Concrete Inevitabilities

By J.B. Werner

Just about every watershaper knows that concrete is a great material: strong, resilient, formable and capable of long service. But judging by usual practice, says past concrete forensic examiner Jerry Werner, not all watershapers seem to be fully aware of the basic permeability of the material or recognize the fact that almost all concrete structures will benefit from the use of waterproofing agents – a point, he says, that should be considered in the design process.

’ve come to the world of watershaping from a different perspective.

Back in the 1960s, I worked for a company that built poured-in-place concrete homes in Florida. Right from the beginning, I couldn’t help noticing the importance of waterproofing in the performance of these structures – or the consequences of not taking the potential for water intrusion seriously.

My interest in this subject took on new significance in 1989, when I formed a Florida firm that conducted forensic analyses in all manner of structural failures as a service to condominium associations, the highway department and the insurance industry. As part of that work, I saw the countless ways in which moisture could intrude into concrete structures and cause them to deteriorate. And I observed that these issues were particularly problematic around the Florida coast, where salt and water combined to compromise concrete-encased structural steel.

Although my career has taken a number of twists and turns in the past 50 years, I’ve always stayed involved with concrete and water and eventually began working on a consulting basis with Aquron, the Rockwell, Texas-based manufacturer of a family of waterproofing products. Eventually, my involvement with this firm led me to my current special interest in watershaping.

I immediately recognized, of course, that at the most basic level, all pools, spas and other types of watershapes exist to contain water. But I also soon learned that, as a rule, many industry professionals had only a limited understanding of concrete’s basic permeability and the fact that *all* concrete allows moisture to intrude to one degree or another.

Into Pools

I began focusing on waterproofing issues related to watershapes in 2005, and to say that I was surprised by the initial reactions I met in approaching industry professionals about waterproofing would be an understatement. Indeed, it was like hitting a brick wall over and over again: Nearly everyone I dealt with was convinced that the plaster lining of the typical pool or spa or fountain was a perfect waterproofing measure and that nothing else was needed.

It didn’t even seem to be a conscious decision: Most simply assumed that the approaches that had been used for generations were perfectly valid, and so they had never even given things a second thought.

Yes, they mostly knew that shotcrete, gunite and poured concrete were all somewhat permeable, but even if they were able to grasp the fact that plaster was imperfect as a barrier to water intrusion, *very* few saw the groundwater that surrounded their shells as any source of concern. As time passed, I came to see that just about everyone was operating with the same mindset.

This was something of a shock to me. Here were structures that contain water on one side but are generally built below grade and exposed to moisture and groundwater on the other. Professionally, I couldn’t think of a situation where waterproofing would be more beneficial to a structure’s long-term performance, but I increasingly developed a sense that because moisture intrusion with an inground concrete pool is essentially invisible, the industry had accepted an out-of-sight, out-of-mind mentality about the issue.

Photo courtesy Rock Solid Tile, Calabasas, Calif.


A


B

Moreover, I found that the level of understanding was so limited that even the term "waterproofing" was problematic. (Truth be told, I have my issues with that word as well, and I personally prefer to discuss "moisture intrusion prevention." This is why, in seminars, I poke fun at the terminology and point out that other terms – including "watertight," "water-repellent" and "water-resistant" – only make things more confusing and that what we're really talking about is preventing moisture from entering the concrete. For convention's sake, however, I'll stick with "waterproofing" here.)

Things began to improve, however, when I began having regular conversations about the efflorescence that affects so many concrete structures. This gave me the opportunity to explain that efflorescence is essentially the result of water penetrating the concrete matrix, reacting with the soluble salts it encounters in passing through the matrix. Ultimately, internal pressure from these reactions forces the moisture that now carries those salts out of the matrix and out onto the surface, where the moisture evaporates and the salts remain.

This discussion, I've found, has helped many a watershaper see that solving the problem primarily boils down to preventing moisture from entering the concrete in the first place.

Bigger Universe

I've also learned through the years that people who are unfamiliar with these issues will better understand what's happening if I put things in a broader context.

That's easy, because in my investigations of concrete problems and failures (some of them truly catastrophic), I saw the damaging effects of moisture intrusion on structures that were built to much higher standards and that had been designed for far more critical applications than almost anything I've seen in watershaping.

I've seen moisture intrusion cause significant damage, for example, to parking garages, high-rise balconies, bridge abutments, tunnels and a host of other significant structures. Each scenario is different, of course, but I can confidently say that my experience shows that *all* concrete structures are susceptible to moisture intrusion on one level or other.

