ORDERING Ready-Mix Concrete

I've been producing concrete for more than 30 years at my company's batch plant in Iowa. By now, I know just about what to

by Don Kincaid

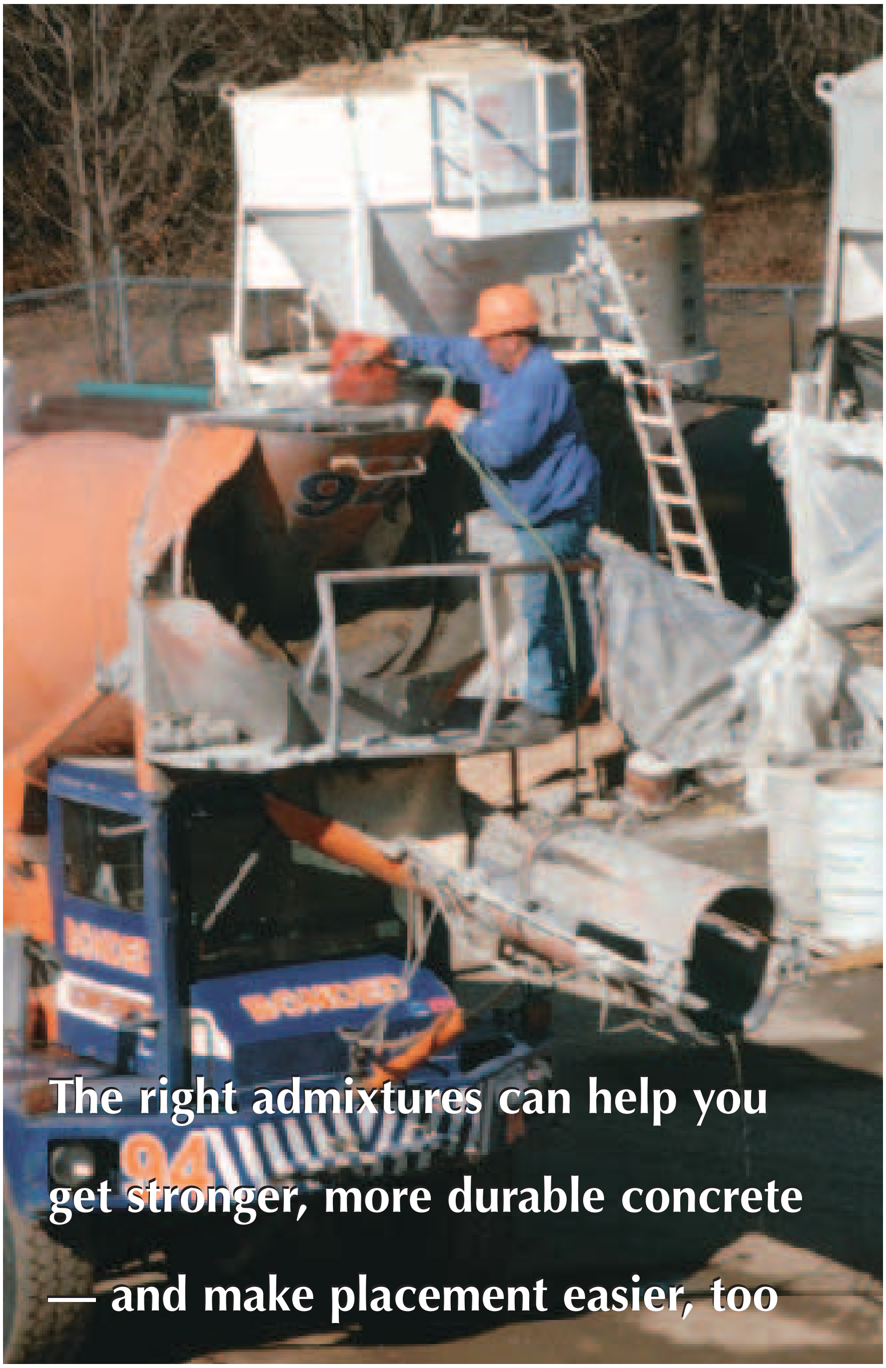
expect from any mix my plant produces. If you know what you want to accomplish, I can tell you which concrete mix is appropriate.

