by Dennis Golden

HOT-WEATHER CONCRETING

To produce first-quality concrete in hot, dry weather, plan ahead, work quickly, and cure properly

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Curing compounds are quick and easy to apply, making them the first choice of most contractors for controlling evaporation in hot weather.

In summer, the desert Southwest deals out severe conditions for concrete work. Temperatures over 100°F, relative humidity in the negative numbers, and persistent hot, dry winds can teach hard lessons.

I've spent many years on both ends of the concrete chute, as a crew leader for our family place-and-finish business and as a technologist and quality-control manager for two Albuquerque ready-mix suppliers. I've seen some heated disputes over badly cracked or poorly finished slabs — failures that could have been prevented with adequate planning and proper handling, or simply by providing enough manpower.

For the most part, though, I've seen concrete work performed successfully under harsh desert conditions. And if we can successfully place, finish, and cure concrete in Albuquerque in July, you can do the same in summer conditions anywhere in the United States.

In this discussion, I'll focus on typical residential jobs, where appearance and durability are your main objectives. That could be anything from a large foundation slab to a small driveway. I'm not talking about jobs requiring specially engineered, high-strength concrete mixes that include expensive chemicals to enhance performance; I'm talking about ordinary placements, using conventional ready-mix.

Challenges of Hot Weather

Experienced contractors have good reason to shy away from placing concrete in hot weather. Concreting isn't easy work under ideal conditions, but all the situations you encounter during a "normal" placement are exaggerated in periods of high heat and low relative humidity.

In hot, dry, windy weather, everything happens faster. In particular, the concrete sets faster: The American Concrete Institute (ACI) says, for example, that "if the initial setting time for a concrete mix is 2.5 hours at 60°F, that time is likely to be reduced to about an hour or less at 95°F." My field experience bears these numbers out.

The mix will also lose its slump faster. If you're not quick about getting it into place, concrete that starts out at a 5-inch slump can be nearly unworkable by the time all nine yards are off the truck. Finally, in extreme conditions, mois-

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Figure 1. *When pouring in hot weather, any slowdown will compound your problems, so have plenty of workers on hand.*

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Figure 2. *Wetting the subgrade before a pour prevents downward water migration, helping to keep slabs from cracking.*

ture will evaporate from a slab surface very rapidly.

Control of the Job

You can't control the weather, obviously. But the job factors you can control are your keys to producing top-quality concrete in hot, dry conditions. You must provide sufficient manpower, maintain a quick work pace, control the use of water on the site, possibly provide protection from sun and wind, and apply suitable curing methods in a timely fashion.

There's one other thing you can control: scheduling. When the weather is really bad, procrastinate if at all possible. Doing your job a few days later, when the heat wave breaks, beats the heck out of dealing with the headaches you'll have if weather conditions ruin the quality of your finished job.

But if you decide to go ahead with a pour, do it early. The best way to beat the heat is to get an early start. The sooner you start, the sooner you'll finish (and the sooner you'll be at the beach). Have your tools ready to go at the first light of day, and start your placement shortly thereafter.

Break big placements into smaller sections if you can — especially if this will keep you from having to pour in the middle of a hot day. It's best to have the concrete in place before the heat really sets in.

Manpower and pace. Once your pour has started, delays can be big trouble. Don't allow any interruptions — leave the cellular phone in the truck. On a hot day, slump loss is going to happen fast. You need to get your load on the ground and in the forms as quickly and efficiently as possible.

This is where adequate manpower makes the difference (see Figure 1). If the job would normally call for one person for every ten yards of placement, you should plan for 1.25 to 1.5 experienced people in hot weather. Everyone should know their place and be in it when placement begins. Break time is later; depending on the size of the pour, it could be much later.

Anticipate breakdowns. If your placement is flat work big enough to require a finishing machine, have an extra on hand in the event of a mechanical problem. If it's a wall pour that requires a vibrator, have an extra available.

Water: The Key Element

Most of the problems we face in the heat of summer have to do with water: Either there's too much of the stuff where it doesn't belong or not enough where it does belong. Although many ingredients of the mix affect the workability of the material, water is typically the only part that the purchaser has control over once the truck arrives on site.

Retempering. On hot days, your mix may get stiff while there are still a few yards left on the truck, and you'll be tempted to add some water. Watch out: You might get away with it, but you might not. Based on laboratory and field experience, ACI has concluded that "strength reduction, as well as other detrimental effects of hot weather, are directly proportional to the amount of retempering water added."

ACI strongly recommends that no more than 2 to 2.5 gallons of water per yard be added on site for retempering. This should be done once, before the concrete comes off the truck. Get it to a 4-inch slump and hustle the concrete into place while it's still workable.

Some contractors use additives like set retarders and superplasticizers to help lessen the problems of rapid set or slump loss in hot weather. But in my experience, these additives can be a mixed blessing. Superplasticizers can make a stiff mix flow easily, but the effect wears off suddenly, which can complicate finishing. And set retarders can also have unexpected effects that can make life difficult for finishers not used to working with them.