This is not unknown to the concrete industry at large: During my time as a forensic investigator, we based certain evaluations on information available through the American Concrete Institute's Standard 318 – a set of recommendations for design engineers that defines issues such as compressive strength for various applications. Based on ACI 318.08, in 2009 the American Shotcrete Association adopted a compressive strength of 4,000 psi as a minimum standard for swimming pools.

For this reason, I was puzzled to learn that, for concrete pools and spas, ACI recommendations were not seen as the standard by many in the pool industry. And that was true despite the fact that nobody questions the standard with other types of structures and that it's not something those who build highway bridges or tunnels, for example, would ever choose to dispute.

In the residential pool industry, however, concrete strength seems to be an enduring subject of discussion, with some standing by a 2,500 psi level as the acceptable norm. Personally, I would agree with those who say that, when properly mixed and applied, that level is so low that it's almost impossible to achieve – in other words, that those who strive to install 2,500 psi shotcrete are actually (if unknowingly) applying 4,000 psi concrete as a matter of course. So to my mind, the "debate" really isn't a debate after all.

What intrigues me, however, are those who contend that by reaching a 4,000 psi concrete strength, they are effectively making the matrix so dense that no moisture can penetrate it. Although I would strongly agree that denser concrete has a greater ability to withstand moisture intrusion, my experience outside the industry with structures made with concrete of far greater compressive strength still reveal damage resulting from moisture intrusion.

This is why I contend that all concrete structures – even those built to the 4,000 psi standard or better – still benefit from *some* form of waterproofing, even if it is only as an extra layer of protection.

Built to Last

That said, it's important to bear in mind that the foremost preventive measures when it comes to waterproofing are proper engineering and sound construction. It's simple: If a structure fractures, it doesn't matter what type of waterproofing agent you use, because the structure in question will immediately become susceptible to moisture intrusion.

That's why I join those who advocate the use of proper structural engineering relative to soil conditions and other forces that influence a given structure. It's also why I so strongly recommend sound concrete-application practices, especially when it comes to proper coverage of structural steel that is meant to be encased in concrete. Without these fundamentals in place, waterproofing becomes irrelevant.

Returning to ACI 318.08: The document defines three categories of concern with respect to compressive strength, calling on engineers to look at each and define which most critically applies to their situation and the design process: The first has to do with prevention of moisture intrusion in structures intended to hold water. Here, the standard calls for 4,000 psi, again supporting those who call for that as a minimum standard in pool structures.

The second deals with freeze/thaw conditions and includes a recommended strength of 4,500 psi. The third considers coastal areas where chloride intrusion can be a problem and recommends a strength of 5,000 psi. (There's a fourth category dealing with sulfur attacks, but its occurrence is not relevant most of the time.)

Looking at these recommendations, one might argue that compressive strength alone addresses the issue of waterproofing. But again, there are numerous examples of concrete applied at levels as high as 7,000 psi – properly engineered and capably installed – that show clear signs of moisture intrusion. So while I certainly recommend strict adherence to ACI standards, prudence also asserts that all critical concrete structures (including pools, spas, fountains and other watershapes) should be installed with additional waterproofing measures in place.

If that position needs support, please consider that the International Concrete Repair Institute has estimated that the total cost for repairing, rehabilitating, strengthening and protecting of concrete structures (including waterproofing) amounts to $18 to $21 billion annually in the United States. There's no reasonable way to see concrete watershapes as being somehow immune from these challenges. On that level, it's not so

Water's ability to penetrate concrete is an issue even in critical applications – as seen here with this parking structure (A) and bridge abutment (B). If concrete structures made to the highest applicable standards are subject to this level of deterioration, it's highly unlikely that, say, the exposed undersides of a pool deck (C) will not display similar challenges.

much a workmanship issue as it is the nature of the concrete beast combined with the characteristics of water and the deterioration it causes.

As for plaster, the National Plasterers Council has adopted the position – rightly so, I believe – that even though plaster retards the intrusion of water into a concrete substrate, it is neither a perfect nor infallible barrier nor a guarantor of a vessel's watertightness.

Better Than the Rest

Given all of this history and the basic natures of concrete, water and watershape shells, I believe strongly that watershape designers and contractors should all be more aware of and in tune with waterproofing issues – perhaps to an even greater degree than other concrete-construction professionals.

Consider water's position (literally) in all of this: It's present inside the pool and, despite plaster's helpful role, does everything it can to find ways out. In fact, it is *always* ready to take advantage of any opportunity to penetrate any lining or find its way around it via the tile line or the various fittings that penetrate a shell.

