Hot Weather Shotcrete

By William T. Drakeley

Wetting of the entire cast or shot surfaces is essential

Placing shotcrete in hot weather can be a risky proposition if you don't follow basic guidelines. Success under these conditions, calls for controlling concrete temperature and mixture design while also managing details of the installation and curing processes.

The summer is always busy, but that may be a huge understatement this year. The country is coming back to life with consumers very aware of their personal space and wanting to do more with it – which, often times means adding watershapes.

As a result, the heightened demand for our pool industry's products will likely lead to all sorts of logistical and supply issues. The availability of concrete may well be one of those critical issues. Ready-mix suppliers have informed me that during this forced downtime, many homeowners, do-it-yourselfers, are taking on their own concrete work. Suppliers caution that when the contractors fully come back online during the summer, there could be delays in product supply and even shortages of ready-mix delivery trucks. To varying degrees, it's often true that hot weather and elevated temperatures drive up demand.

Especially with the current extraordinary circumstances, the first step in hot-weather concrete work, whether you're doing wet-mix or dry-mix shotcrete, is you need to communicate with your concrete material suppliers and place orders well in advance. That's the only way you'll

Wetting down freshly shot walls after finishing

know what to expect for availability and delivery, so you can schedule accordingly and in turn let the client know what to expect.

Beyond that basic caveat, there are specific measures and conditions required whenever you're placing concrete in hot weather. Shotcrete placement in hot weather requires temperature control, environmental control, and jobsite control.

ENVIRONMENTAL CONDITIONS

I currently serve as Chair of American Concrete Institute's (ACI) 506-H Pool Shotcrete Committee. We are writing guidelines for the shotcrete placement process, as it pertains to both wet- or dry-mix for pools. In the hot weather shotcrete section, we refer to the existing hot weather concreting documents from ACI 305, which define acceptable concrete temperatures and procedures.

According to the ACI 506 pool shotcrete document, you should always keep concrete as cool as possible. You should not apply shotcrete when ambient temperatures are over 95°F (35°C), unless special precautions are taken. The precautions should be reviewed by the pool designer or other experienced engineer. You can cool the concrete by using cold water to mix it, misting systems, wetting blankets, and shade. Each of these options slow down evaporation and help reduce the potential for early age plastic shrinkage cracking on the surface of the concrete.

Considering what's happening in the fresh concrete matrix helps explain why these measures are necessary. When you mix water with portland cement hydration occurs. The cement hydration produces changes in the cement particles that lead to strengthening as the particles interlock. The hydration process leads to a volumetric change in the concrete, as well as additional heat from the chemical reaction.

When you're already working in warm conditions, you can easily wind up generating too much heat if you're not taking measures to cool down the environmental temperatures and the concrete itself. If temperature of reinforcement, embedments, or forms is greater than 120°F (49°C), use a fine mist of water to moisten and cool hot surfaces. Remove standing water before shotcrete placement.

Yes, it is possible to successfully place shotcrete in temperatures over 105°F (41°C) or even higher – consider Arizona and Nevada. But you must take recommended precautions. Do everything you can to avoid the heat of the day by working in the morning, if possible. You may also consider erecting a shade structure to keep the concrete, forms and reinforcing out of direct sunlight.

TIMELY APPLICATION

Shotcrete is very time-sensitive and that's particularly true in hot weather. Whenever you see a concrete truck on site, spinning and mixing the concrete you're watching a clock ticking. Under normal conditions, with no added measures, you have about 90 minutes from the time the water is added to the truck until you get it into place. All things being equal, that timeframe shortens in hot weather.

You may consider adding water to the concrete in the ready-mix delivery truck to cool the mixture and slow down the hydration process. This may seem like an easy way to extend how long you have to shoot, trim and finish the concrete in place. But DON'T do this, you're increasing the water-to-cementitious ratio (w/cm), reducing the concrete's strength, increasing the permeability and ultimately producing a pool shell that is less durable.

Maintaining the right w/cm is another key factor to keep in mind, especially in elevated temperatures. The w/cm is driven by the application. Where you want dense, low permeability concrete that will better resist environmental issues such as corrosion from saltwater exposure, you go with a 0.40 ratio. That doesn't have as much water to dilute the hydrating cement as one may see in a more typical 0.50 ratio used in concrete flatwork.

So, how can we produce a concrete mixture that slows down the setting time in warm weather? In addition to physical measures to keep things cool, you can use concrete retarding admixtures that can stretch the time-frame to three hours without compromising strength.

There are also hydration control admixtures (sometimes called "set stabilizers"), such as MasterSet DELVO that can suspend the hydration process for a set time, enabling us to extend the time for using the ready-mix concrete to four or even five hours. Not only do hydration control ad mixtures help in hot weather, they can also be extremely helpful where delivery takes a long time for whatever reason.

Cracking in the concrete pool shell from inadequate curing will mirror through the plaster coating.

Partial wetting is not acceptable. All exposed concrete must be kept continuously wet for 7 days.

