



Admixtures for Concrete

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Admixtures for Concrete

Admixtures are those ingredients in concrete other than portland cement, water, and aggregates that are added to the mixture immediately before or during mixing (Fig. 6-1). Admixtures can be classified by function as follows:

1. Air-entraining admixtures
2. Water-reducing admixtures
3. Plasticizers
4. Accelerating admixtures
5. Retarding admixtures
6. Hydration-control admixtures
7. Corrosion inhibitors
8. Shrinkage reducers
9. Alkali-silica reactivity inhibitors
10. Coloring admixtures
11. Miscellaneous admixtures such as workability, bonding, dampproofing, permeability reducing, grouting, gas-forming, antiwashout, foaming, and pumping admixtures

Table 6-1 provides a much more extensive classification of admixtures.

Concrete should be workable, finishable, strong, durable, watertight, and wear resistant. These qualities can often be obtained easily and economically by the selection of suitable materials rather than by resorting to admixtures (except air-entraining admixtures when needed).

The major reasons for using admixtures are:

1. To reduce the cost of concrete construction
2. To achieve certain properties in concrete more effectively than by other means
3. To maintain the quality of concrete during the stages of mixing, transporting, placing, and curing in adverse weather conditions
4. To overcome certain emergencies during concreting operations



Fig. 6-1. Liquid admixtures, from left to right: antiwashout admixture, shrinkage reducer, water reducer, foaming agent, corrosion inhibitor, and air-entraining admixture. (69795)

Despite these considerations, it should be borne in mind that no admixture of any type or amount can be considered a substitute for good concreting practice.

The effectiveness of an admixture depends upon factors such as type, brand, and amount of cementing materials; water content; aggregate shape, gradation, and proportions; mixing time; slump; and temperature of the concrete.

Admixtures being considered for use in concrete should meet applicable specifications as presented in Table 6-1. Trial mixtures should be made with the admixture and the job materials at temperatures and humidities anticipated on the job. In this way the compatibility of the admixture with other admixtures and job materials, as well as the effects of the admixture on the properties of the fresh and hardened concrete, can be observed. The amount of admixture recommended by the manufacturer or the optimum amount determined by laboratory tests should be used.

Table 6-1. Concrete Admixtures by Classification

Type of admixture	Desired effect	Material
Accelerators (ASTM C 494 and AASHTO M 194, Type C)	Accelerate setting and early-strength development	Calcium chloride (ASTM D 98 and AASHTO M 144) Triethanolamine, sodium thiocyanate, calcium formate, calcium nitrite, calcium nitrate
Air detrainers	Decrease air content	Tributyl phosphate, dibutyl phthalate, octyl alcohol, water-insoluble esters of carbonic and boric acid, silicones
Air-entraining admixtures (ASTM C 260 and AASHTO M 154)	Improve durability in freeze-thaw, deicer, sulfate, and alkali-reactive environments Improve workability	Salts of wood resins (Vinsol resin), some synthetic detergents, salts of sulfonated lignin, salts of petroleum acids, salts of proteinaceous material, fatty and resinous acids and their salts, alkylbenzene sulfonates, salts of sulfonated hydrocarbons
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, phthalocyanine, umber, chromium oxide, titanium oxide, cobalt blue
Corrosion inhibitors	Reduce steel corrosion activity in a chloride-laden environment	Calcium nitrite, sodium nitrite, sodium benzoate, certain phosphates or fluosilicates, fluoaluminates, ester amines
Dampproofing admixtures	Retard moisture penetration into dry concrete	Soaps of calcium or ammonium stearate or oleate Butyl stearate Petroleum products
Foaming agents	Produce lightweight, foamed concrete with low density	Cationic and anionic surfactants Hydrolized protein
Fungicides, germicides, and insecticides	Inhibit or control bacterial and fungal growth	Polyhalogenated phenols Dieldrin emulsions Copper compounds
Gas formers	Cause expansion before setting	Aluminum powder
Grouting admixtures	Adjust grout properties for specific applications	See Air-entraining admixtures, Accelerators, Retarders, and Water reducers
Hydration control admixtures	Suspend and reactivate cement hydration with stabilizer and activator	Carboxylic acids Phosphorus-containing organic acid salts
Permeability reducers	Decrease permeability	Latex Calcium stearate
Pumping aids	Improve pumpability	Organic and synthetic polymers Organic flocculents Organic emulsions of paraffin, coal tar, asphalt, acrylics Bentonite and pyrogenic silicas Hydrated lime (ASTM C 141)
Retarders (ASTM C 494 and AASHTO M 194, 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 of concrete Reduce water-cement ratio	Sulfonated melamine formaldehyde condensates Sulfonated naphthalene formaldehyde condensates Lignosulfonates Polycarboxylates