Good organization and fast work are the most reliable ways to beat the heat. Modified mixes may help, but don't try them for the first time on a big job on a hot day. Gain experience first with small placements under normal weather conditions.

Wetting the ground. Though you don't want too much water in the mix, you don't want too much to escape, either. To control the water's migration downward, wet the subgrade and the formwork before placement begins (Figure 2). Get the ground plenty moist, but don't create standing water or puddles. Wetting everything down serves the additional purpose of cooling the forms and subgrade, helping to keep the concrete temperature in the proper range.

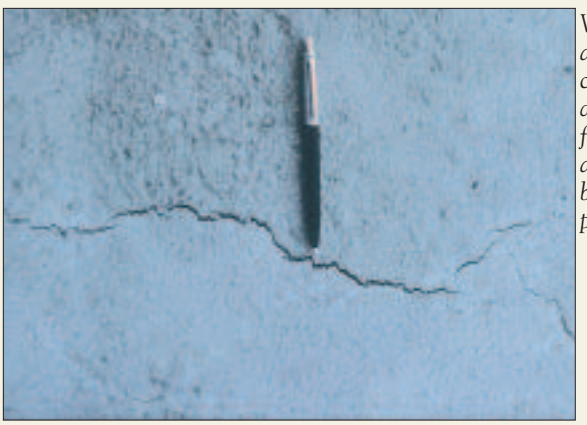
If you are including a poly vapor barrier below the slab, cover the poly with 3 inches of damp, compacted sand. Don't neglect this step: If you place concrete directly on plastic, serious slab cracking is a good possibility (see "Sub-Slab Vapor Barriers," 5/94).

Plastic Shrinkage Cracking

Plastic shrinkage cracking is a potential problem that looms over every placement done in hot, dry, breezy weather conditions. If there is a more exasperating problem to be faced in the heat, I've yet to witness it.

Typically, shrinkage cracking strikes after you've poured, straight-edged, and bull-floated. As you begin to apply the final finish, cracks start to open up right behind your trowel. The only solution is to reseal those cracks. With a lot of blood, sweat, and tears, the guy with the trowel can often do it. As soon as the final finish is applied, start curing. If you don't, those plastic shrinkage cracks could reappear, anywhere from one to six hours after the pour.

Shrinkage cracking can be hard to beat once it has gotten a start. The guy out on the slab has to fight it with whatever tools he has (usually a steel finishing trowel or a magnesium float). Once that concrete hardens up, though, he's lost it — the cracks that are left are permanent.



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When evaporation rates are high, shrinkage cracking may result despite your best efforts to fight it. These fine cracks are an appearance flaw, but not a structural problem.

However, this isn't a catastrophe; shrinkage cracking is primarily an appearance defect. In concrete that gets rained and snowed on, and goes through a lot of freezing and thawing in service, shrinkage cracks can contribute to surface deterioration over the years, but they won't cause structural failure.

— *D.G.*

You can use water that arrives on the mixer for wetting the forms and ground, but it's better to have a source of water on site. That way, you can wet down before the truck arrives, which will be like putting time in the bank. Also, you'll have water available for other tasks, such as cleanup and possibly curing.

Controlling evaporation. The wet mix also loses water by evaporation during placement and finishing. Evaporation can rob the cement of the water it needs for proper hydration, reducing its final strength and durability. However, the most common problem caused by evaporation is plastic shrinkage cracking (see sidebar above).

When water evaporates from freshly placed concrete, the concrete takes up less space. That's called plastic shrinkage because it happens while the concrete is still "plastic," or soft. When the shrinkage happens fast enough, the concrete pulls away from itself, creating fine cracks. ACI has determined that when the rate of evaporation approaches 0.2 pounds per square foot per hour, the conditions are right for plastic shrinkage cracking to occur. It's a good idea to avoid pouring under those conditions.

Get in touch with your feelings. How in the world do you know when the evaporation rate is 0.2 pounds per square foot per hour? There are complicated scientific methods that quality-control engineers use on big commercial projects, but unless you go out and buy a portable weather station to monitor air temperature, relative humidity, and wind speed, and a probing thermometer to measure the concrete temperature, the scientific approach won't do you much good.

Instead, just check out how you personally feel (no, I haven't been out in the Santa Fe sun too long). If you feel hot and sticky and are wet with perspiration, the evaporation rate is probably not high enough to cause you a problem. But if it's hot out and you feel the heat but are reasonably dry, the evaporation rate is at or above what is necessary to cause you grief. You sweat at around 0.2 pounds per square foot per hour, and if you're dry, that means that you are evaporating at about that same rate, and should consider waiting for better weather.

Shade helps to reduce evaporation. If shielding your pour from the sun is feasible, consider it. For instance, it might make sense to build the garage first, then pour the slab.

Bleed water. When the pell-mell rush of the pour has passed, and the screeding, bull-floating, and hand-floating operations have taken place, there may be a chance for everyone to take a breath. But water is still an issue. What's called "bleed water" will be making its way to the surface. The surface of the slab will look like a wet, gray mirror. It's important not to trowel the bleed water back into the wet surface: The increased water-to-cement ratio can cause a "dusting" surface and decreased durability.

