Failures of Trust

By Dave Peterson & William T. Drakeley

Fig. 1: Dry mix, low w/c ratio, low cementitious content, water added to floor

Engineers carry an almost sacred trust, with watershapers relying on them to design structures and systems that are reliable, science-based and code-compliant. When that trust is broken, the consumer's investment is at risk -- as is the watershape builder's reputation.

Engineers are highly trusted. In a recent Gallup poll asking which professions are the most trusted, nurses were number one and engineers came in second. Engineers placed above medical doctors, police, psychiatrists and clergy. Not surprisingly, used-car salesmen and members of Congress were at the bottom of the polls!

That high level of public trust begs the question of whether or not engineers truly warrant such rock-solid credibility? Engineers are not all the same and certainly when considering the profession, most are trustworthy, practicing ethically and responsibly. However, there are some that most assuredly are not. Unfortunately, a clear and compelling example of less than responsible engineering can be found here in the pool industry.

When you obtain a set of plans from a consulting engineer – a structural design, for example – you have every right to believe that their calculations, specifications and plans are properly prepared and correct for the project at hand. In most cases, that trust is well-founded; but there are some glaring exceptions.

You run into problems with what we call "mail order" or "off the shelf" plans developed and sold by a few engineering firms. By packaging generic plans, these firms enhance their profits while dumbing down their specifications and allow builders to cut corners.

Some people refer to these as "standard plans," which is a euphemism and misnomer. No two pools are exactly alike. The soils are never exactly the same, nor the property, the environmental conditions, and certainly not the homeowners. Therefore, there really is no such thing as a standard plan. We believe engineers that market plans as such are not meeting the standards required of true professional engineers.

PERPETUATING MYTHS

The unfortunate fact is, many pool builders will use an engineer's generic design, plans and specifications if they think it will lower the cost of the pool, when compared to more rigorously engineered plans designed for a specific pool project. Some builders will ask, why should I use #4 (#13M) reinforcing bars when this engineer says I can get away #3 (#10M)? Mail-order engineers give them the answer they want.

In other words, not all engineers should be trusted. Some of the lowered standards you see in mail-order plans do, in point of verifiable fact, lead to failures or produce a final pool structure that is much less durable. The fact that the engineer's plans and resulting structure was not engineered for the specific conditions of a particular site only becomes known, all too often, in the discovery phase of an expensive and time-consuming lawsuit.

The ugly truth is, there are engineers who will lie to you because they're more concerned with their bottom line than they are with their responsibility to prepare proper designs as expressed in the integrity of their plans. They may ignore some ethical codes while seeking profits.

The good news is it's often easy to spot an unscrupulous engineer in the pool construction industry if you know what to look for. Usually, the corners they cut will be obvious in their project deliverables.

In our industry the biggest area of deception is concrete and reinforcement. They cut corners in the compressive strength and permeability of concrete, cover over the embedded reinforcing steel, the size and spacing of reinforcing steel and even the thickness of the concrete. They attempt to get away with it by using clever language that's meant to confuse builders and authorities having jurisdiction.

One of the arguments, for example, is that it's okay for concrete to be permeable, because that's the plasterer's job. Builders don't have to worry about water permeating the concrete shell because the plaster is there to stop it. Well, that's just not true. A properly designed and constructed concrete pool shell should be functionally watertight.

Fig. 2: Thin wall shotcrete, insufficient concrete placement and no encapsulation of surrounding penetrations or steel reinforcement

The National Plasterers Council, for example, is clear that plaster is not a waterproofing coating or membrane. They require their product to be applied to a watertight concrete shell. That's because water that makes it through the plaster will flow more readily through a porous shell. Once that happens you can have all sorts of problems, including corrosion of the reinforcing steel or even through wall leakage, compromising the soil around the outside of the pool shell.

We often see similar shortcuts with specifying concrete cover over the reinforcing steel, which is essential to structural integrity, and long term durability of the pool shell. If there's inadequate cover, water can penetrate to the reinforcing steel and initiate corrosion that may spall the concrete off and could lead to expensive repairs. The same is true with under sizing the reinforcing steel. The reinforcing must be designed for all expected loads the pool shell will experience in its lifetime. This includes containing the water, standing against backfilled soil loads, surviving seasonal temperature swings and concrete shrinkage. As an example, using #3 bars at large spacing horizontally is not sufficient in many situations to properly carry the internal stresses from thermal changes and concrete drying shrinkage for an empty pool. Sub-standard plans may also cut corners on specified concrete wall thickness based on

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CORE NO.	THICKNESS	LOCATION
5	7 1/4"	Bottom - 13'6" W 14'8" N of SE Corner of Trough
6	9 5/8"	Bottom - 17' W 13' S of NE Corner of Trough
7	13 1/2"	Steps - 13'3" W 3'1" N of SE Corner of Trough
8	13"	Steps - 15'6" W 3' S of NE Corner of Trough