Table 6-1. Concrete Admixtures by Classification (Continued)

Type of admixture	Desired effect	Material
Superplasticizer* and retarder (ASTM C 1017, Type 2)	Increase flowability with retarded set Reduce water–cement ratio	See superplasticizers and also water reducers
Water reducer (ASTM C 494 and AASHTO M 194, Type A)	Reduce water content at least 5%	Lignosulfonates Hydroxylated carboxylic acids Carbohydrates (Also tend to retard set so accelerator is often added)
Water reducer and accelerator (ASTM C 494 and AASHTO M 194, Type E)	Reduce water content (minimum 5%) and accelerate set	See water reducer, Type A (accelerator is added)
Water reducer and retarder (ASTM C 494 and AASHTO M 194, Type D)	Reduce water content (minimum 5%) and retard set	See water reducer, Type A (retarder is added)
Water reducer—high range (ASTM C 494 and AASHTO M 194, Type F)	Reduce water content (minimum 12%)	See superplasticizers
Water reducer—high range—and retarder (ASTM C 494 and AASHTO M 194, Type G)	Reduce water content (minimum 12%) and retard set	See superplasticizers and also water reducers
Water reducer—mid range	Reduce water content (between 6 and 12%) without retarding	Lignosulfonates Polycarboxylates

* Superplasticizers are also referred to as high-range water reducers or plasticizers. These admixtures often meet both ASTM C 494 (AASHTO M 194) and ASTM C 1017 specifications.

AIR-ENTRAINING ADMIXTURES

Air-entraining admixtures are used to purposely introduce and stabilize microscopic air bubbles in concrete. Air-entrainment will dramatically improve the durability of concrete exposed to cycles of freezing and thawing (Fig. 6-2). Entrained air greatly improves concrete's resistance to surface scaling caused by chemical deicers (Fig. 6-3). Furthermore, the workability of fresh concrete is improved significantly, and segregation and bleeding are reduced or eliminated.

Air-entrained concrete contains minute air bubbles that are distributed uniformly throughout the cement paste. Entrained air can be produced in concrete by use of an air-entraining cement, by introduction of an air-entraining admixture, or by a combination of both methods. An air-entraining cement is a portland cement with an air-entraining addition interground with the clinker during manufacture. An air-entraining admixture, on the other hand, is added directly to the concrete materials either before or during mixing.

The primary ingredients used in air-entraining admixtures are listed in Table 6-1. Specifications and methods of testing air-entraining admixtures are given in

ASTM C 260 and C 233 (AASHTO M 154 and T 157). Air-entraining additions for use in the manufacture of air-entraining cements must meet requirements of ASTM C 226. Applicable requirements for air-entraining cements are given in ASTM C 150 and AASHTO M 85. See Chapter 8, Air-Entrained Concrete, Klieger (1966), and Whiting and Nagi (1998) for more information.

WATER-REDUCING ADMIXTURES

Water-reducing admixtures are used to reduce the quantity of mixing water required to produce concrete of a certain slump, reduce water-cement ratio, reduce cement content, or increase slump. Typical water reducers reduce the water content by approximately 5% to 10%. Adding a water-reducing admixture to concrete without reducing the water content can produce a mixture with a higher slump. The rate of slump loss, however, is not reduced and in most cases is increased (Fig. 6-4). Rapid slump loss results in reduced workability and less time to place concrete.

