Progression of Work after Shotcrete Application

By Ron Lacher

Because of its role in the concrete construction industry, the American Shotcrete Association (ASA) receives many questions, both technical and nontechnical, from those interested in the shotcrete process. As a service to those interested parties, ASA submits those questions to a technical team of members that collectively formulates replies. Some of these questions and answers may be published in *Shotcrete* magazine, as well as on the ASA Web site under "FAQs."

A couple of months ago a two-part question was submitted to ASA that asked, "How soon after shotcrete application in a swimming pool can form materials be removed?" The inquiry also included, "How soon after shotcrete application can tile installation be started?" These are questions I'm frequently asked. I want to revisit the topic, and the "Pool & Recreational Shotcrete Corner" provides the perfect venue for that discussion.

When we talk about the appropriate timing to continue work on a swimming pool after shotcrete application, be it form removal, tile installation, or any another phase, the real underlying question is, "Has the shotcrete developed all the properties necessary to permit each subsequent yet individual phase to continue?" The tried and true specification that we hear over and over is the structural designer's specified compressive strength, for example—4000 psi (27.6 MPa) usually at 28 days. Whereas a specified compressive strength may be necessary for the pool to meet the requirements as a structural element, that specified compressive strength may not be needed as a prerequisite to begin other phases. Additionally, we may be looking for the attainment of other properties in addition to compressive strength—for example, surface hardness, abrasion resistance, surface permeability, absorption, flexural strength, and drying shrinkage. As we'll see, subsequent phases may have differing requirements of shotcrete properties.

Before moving on, let me mention the importance of proper curing. The attainment of the individual properties we may be looking for to continue with the next phase comes from the maturing of the shotcrete through the hydration process. As we already know, hydration is a chemical process that results in the maturing or hardening of the shotcrete. Shotcrete does not harden by drying; in fact, drying will completely stop the hydration process and result in under-strength shotcrete. So, it is really adequate moisture after final set that is necessary for maturing or hardening of the shotcrete. Providing adequate moisture for maturing or hardening of shotcrete is called curing. ACI 308R-01, "Guide to Curing Concrete," covers the curing topic thoroughly, and I encourage anyone working with concrete to become familiar with this document.

In accordance with ACI 308R-01, the term curing is used to describe the process by which hydraulic cement concrete matures and develops hardened properties over time as a result of the continued hydration of the cement in the presence of sufficient water and heat. At this point, it's sufficient to say that proper curing is critical to the attainment of all the properties necessary to permit each subsequent yet individual phase of the pool construction to continue. But, in the swimming pool industry, this important facet is often left to the homeowner without detailed instructions provided for this critical aspect.

Let's move on to the questions at hand and first consider the timing of form work removal. To answer that question, we need to know if the forms are the simple bender board or other flexible material typically located at the outside of the pool's bond beam and used to set the elevation, shape, and dimensions of the pool. Or is the form removal being asked about complicated false work supporting a completely out of grade, pile-supported swimming pool? Form removal timing for these two scenarios would be vastly different. If we're talking about the bender board located at the outside of the pool's bond beam, quite honestly, that should be removed as soon as the shotcrete has gained sufficient strength—approximately 500 psi (3.5 MPa)—to not damage the carefully cut edges and lines establishing the pool's shape, bond beam, steps, and benches. It's typical for shotcrete waste, that is, rebound and cuttings, to be shoveled out of the pool and, in doing so, the wood forms, stakes, and kickers are often partially buried in the waste material. It's not uncommon for this type of form removal process to take place within a day or two of shooting the pool as long as care is exercised.

If the forms are supporting a structural element of the pool, the timing of form removal is a

completely different story. In this case, supervision from the pool's structural designer should always be sought before the form work or false work is removed. It may be possible to remove the form work before the full specified shotcrete strength is attained as long as the pool is not filled with water. The pool's permanent structural support system would have been designed to include the weight of water in the pool, typically substantially greater than the weight of the shotcrete shell. So as long as the pool is not filled with water, the structural designer may approve the form work removal at a lesser strength than the 28-day specified strength.

