	Latex, Calcium stearate
Pumping aids	Improve pumpability	Organic/synthetic polymers, organic flocculents, bentonite, hydrated lime

Table 1. Concrete Admixtures by Classification (Continued)

Type of Admixture	Desired Effect	Material
Retarders (ASTM C 494, Type B)	Retard setting time	Lignin, Borax, Sugars, Tartaric acid and salts
Shrinkage reducers	Reduce drying shrinkage	Polyoxyalkylene alkyl ether, Propylene glycol
Superplasticizers (ASTM C 1017, Type 1)	Increase flowability; Reduce water-cement ratio	Sulfonated melamine/naphthalene formaldehyde condensates, Polycarboxylates
Superplasticizer and retarder (Type 2)	Increase flowability with retarded set; Reduce w/cm ratio	See superplasticizers and water reducers
Water reducer (ASTM C 494, Type A)	Reduce water content at least 5%	Lignosulfonates, Hydroxylated carboxylic acids, Carbohydrates
Water reducer and accelerator (Type E)	Reduce water (min 5%) and accelerate set	See water reducer Type A (accelerator added)
Water reducer and retarder (Type D)	Reduce water (min 5%) and retard set	See water reducer Type A (retarder added)
Water reducer—high range (Type F)	Reduce water content (minimum 12%)	See superplasticizers
Water reducer—high range—and retarder (Type G)	Reduce water content (minimum 12%) and retard set	See superplasticizers and water reducers
Water reducer—mid range	Reduce water content (6–12%) without retarding	Lignosulfonates, Polycarboxylates

Air-Entraining Admixtures

These admixtures introduce and stabilize microscopic air bubbles. This is critical for two primary reasons:

1. **Durability:** It dramatically improves resistance to freezing, thawing, and surface scaling caused by deicers.
2. **Workability:** It significantly improves workability while reducing segregation and bleeding.

Fig. 2. Frost damage (crumbling) at joints of a pavement (top), frost induced cracking near joints (bottom), and enlarged view of cracks (inset). (61621, 67834, 67835)

Fig. 3. Scaled concrete surface resulting from lack of air entrainment, use of deicers, and poor finishing and curing practices. (52742)

You can achieve entrained air using air-entraining cement (interground at the mill) or by adding the admixture directly to the mixer.

Water-Reducing Admixtures (WRA)

You use WRAs to reduce mixing water (lowering the w/cm ratio), reduce cement content, or increase slump.

Conventional Water Reducers (Type A)

- **Reduction:** Typically 5% to 10% water reduction.
- **Strength:** Generally increases due to the lower w/cm ratio.
- **Slump Loss:** Be aware that the rate of slump loss is **not** reduced; in most cases, it increases (see Fig. 6-4).

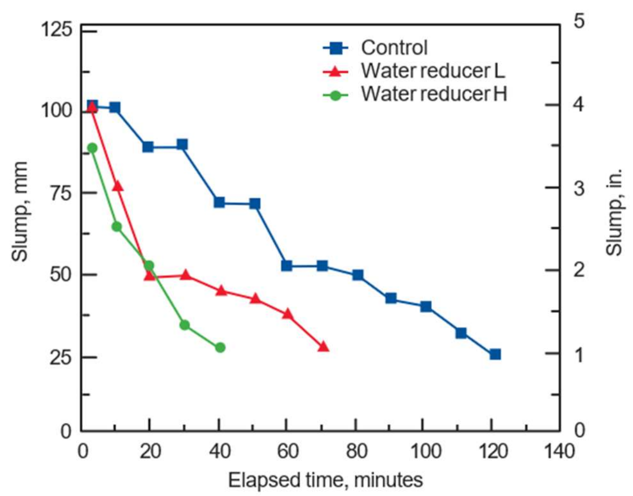

Fig. 4. Slump loss at 23°C (73°F) in concretes containing conventional water reducers (ASTM C 494 and AASHTO M 194 Type D) compared with a control mixture (Whiting and Dziedzic 1992).

Mid-Range Water Reducers

- **Reduction:** 6% to 12% water reduction
- **Application:** Ideal for slumps of 5 to 8 inches. They reduce stickiness and improve finish ability, particularly in concretes containing silica fume.

High-Range Water Reducers (HRWR / Superplasticizers)

- **Reduction:** 12% to 30% water reduction.
- **Performance:** Can produce compressive strengths exceeding 10,000 psi (70 MPa) and reduced chloride-ion penetration.