It's also present *outside* the shell, sometimes as incidental water from rainfall or irrigation, other times as groundwater that flows through a given piece of property. Whatever the source, water comes in direct contact with the back of a shell that has no plaster lining or protection of any kind. And where you might be able to see where it might intrude on the *inside* of a watershape, there is simply no way to know what's happening on the *outside* of the structure because it's buried or otherwise hidden from view.

Where outer walls are exposed, as with vanishing-edge walls or raised spa walls, efflorescence resulting from moisture transmission is quite frequently an issue. Also, water in transit over the face of, say,

In many cases, even carefully crafted pools will fall victim to a degree of moisture penetration that manifests itself as efflorescence (A & B). In others, poor construction will be unmasked by water's ability to work its way through any flaws it finds in a shell (C).

a tile finish can pull out soluble salts from the grout as well as the mortar bed. On smaller scales, there are concerns about rainwater falling on decks or, in some cases, consideration of splash-out and the possibility that this water might offer opportunities for moisture intrusion. Saltwater chlorination has been blamed for deterioration as well.

It's a tough environment, in other words, and even temperature fluctuations play an important role. In my forensic work, I've found numerous instances in which sudden changes in temperature have caused expansion and contraction that led to tile cracking or pop-offs – thereby giving water direct access to the concrete substrate. Proper waterproofing can reduce the effects of these extremes.

And if you factor in other features – grout, coping, deck material, artificial rock structures, natural rock features and more – virtually everything in and around a pool, spa or other watershape will present situations in which waterproofing might offer a much-needed layer of protection.

At that point, the questions are all about what you need to protect. Are you willing to take the chance of efflorescence building up behind tile on a vanishing edge wall and eventually causing pop-offs? Is it worth risking groundwater intrusion into a shotcrete shell that might eventually corrode its structural steel? Do you want to protect your perimeter-overflow gutter system?

Given a clear, understood choice, my sense is that most professionals (and their clients) will answer yes to these and a host of other questions. But if you ask those same professionals if they've factored all of this into their previous projects, the honest among them would mostly say *no*. And this is so despite the fact that waterproofing should be part of the design process, *not* an afterthought.

You Choose

Of course, saying *yes* would be a lot simpler if waterproofing was a one-solution-fits-all proposition – but it's not. There are instead a whole range of possibilities and all sorts of products, and doing the job correctly means selecting the right approach for the application and following the waterproofing supplier's instructions to the letter.

That means doing some research and asking lots of questions, which is more than some watershapers prefer to do. But if you leave waterproofing to guesswork or even to assumptions based on experience, it's likely you may go to a lot of trouble and not achieve the elimination of moisture intrusion you seek.

Explaining all of the nuances of available waterproofing products and options would take a discussion several times the length of this article, but for starters, it is useful to know that they come in three basic forms: coatings that are applied to the surface to create a membrane; admixtures that are intrinsic to the concrete and are added at the mix plant; and penetrating spray-on products that are applied topically and migrate into the concrete matrix.

Each of these has its place, and in the spirit of keeping things generic here I won't make any specific recommendations. I won't even pitch the products we offer at Aquron, because as good as they

Photo courtesy Rock Solid Tile

Preparation of deck and pool surfaces can involve the use of a single waterproofing approach (A), but in some cases – as with the preparation of the pool in B for an all-tile finish – it warrants use of waterproofing schedules that use multiple treatments, sometimes from multiple suppliers.

may be, they only have true merit if chosen for the right application and properly applied. And that's true of many products in the marketplace, no matter the supplier.

As I see it, my competition isn't other waterproofing companies; rather, it's the watershaping industry's general lack of acceptance of the need for waterproofing – an information gap I hope I have remedied to some extent with this article.

It's also important to note that no waterproofing system is flawless: Water is called the "universal solvent" for good reason, and all of us in this business know that, given enough time, water may find its way into and through almost any material to which it is steadily exposed. As I see it, what watershapers need to do is stack the deck in their favor as best they can – which makes waterproofing a smart and affordable form of insurance.

I've long heard it said that watershapers have to be good at (or at least familiar with) disciplines ranging from masonry, hydraulics and structural engineering to water chemistry, material and equipment selection and design aesthetics, among others. With so much going on in today's watershapes, with so much required to get the job done right, it only makes sense to try to make sure the primary element we all work with – that is, water – stays right where it belongs.

Waterproofing is a concern well beyond the shell itself – as here, where the coping, deck, natural stone and rock waterfall will all benefit by being protected from moisture intrusion.