When discussing the topic of shotcrete strength attainment and the continuation of work, the timing of backfilling against an out-of-grade pool wall must be included in that discussion. Frequently, because of site conditions or other reasons, pool walls are built exposed or out of grade. Contractors need to backfill so the work around the exposed wall can continue. Also, it's unlikely that the pool wall would have been designed for the very high loads brought about by heavy compaction equipment. Consequently, this is an area where care and good judgment must be exercised. My first recommendation is that the advice of the pool's structural designer should always be sought before beginning backfilling. If that advice is not available, my recommendation would be to wait at least 7 days where, with proper curing, the shotcrete would have attained at least 50% of its 28-day strength (ACI 308R-01). Backfilling would only then be performed by hand and compaction attained with hand-operated equipment using the utmost care.

Up to now we've talked mainly about formwork removal issues, but there was a second part to the question asked, that is, how soon after shotcrete application can tile installation be started? Batter boards, attached to the pool shell with concrete nails, are frequently used in the tile or coping installation process. The concrete nail installation can cause some minor damage to the shotcrete surface if the shotcrete is either too weak or too strong. Because the repair would generally be a simple matter, shotcrete strength is usually not a major concern regarding the batter board installation. There are a couple of other important issues relating to tile installation that may be affected by time. The first is the moisture content of the shotcrete substrate. Most swimming pool tile installations would begin with the application of a scratch and float coat of cementitious mortar to provide a plumb, straight, and uniform surface for the tile application. Other than a saturated surface dry substrate, the moisture content of the shotcrete would not normally be

Typical bender board form work around a swimming pool that sets the shape, elevation, and dimensions

Pier-supported, out-of-grade swimming pool required complicated false work during construction

After shotcrete, backfilling of the pool wall will be necessary before work on the pool can continue

a concern. If specialized thinsets, water proofers, or other coatings, however, are to be applied as a part of the tile installation process, the manufacturer of the product should be contacted for specific requirements, especially regarding substrate moisture content.

Batter board attached to the pool shell with concrete nails. Note the minor damage to the top of the pool wall

Vanishing edge weir wall where shrinkage cracks reflected through water line tile. Repair was by epoxy injection

A far more important issue relating to the timing of tile installation is the possibility of drying shrinkage cracking occurring in the shotcrete after tile installation but before filling of the pool. Shotcrete swimming pool shells are frequently left uncompleted for extended periods and may be subject to drying shrinkage cracking, especially in hot, dry climates. Drying shrinkage cracks are also observed with greater frequency in pool elements such as vanishing edge weir walls and gutter walls that are exposed to the atmosphere on both sides of the wall. If tile installation takes place shortly after shotcrete application and the pool is left unfilled for an extended period, there is a risk that drying shrinkage cracking may occur and reflect through the tile, permitting leaks. If the pool is to be left unfilled for an extended period, it is recommended that the possibility of drying shrinkage cracking be considered when scheduling the installation of the tile. If the tile installation phase must take place shortly after the shotcrete installation, an appropriate elastomeric crack isolation membrane should be incorporated into the tile installation. Also, before filling, the pool tile should be carefully inspected for shrinkage cracks that may have reflected through the setting bed from the shotcrete substrate.

Similarly, drying shrinkage cracking can reflect through nonelastomeric, cementitious waterproofing materials that may be used to waterproof pool gutters. If the gutters are hidden at the time of pool filling—for example, in a slot inlet perimeter overflow pool—the drying shrinkage cracking and the potential for leaking may not be detected by visual inspection. The possibility of drying shrinkage cracking in hidden or inaccessible gutters should be considered when selecting waterproofing materials and in the construction phasing of hidden gutters and other inaccessible elements.

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