

How Mid-range Water Reducers Enhance Concrete Performance

In addition to their influence on water content, slump, and strength, these new admixtures improve concrete placement and finishability and are uniquely suited to the needs of the flatwork contractor

By GLENN E. SCHAEFER

Today's concrete contractors, producers, and specifiers require greater versatility and increased levels of performance from concrete. Advances in admixture technology have helped modern concrete meet these increased, and often technically challenging, demands. One of the results of this evolution is a new class of concrete admixtures: mid-range water reducers. These water-reducing admixtures provide the finishing contractor with some unique benefits.

Until recently, ASTM's standard classifications were sufficient to define most commercially available water-reducing admixtures (see box on next page). As the table shows, mid-

range water-reducer properties, such as admixture dosage rate and concrete-strength enhancement, fall between those of conventional water reducers and superplasticizers. While the name mid-range accurately identifies the magnitude of water reduction achieved with these products, ASTM has no separate designation for them; they fall either in ASTM C 494 Type A or Type F, or in some cases, fall in both categories, depending on dosage.

Although they can produce high-range water reduction (over 12%), mid-range water reducers do not typically contain naphthalene sulfonates or other compounds typically found in Type F high-range products. Chemically, mid-range water reducers are much closer to

Benefits of Mid-range Water Reducers

Although mid-range water reducers, like standard water-reducing admixtures, improve concrete strength by reducing the water-cement ratio and enhancing hydration, they also provide the following benefits:

- More predictable and consistent set times
- Ability to obtain needed slump without spotty setting problems
- Improved workability at a given slump
- Improved surface slickness, which results in easier finishing and better concrete surfaces
- Faster pumping and placement

Predictable setting time and dosage-rate flexibility. To gain greater improvements in concrete strength or slump, Type A water reducers and Type G retarding high-range water reducers are sometimes added to concrete mixes in dosage rates beyond their normal range. Unfortunately, high dosages of conventional water reducers can also result in longer set times. Mid-range water reducers, however, have a neutral influence on set over a wider range of dosage rates.

Many of the benefits achievable with these mid-range products stem from this dosage flexibility. Concrete producers, for example, can use mid-range water reducers at varying dosage rates to obtain desired slump levels or water reductions in concrete without causing spotty set-

properties.

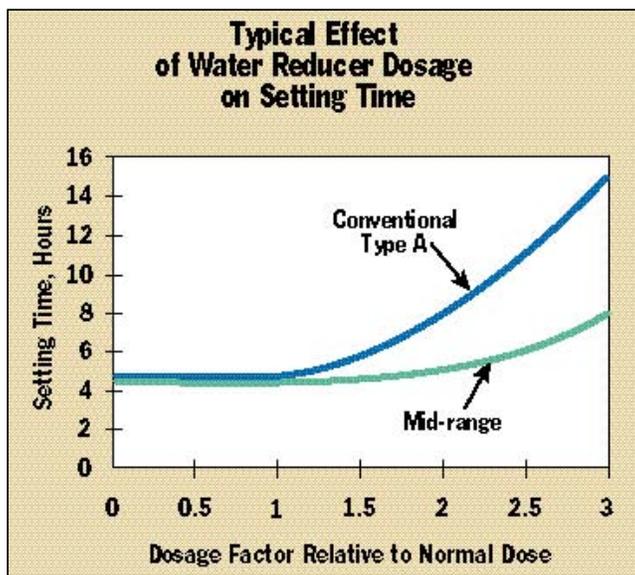


Figure 1. Effects of various dosages on setting times for standard and mid-range water reducers.

ting problems for the contractor. Contractors benefit because the concrete's predictable, consistent set times allow them to maintain production schedules and use crews more efficiently. Figure 1 compares the effects that various dosages of standard and mid-range water reducers have on setting times.

Mid-range water reducers also tend to be more stable over a wider range of temperatures. Conventional Type A water reducers tend to retard setting at cooler temperatures (below 50°F). Mid-range water reducers typically have the same effects on concrete properties during cold weather as they do at more favorable temperatures.

Improved workability and finishing at a given slump. In addition to performing the normal role of dispersing the cement particles in the mixing water, many mid-range water reducers contain a surfactant, or "slickening agent," that helps the concrete particles slide over and around each other more freely. Contractors say this slickness can be felt during concrete placement and finishing operations, and that it often results in greater productivity and better surfaces.

Concrete containing mid-range water reducers has been described by contractors as creamier, fatter, having less drag, and easier to close. Contractors often report that concrete containing mid-range water reducers rakes and screeds as if its slump was 2 to 3 inches higher. For example, if specifications call for a 4-inch slump, the concrete feels like it has a 6- or 7-inch slump.

Finishing enhancement is more difficult to quantify; however, photographs taken with a scanning electron microscope (Figure 2) show that concrete with a mid-range water reducer has a much smoother surface than conventional concrete after three passes with a steel trowel. Improved workability and finishing help speed jobs and improve concrete quality.

Faster pumping and placement. When using concretes containing

mid-range water reducers, the slump can be adjusted by varying the admixture dosage while maintaining the same water-cement ratio. Thus, the workability needed for concrete pumping and placement can be achieved without the detrimental effects of added water or altered setting characteristics.

Types of Mid-range Water Reducers

ASTM C 494 currently recognizes five categories of water-reducing admixtures. There are two categories of set-neutral water-reducing admixtures: conventional water reducers (Type A), and high-range water reducers (Type F). There are also two classes of retarding water reducers: water-reducing retarders (Type D), and retarding high-range water reducers (Type G). Finally, there is one type of accelerating water reducer (Type E).