An increase in strength is generally obtained with water-reducing admixtures as the water-cement ratio is

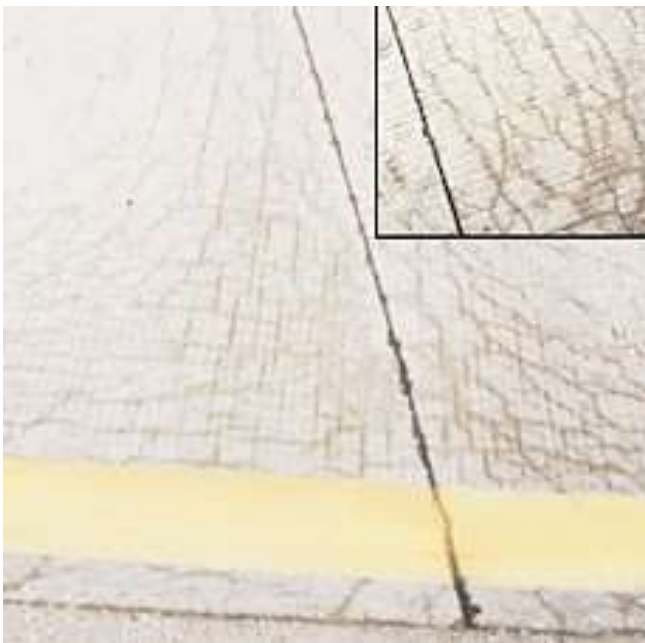


Fig. 6-2. Frost damage (crumbling) at joints of a pavement (top), frost induced cracking near joints (bottom), and enlarged view of cracks (inset). (61621, 67834, 67835)

reduced. For concretes of equal cement content, air content, and slump, the 28-day strength of a water-reduced concrete containing a water reducer can be 10% to 25% greater than concrete without the admixture. Despite reduction in water content, water-reducing admixtures may cause increases in drying shrinkage. Usually the effect of the water reducer on drying shrinkage is small compared to other more significant factors that cause shrinkage



Fig. 6-3. Scaled concrete surface resulting from lack of air entrainment, use of deicers, and poor finishing and curing practices. (52742)

cracks in concrete. Using a water reducer to reduce the cement and water content of a concrete mixture—while maintaining a constant water-cement ratio—can result in equal or reduced compressive strength, and can increase slump loss by a factor of two or more (Whiting and Dziedzic 1992).

Water reducers decrease, increase, or have no effect on bleeding, depending on the chemical composition of the admixture. A reduction of bleeding can result in finishing difficulties on flat surfaces when rapid drying conditions are present. Water reducers can be modified to give varying degrees of retardation while others do not signifi-

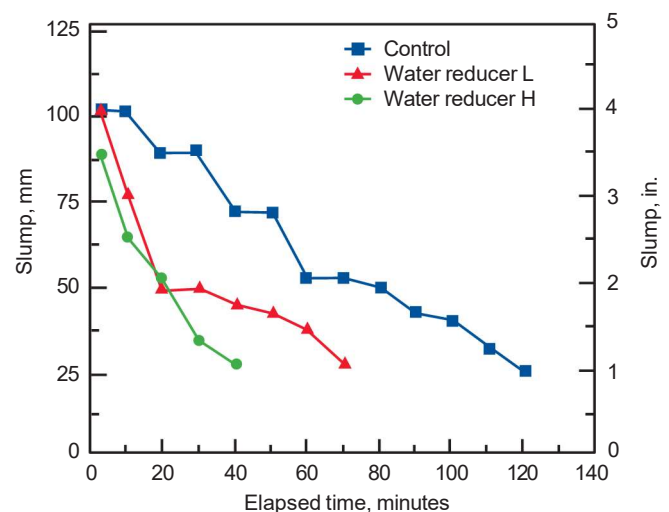


Fig. 6-4. Slump loss at 23°C (73°F) in concretes containing conventional water reducers (ASTM C 494 and AASHTO M 194 Type D) compared with a control mixture (Whiting and Dziedzic 1992).



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