Say you have a job where it takes more than two hours for the ready-mix truck to reach the jobsite, using hydration control you adjust the dosage, so the concrete arrives as if it was just batched and gives you the maximum workability on the job without reducing the concrete strength.

Different chemicals and supplemental cementitious materials (SCM) will impact hydration and set times at different rates, therefore you should understand the performance characteristics of the products being adding to the mixture, whether they are set retarders, hydration control, high-range water reducing admixtures, or SCMs like fly ash, slag or silica fume. As you alter the chemistry and composition of the concrete mixture, you need to be aware of its impact on workability and set times.

READY TO WORK

Just as scheduling becomes a critical issue in hot weather, the same is true of mixture design. Most concrete suppliers know their own products and can easily adjust the mixture design to suit your needs and situation, but you must communicate your needs to them first! I lay it all out for them when setting up for the job. For example, I will tell the supplier, "Here's the thickness of the wall, the reinforcing steel schedule, how far the job site is from the batch plant, how far we have to pump it, the anticipated temperature range we'll be working in and the desired compressive values and durability factors." I'm always looking for the best mixture design for each particular situation so that we will get the concrete placed properly and creating the best structure in place. If you don't consider all the factors in the concrete mixture design, you may have concrete with insufficient compressive strength, lower density, excessive shrinkage cracks or other problems.

While the concrete mixture design is all about preparation and forethought, the same is true when it comes to orchestrating the physical work onsite. When we're working in hot weather, it's a very carefully choreographed process. We have guys wetting down the steel, finishing the concrete immediately using trowels and radius boards, and then wetting down the hardened concrete to slow down evaporation and reduce the potential for early age plastic shrinkage cracking.

Hot weather concrete placement takes planning and experienced crews. This is no place to train a rookie because you've got to move fast and work efficiently to stay ahead of the setting of the concrete and maintaining moderate temperatures. Everything is more time-sensitive and unforgiving, making for a more challenging process on site where you must keep moving or risk a failed structure.

Time and time again, we've seen situations where the contractor was careless. They weren't managing the temperature with misters or wetting the surface after finishing. They didn't plan ahead to control the chemistry of the concrete mixture. It was a blistering hot day and they didn't cool down the reinforcing steel and substrate. Or the concrete set too fast and they didn't get the work done in the right time frame. When you see those missteps, the pool will crack, often before the plaster is installed and there will be a range of cosmetic and often structural issues for the life of the pool.

IT'S CURED

Finally, curing is another crucial part of the process that can be dramatically impacted by high temperatures. ACI defines curing as action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and (if applicable) pozzolanic reactions to occur so that the potential properties of the mixture may develop. ACI recommends a minimum of 7 days curing time. For shotcrete, our committee recommends

keeping the surface constantly wetted for seven to 7 days as a bare minimum.

During the curing process, your goal continues to be to provide water to the unhydrated cement in the concrete to build strength and produce lower permeability. In hot weather, you need to be aware that the curing process will need to be accelerated (due to evaporation) and if it goes unchecked, the strength of the concrete may be reduced.

As is true during concrete placement, during curing you encounter heat from two sources -- the chemical hydration reaction and the environment. You must rigorously follow curing guidelines to keep the moisture in the concrete mix. It is well established that if you keep the concrete wetted for 7 days, you'll be significantly increase compressive strength. It's not unusual to find concrete that has a specified 28-day compressive strength of 4000 psi (28 MPa) breaking at 4,000 psi and higher after just 7 days of curing. The basic fact is the longer you water cure concrete the stronger it becomes, will have a lower permeability and ultimately last longer. If, on the other hand, you don't follow the curing protocol, the strength will be far, far less. It absolutely destroys the compressive value.

Moisture can be maintained by sprinkling, flooding, fog, or by covering with continuously moistened canvas, cloth mats, straw, sand, or another approved material. Wood forms left in place during the curing period should also be kept wet. Formed surfaces should be thoroughly wetted immediately after forms are removed.

If you're in an area impacted by drought, we recommend using damp burlap that is kept wet to keep the concrete surface wet. Alternatively, a sprinkler hose will work just fine but will use more water. Either way, you have to keep it wet and keep it cool.

If you follow the basic guidelines discussed above, you'll wind up with a pool shell with high compressive values and minimal cracking.

The bottom line is when you're working high temperatures you must follow expert guidelines. Slowing everything down when it's hot is not always the easiest thing to do, but in the world of concrete placement, it's absolutely necessary.

William Drakeley *is principal and owner of Drakeley Industries and Drakeley Pool Company in Bethlehem, CT. He holds the distinction of being the first pool builder to sit as a voting member of the American Shotcrete Committee 506 – Shotcrete, and he serves as secretary of the ACI C660 Nozzleman Certification Task Group. He is a co-founder of, and instructor for, Watershape University, teaching courses on shotcrete application at numerous trade shows. Drakeley is a valued contributor to WaterShapes, Shotcrete Magazine and other industry publications.*