Concrete in general is a pretty simple material, with just four main ingredients: cement, water, sand, and stone. Those elements mostly determine its characteristics. But most concrete also contains a variety of admixtures, which have an important effect on the results.

For best results, you should use admixtures where they're appropriate. It's important to understand all their effects because they can change the way concrete behaves. You may have to adjust your concreting practice to fit the characteristics of the mix you've ordered.

The Pozzolans

Most mixes we produce today include either fly ash or slag, which are types of pozzolans. Fly ash is a byproduct of coal-burning power plants, while slag is a byproduct of steel smelting. Finely ground, they can substitute for 15% to 50% of the cement in a mix. As waste products, they're a lot cheaper than cement, and added to the mix they produce better concrete. They plug pores and



The right admixtures can help you get stronger, more durable concrete — and make placement easier, too

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strengthen the concrete matrix. Their rounded shape also lubricates the mix, allowing you to use less water.

Pozzolans reduce the heat of hydration, which can lengthen set times. That's good in hot weather, when concrete sometimes sets too fast, but it can be inconvenient in cooler weather. Some water-reducing admixtures also have a retarding effect — the combined effects of a pozzolan and a water-reducer can stretch out your schedule by a couple of hours. Your ready-mix supplier can usually predict the set time for any mix design, so if it's a concern, ask.

Air Entrainment

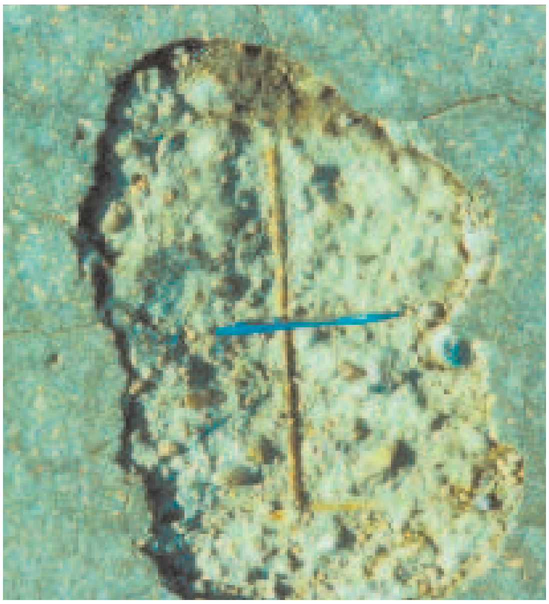
During mixing, all concrete will trap some air in the form of big bubbles. Those big bubbles aren't good — we vibrate the concrete to get rid of them. But the tiny, well-spaced bubbles we call entrained air are desirable, especially in concrete that will be exposed to freezing weather, such as sidewalks, driveways, and garage slabs.

There is such a thing as air-entraining cement, but usually we just use an air-entraining admixture, aiming to get 4% to 6% entrained air by volume. The tiny bubbles make the concrete more workable and reduce the need for water, but, more important, those air-filled voids in the hardened concrete act as a safety valve when water in the concrete freezes and expands. The bubbles also block the flow of bleed water from the concrete during placement, which helps maintain good curing conditions and reduces the formation of bleed channels. That reduces the permeability of the end product.

When to avoid it. There are times when you don't want air entrainment. I don't recommend it for a finished floor indoors. If you're going to try for a smooth, hard, finished surface using a steel trowel, air entrainment can be inconvenient. It makes the concrete sticky and causes pickups on the trowel, especially in the last couple of passes across the floor. Worse, it can fool the finisher about when it's time to get on the slab and start troweling, due to the reduced bleed characteristics of air-entrained concrete.

Timing is everything. The reason for troweling a slab is to "tighten up" the top layer of cement. What's happening is that as the cement particles hydrate and the little arms of crystal grow and intertwine, we are compressing and densifying the surface by driving air and water out of it, just like squeezing a sponge. We are destroying the air void system in the top surface. The idea is to let those particles interlock better and make that surface denser and less permeable.