While you're waiting for the bleed water to evaporate, take a break and get a drink of water yourself. Once the bleed water is gone and the surface has lost its shine, it's time to hustle again. Apply the final finish quickly, and move on immediately to curing.

Curing

The purpose of curing is to maintain the conditions that allow the cement in the mix to hydrate completely. This will give you strong, hard, durable concrete. In hot weather, curing has one simple objective: to keep the water in the concrete from evaporating away.

To be effective, curing has to start as soon as the concrete is finished, and continue without interruption for at least seven days. Continuous curing for 28 days is better — the longer you cure, the stronger, harder, and more durable your concrete will be.

People use a variety of techniques to trap moisture in freshly poured concrete. The most common method is to spray on a liquid curing compound, which forms a thin film over the concrete surface. Other options include ponding, sprinkling (or fogging), covering the concrete with sheets of poly, and applying wet burlap, wet hay, or wet sand.

Figure 3. *Besides compounds, other curing methods include sprinkling (left), which requires continuous monitoring, and poly (right), which is labor-intensive and may stain the slab.*

Curing compound. This method offers several advantages. It can be applied right away, often without even walking on the freshly finished surface (see photo). It's easy to apply correctly, and it forms an excellent seal. Once it's on, you can leave it on indefinitely, extending the time period of effective curing. You don't have to stand there and watch it, or even come back to check on it. It's cheap, and it's readily available. If your ready-mix supplier doesn't carry it, they'll know who does.

These compounds are usually either wax- or resin-based. They can be applied efficiently with a portable garden-type sprayer. On very small placements, you can even apply them with a paint roller.

Curing compounds generally contain a color. Wax-based compounds are usually solid white, while the resin bases are usually opaque red. Solid white wax-based curing compound can be the right choice in hot weather because it reflects sunlight, but watch out: Some white curing compounds are slow to lose their color. This can leave you with an unattractive placement and an unhappy customer. Check with the manufacturer.

Resin-based cures, on the other hand, can be a little difficult to see during the application, but the dye fades quickly, leaving the concrete looking like concrete.

To get the correct thickness of coverage, aim for covering the square footage specified in the instructions. You can expect to cover 150 to 200 square feet per gallon. Curing compounds should be applied immediately after final finishing. It is very important to get complete coverage with an even, unbroken coat. If you are uncertain about the coverage, apply a second coat at right angles to the first.

Keep in mind that curing compounds may affect the adhesion of paints or adhesives later. If this is a concern, check the manufacturer's recommendations.

Sprinkling. This is a good method for hot weather, since it provides cooling as well as controlling evaporation (Figure 3). But there are a lot of practical difficulties involved, which may be why I've almost never seen a residential contractor curing with a water spray.

For one thing, there must be an unlimited source of water available, and no concern about the effects of the runoff, or about children seeing an oscillating sprinkler as an invitation to cool off.

Also, timing is critical to the sprinkler method. The water should be turned on as soon as there is no longer a chance of your surface washing away. Sprinkler curing also requires seven days of monitoring; for it to work properly, you can't let the surface go through periods of wetting and drying. If it does, you are inviting surface crazing.

Ponding. In some small flat placements it may be feasible to submerge the entire surface for the curing period, by building earthen or wet sand dams around the placement and flooding it.

If you decide to go this route, use water that is no more than 20°F cooler than the concrete it's covering. Colder water can cause thermal stress cracking. Also, if the ponding water is high in iron or other minerals, it might stain the surface.

Plastic sheeting. Plastic would be good to use over the top of a wall pour. White poly is better than clear or black; black poly heats up in the sun, and clear poly will let sunlight through and trap the heat like a greenhouse.

Builders sometimes use sheets of poly to cure slabs, but it's not my favorite method. For some reason plastic has a tendency to discolor a smooth slab. And unless your timing is perfect, you run the risk of marring the smooth surface you worked so hard to apply.

Moreover, there's labor involved in sealing laps and penetrations with duct tape. If you're not there to keep an eye on things, someone may tear the plastic or remove sections of it. And eventually, someone needs to remove the poly and dispose of it. In terms of cost and effectiveness, poly comes in second to curing compound — which is why, in the Southwest at least, it's much less popular with residential contractors.

Curing wall placements. Leaving the forms on is a great method for walls. However, wood forms must be kept moist during periods of hot, dry weather. And you'll have to use another method for the exposed top of the wall.

Methods to avoid. I've seen wet burlap used on large highway median projects, and by a contractor doing a massive flood-control job, but never by a small- or medium-volume contractor. Wet burlap will cure concrete, but it's expensive, messy, labor-intensive, and smelly. I would also avoid other wet coverings, such as hay, sand, or sawdust. The possible damage to your work, combined with the prospect of dealing with this guck at a later date, should be enough of a deterrent to anyone even considering these methods. ■

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