This classification scheme is based on the amount of water reduction achieved with a standard concrete mixture under laboratory test conditions. By specification, high-range water reducers (HRWRs), commonly called superplasticizers, must produce at least a 12% water reduction, compared to the water content of a reference mixture at a comparable 3½-inch slump. Conventional water reducers must produce at least a 5% water reduction. Mid-range water reducers fall in the middle, producing at least an 8% water reduction.

Many ready mix suppliers today offer concretes containing mid-range water reducers. The admixture is available in both chloride and nonchloride versions. Both provide similar benefits, although the chloride types are more cost-effective and are usually used where potential corrosion of embedded metals is not an issue. In cases where a choice must be made, the admixture manufacturer can sup-

Water reducers can enhance concrete strength in three different ways:

By reducing the water-cement ratio. Generally a decrease of 1 gallon of water per cubic yard of concrete can increase later-age compressive strength by as much as 250 psi.

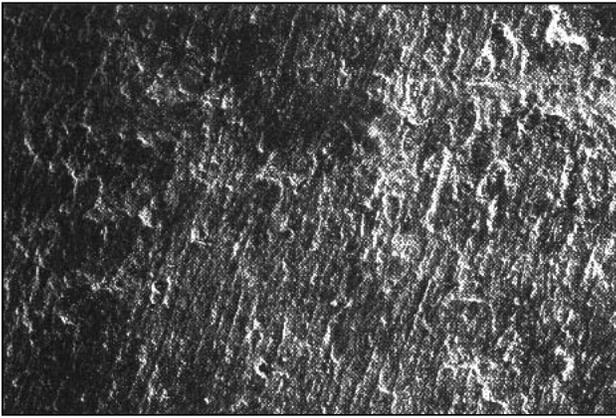
By improving access of water to the cement surface. All types of water reducers improve dispersion of the cement grains within the concrete matrix. The reduction in clumping exposes more cement surface area to the mixing water. This allows more complete hydration of the individual cement grains, which produces increased strengths at all ages.

By chemically enhancing the hydration of cement, resulting in more reaction and higher strength. The strength increase with age will depend on the admixture chemical type: Accelerating components increase early strength, while retarding components increase later-age strength.

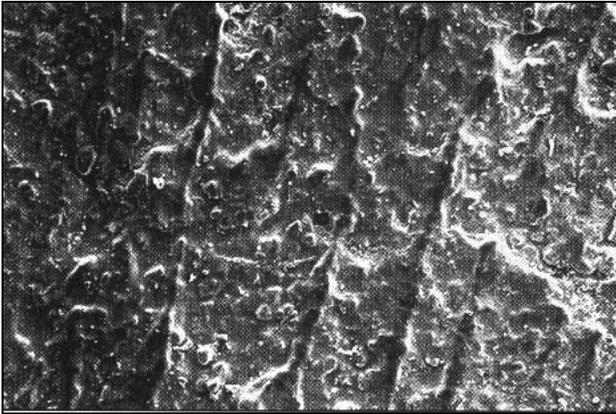
Comparing the Different Types of Water Reducers

PROPERTIES OF CONVENTIONAL, MID-RANGE, AND HIGH-RANGE WATER REDUCERS

Water Reducer	Typical Water Reduction	Typical Dosage Rate	Strength Enhancement	Finishability
Conventional (ASTM C 494, Type A)	5%-10%	3-5 oz/cwt	10%	Average
Mid-range	8%-18%	5-10 oz/cwt	15%	Excellent
High-range (ASTM C 494, Types F & G)	12%-25%	12-16 oz/cwt	20%+	Average



Concrete with mid-range water reducer



Concrete with conventional Type A water reducer

Figure 2. Although finishing enhancement is difficult to quantify, these scanning electron microscope photos of finished concrete surfaces show a smoother texture for the concrete containing a mid-range water reducer (top) after three passes with a steel trowel.

ply the chloride content contributed by various admixture dosages so engineers can make judgments based on applicable American Concrete Institute recommendations.

Applications

Mid-range water-reduced concrete is suitable for many applications, particularly slabs on grade, such as driveways and sidewalks, elevated slabs, and other types of

flatwork. Its adjustable slump and surface slickness minimize time delays on projects where placement is difficult or pumping is necessary. Also, the rich feeling imparted to the concrete decreases the detrimental effects of manufactured sands and harsh concrete mixtures on finishing.

There are also benefits to using mid-range water reducers in concrete not intended for flatwork. The tendency of mid-range water-reduced concrete surfaces to close easily makes the admixture well-suited for extruded concrete, slipform work, and roller-compacted concrete pavements.

But despite the high water reduction some mid-range products can achieve, mixes typically have slumps of only 5 to 6 inches. High-range water reducers still have to be used to obtain flowing concrete with slumps of 8 inches or more, or to obtain very low water-cement-ratio concrete. As with Type A water reducers, mid-range water reducers can be used in conjunction with high-range water reducers to obtain the benefits of both. Be care-

ful not to overdose the mix when combining mid- and high-range water reducers.

Given the multiple benefits of mid-range water reducers, contractors' costs may be a little higher for mid-range water-reduced concrete than for concrete made with conventional Type A products. But on many jobs these benefits (increased dosage-rate flexibility, workability, and productivity) can significantly outweigh the extra material costs. 

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