But you have to wait for the right moment to start that. If you start when there's bleed water on the surface, you'll drive the water down into the top layer and actually weaken it instead of strengthening it. So you



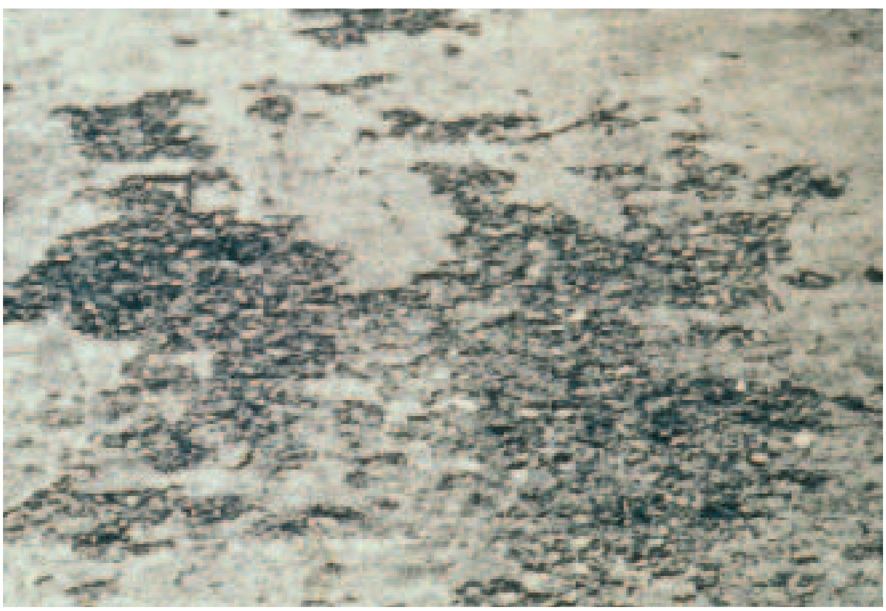


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Figure 1. An air-entraining admixture can help prevent freeze-thaw damage such as the spalling shown at right. But entrained air slows the rise of bleed water, which can fool the finisher into starting to steel-trowel the surface before the bleed water has fully escaped. Trapping rising bleed water can create a weak layer just beneath the surface and lead to surface scaling (below).

wait to start until after all the bleed water has evaporated off the surface and the slab is no longer shiny.

With air entrainment, bleed water escapes more slowly. On a hot, dry day, it might evaporate faster than it bleeds, and the surface will look dry even though there's still a lot of water rising through the slab. If you steel-trowel too early, you'll tighten up the top surface and trap the rising bleed water under it. Now you've created a water-saturated weak layer right under your finished surface. That could bring blisters and scaling problems in service (see Figure 1, previous page).

You can do a good job finishing a slab with an air-entrained mix if you're careful, but it takes experience to learn to judge the moment. I tell people to carry a plastic trash can lid with them. If you lay that lid down on the slab for five minutes to block evaporation, and there's moisture under it when you pick it up, you still have bleeding going on and it's too early to start finishing that slab.

While I avoid air entrainment for indoor slabs that will get a trowel finish, it's critical for outdoor slabs that will see freezing temperatures. Still, it's better not to polish those outdoor slabs with a trowel. You'll get a tougher surface if you just bull-float and broom-finish — and then, of course, cure properly and seal the surface.

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Figure 2. Because the effects wear off quickly, the ready-mix driver must add superplasticizer directly to the truck just moments before starting the pour.

Water Reducers

There is a whole set of admixtures that reduce the amount of water needed in a batch. They act to break up clumps of cement particles so water molecules can reach the cement. Although they're all water reducers, they fall into different classes because they don't act the same. Some are used often and some seldom, but they all can be useful in the right situation.

Low-range water reducers. Type A, or low-range, water reducers lower the water requirement of a batch by 5% to 8%. This admixture is practically universal today — I use it in almost every mix I send out. The reason is economy: If somebody orders a 4,000-psi concrete, I can reduce my cement requirements by nearly half a bag and still get that strength by using a Type A water reducer. Lowering the water-cement ratio improves the concrete; with a water reducer, I can reduce both the cement and the water and keep the ratio the same. It saves on cement without sacrificing quality.

In fact, there's a quality benefit: With less water and less cement, there's less shrinkage and less potential for shrinkage cracking. Type A water reducer is cheap and effective, so even if you don't ask for it, you'll probably get it.

Superplasticizers. Type G, or high-range, water reducers, also called superplasticizers or just supers, reduce water requirements by as much as 30%. They can add five or six inches to the slump of a batch without increasing the water-cement ratio; or you can reduce the water and pour at a low slump, and drastically boost strength.

Super is expensive and you need to use a high dose of it, so it's uncommon in residential work. It's more often used in making extra-high-strength concrete for engineered projects like dams and high rises. But supers can come in handy on a small job, too. If you want flowing concrete that just streams into place without the rock separating out, superplasticizer gives you that. You'd use it to put the concrete around densely packed reinforcement. It's also very helpful when you have to pump concrete.

Superplasticizers are added at the site (Figure 2). At the plant I would batch you a mix at about a two-inch slump; then the driver would add a measured dose of superplasticizer on site. That would take the slump up to

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Figure 3. Concrete that has been proportioned for a 2- or 3-inch slump (top) can be knocked down to a 6-inch slump with the addition of superplasticizer (middle), while still keeping the high strength and durability that come from a low water-cement ratio. Or concrete proportioned for a 6-inch slump can be knocked down to a 9- or 10-inch slump (bottom), making the material highly flowable and almost self-leveling while still achieving normal strengths.

six or eight inches or more in about three or four minutes (Figure 3).

The drawback is that superplasticized concrete will "revert." Once it gets to an 8-inch slump, you have just 30 minutes to maybe an hour at the most before it goes right back to that 2-inch slump. So if your guys are pouring a basement and they aren't on top of things, the nice wet concrete that's flowing down the chute at the start will suddenly stiffen up 30 minutes later. If you don't have it down, you have to do something to it — either reapply the superplasticizer or put water in it. If you add water, you'll notice at least a visual difference in that part of the pour, if you don't get a performance problem from differential shrinkage.

A superplasticizer adds $10 a yard to the cost of concrete, which starts out around $60 or $70 a yard. So you don't want to have to add it twice. I find most residential contractors unwilling to pay an extra $10 a yard in the first place for something they feel they've always gotten just by adding water.

But unlike using a super, adding water to bring your slump up to 8 or 9 inches cuts the quality of your concrete. So the question becomes how much quality you're willing to sacrifice for speed or money. On a $400,000 house, $10 a yard is not a huge amount, but if the builder won't add that to the budget, $100 a truckload for an admixture can cut the concrete sub out of his profit. If you want the ease of high slump with the benefits of good strength and durability, you'll have to be realistic about the costs.

Mid-range water reducers. A practical middle ground could be to use a mid-range water reducer. These are new enough that they don't even have their own category in the books, but they cut water requirements by some 8% to 12% —

enough to add maybe four or five inches to the slump without affecting strength. They're less expensive than superplasticizers, and they don't have the drawback of the sudden revert.

In fact, at higher dosage rates, mid-range water reducers usually have a set-retarding effect. That means that if you need a set retarder anyway, using a water-reducing set retarder shouldn't add much if anything to the price of a yard. If all you want is the water reduction or slump increase, you can combine a mid-range water reducer with an accelerator and get high slump, good strength, and reasonable working and set times (Figure 4).

Accelerators

That brings us to accelerators. The typical accelerator that almost everyone knows about is calcium chloride. It speeds the chemical action of hydration and increases the heat of hydration. The main benefit is in cold weather: Concrete hydration slows drastically at temperatures below 45°F and practically stops at about 28°F. With chloride, you can keep the concrete's temperature up in the active range long enough for the concrete to set and gain sufficient strength to survive freezing.

But calcium chloride is not an antifreeze. It won't save concrete that hits freezing temperatures before it has reached 500 psi in strength. And even if you use calcium chloride, you still need to keep the concrete at good curing temperatures (50°F or above) for three to seven days minimum.

Some new accelerators do function as antifreezes and will let you place concrete at temperatures as low as 25°F. But they're not used much, certainly not in residential work. You can't pour on frozen ground anyway, because the subgrade will subside when it thaws. And antifreeze accelerators are so

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Figure 4. Superplasticizers or mid-range water reducers are often added when concrete needs to be pumped (above). They allow the concrete to flow into the pump (left), reduce wear on the equipment, and ease the job, all while maintaining high quality in the hardened concrete. But it's important to stay on schedule, because if the water reducer wears off while the concrete is still in the pipeline, the machine may bog down, and clearing the pipe can be difficult.

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Figure 5. In extreme conditions, it's a good idea to check concrete temperature. Between 50°F and 90°F is a safe range, and it's best to start out cool in hot weather and warm in cold weather. On hot, dry days, concrete that comes off the truck too hot may lose slump, set too fast, or develop plastic shrinkage cracking. In cold weather, concrete that starts out too cold may freeze before it has developed the minimum strength needed to withstand damage. To keep fresh concrete in the neighborhood of 65°F, suppliers can use heated water and heated aggregates in cold weather, or chilled water or shaved ice in hot weather. Accelerating admixtures such as calcium chloride help in cold weather, and set retarders help in hot weather.

expensive that it's usually cheaper to build and heat an enclosure — which you'd have to do to get proper curing conditions in very cold weather, in any case.

Other cold weather adjustments. The key to cold weather success is temperature. You want concrete to come out of the chute at 60°F or above — it's not a bad idea to keep a thermometer handy to stick in the concrete and check (Figure 5). Besides using accelerators, suppliers can do things like keep their mix water hot at the plant, or even heat their sand and gravel. In winter here in Iowa, I go to the plant even on weekends to check that my water tanks are hot. If you're looking at doing a job in the winter, you should ask what your supplier provides in the way of cold weather service.

Set Retarders

Set retarders are used for the opposite problem: hot weather. Hydrating concrete generates its own heat, and in combination with hot weather, that can make the concrete lose slump quickly and set too fast. The heat drives off moisture, too, leading to plastic shrinkage cracking: fine cracks that occur when the top layer starts shrinking before it has the minimum strength to hold together (Figure 6, next page). Set retarders reduce the rate of hydration and keep the internal heat down, giving you a little extra time to work. A set retarder in combination with a water reducer is a good strategy for hot weather, but it will help you only so much. Timing your pour for the cool part of the day, wetting the forms and subgrade, or fogging the area is more effective.

Set retarders are tricky. Once during a hot summer, we supplied a large order of concrete with set retarder in it for a big, thick bridge deck. It happened to get cool and cloudy the day they did the work, and that bridge deck took four days to set. Everything turned out all right, but it made me very cautious about using set retarder.

Other hot weather adjustments. Besides using a set retarder, the batch plant can reduce the cement content of a mix and use a higher percentage of fly ash to slow hydration and reduce heat. In very hot weather, suppliers can also use chilled water or even ice chips in the mix. Again, this is something to ask your supplier about.

Synthetic fibers. In my part of the country, where we see both hot summers and freezing cold winters, synthetic fibers seem to help control plastic shrinkage cracking. Fiber interrupts the little cracks and keeps them from spreading.

In recent years, we've had a lot of scaling and flaking problems in our area. Looking into the matter, I've noticed that the contractors who use fiber don't seem to experience those problems as much. So I'm a believer in synthetic fiber, even though it may add $6 a yard to the cost. Fiber is marketed as a substitute for steel wire reinforcing, and for residential slabs that don't need structural reinforcement, I'd as soon see contractors skip the steel wire and use fiber instead. (If you do need reinforcement, use rebar.)

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Figure 6. On hot, dry, windy days, concrete that dries at the surface before it sets may develop random, irregular fine cracks in a process called plastic shrinkage cracking. Keeping the concrete cool and sheltering it from wind and sunlight can help prevent that. Dosing the concrete with a plastic fiber admixture also may restrain cracks from starting or progressing.

Cost vs. Quality

Most admixtures add some cost to the concrete. However, you'll often save on labor. If a water reducer gives you concrete that's easier to place and work, you may be able to pour with a three- or four-person crew instead of a four- or five-person crew and still finish up sooner. If you use fiber instead of steel wire, you don't have to use labor hours placing the steel, or hassle with hooking it up to make sure it ends up where it should.

Instead of sacrificing strength and durability by adding water to save time and labor, I think the better choice is to use the right admixtures. You might not have the rock-bottom price, but you'll get excellent results at a cost that's reasonable.

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