Date Sampled: 2/24/14 Date Tested: 3/6/14

Specimen Identification:	Core #5	Core #6	Core #7	Core #8
Core Location:	Bottom	Bottom	Steps	Steps
Core Diameter (in.)	3.72		3.74	3.73
Core Area (sq. in.)	10.87		10.98	10.93
Length Before Capping (in.)	6.75		7.38	6.88
Length After Capping (in.)	6.94		7.63	7.00
Compressive Strength, psi	2765		2030	2429
Maximum Load (lbs.)	30,050		22,260	26,550
Length/Diameter	1.91		2.04	1.89
L/D Corr. Factor	.98		--	.98
Corrected Compressive Strength, psi	2709		--	2381
Direction of Load applied relative to the horizontal plane of concrete as placed.	Vertical		Vertical	Vertical
Age at Test (days):	171		171	171
Moisture Condition of Specimen:				
During Curing	Moist	Moist	Moist	Moist
At Test	Surface dry		Surface dry	Surface dry
Nominal Aggregate Size:				
Defects in Specimen:				
Time Sample Taken:	11:08am	11:25am	10:55am	11:01am

Fig. 3: Typical report of compressive value test reports

using less than appropriate cover and ignoring the tolerances on placing the reinforcing steel.

THE BIG LIE

The most obvious and egregious shortcut, and the most deceptive, is found in the way that some engineers specify the compressive strength of concrete. This is an almost mythical area that's been perpetuated for years. Frankly, it's disturbing that this one still exists; but, when you look at the deceptive language, it's painfully obvious what's happening.

According to language provided by some mail-order engineers who specialize in pools, "Shotcrete shall have a minimum compressive strength of 2,500 psi (17 MPa)." But then in the next sentence, you'll read "where applicable, shotcrete shall conform with the IBC Section 1904 Durability Requirements."

First of all, where does IBC Section 1904 not apply? The fact is, all pools constructed using pneumatically applied concrete, either wet or dry-mix shotcrete, are subject to the IBC language. Well, guess what? The IBC is clear that concrete should have a minimum compressive strength of 4,000 psi (28 MPa), or 4,500 (31 MPa) or 5,000 (34 MPa) depending on specific soils conditions and exposures. Therefore, saying that the minimum compressive strength can ever be 2,500 psi is simply a flat-out lie. Saying, "where applicable" is nothing more than a way of distracting you from the fact that the IBC standards apply everywhere. The language in IBC 1904 is crystal clear that concrete structures shall comply with the American Concrete Institute's (ACI) 318 Building Code Requirements for Structural Concrete, which defines required compressive strength. It is unambiguous and there is simply no other way to accurately read the applicable Code language.

The reason for the misrepresentation of reality is that these untrustworthy engineers can sell more plans to builders looking to shave costs. If you build 35 pools each year and save $10 per cubic yard of concrete, some builders will see that number adding directly to the bottom line. And, courtesy of these untrustworthy engineers, they have a plan prepared by an "engineer" to point to that seemingly justifies the lower standard.

Cutting to the chase, any engineer that pushes the 2,500 psi standard is betraying your trust. Lower concrete strength creates higher permeability, less ability to protect the embedded steel reinforcement, and thus gives the owner a much less durable pool. And consider this, they are certainly not going to pay for repairing or replacing the pool when it fails to meet the owner's expectations for a durable, serviceable concrete pool shell that should last 50 years or more. Your clients are not going to be happy later on when in the course of a lawsuit they find out that the requirement really was 4,000 psi and you didn't take the time to discover that fundamental fact.

There are differences in the ACI 318 standard based on the type of exposure conditions but even a cursory review of the applicable code language in ACI 318, reveals there are no circumstances where 2,500 psi concrete is acceptable for concrete intended to be watertight.

The bottom line is that watershapes are required to have:

- 4,000 psi, minimum,
- 4,500 psi for freeze-thaw environments,
- 5,000 psi for high sulfates in the soil, and
- 5,000 psi for pools using saltwater chlorine generation.

Any specification or project plan that deviates from that is technically not meeting the code requirements. From our perspective any engineer claiming a 28-day compressive strength of 2,500 psi is acceptable is guilty of negligence, and misrepresentation. They are in effect facilitating the pool builder's desire to keep costs low and as a result allowing them to produce a pool that has nowhere close to the strength, serviceability and durability the pool owners should rightfully expect from their pool.

Fig. 4 Extensive efflorescence from cracks in pool shell due to design and construction issues.

POROUS ARGUMENTS

As mentioned above, concrete in pool shells should be functionally impermeable. That can be confusing for some people. It's a point that some engineers will use to their advantage because all concrete is, to some degree, permeable. To make sense of this issue, you need to understand four key terms when considering concrete:

- Permeable: having minute spaces or holes through which liquid or air may pass. All concrete is permeable.
- Porosity: the ratio, usually expressed as a percentage of the volume of voids in a material to the total volume of the material, including voids.
- Permeability: the ability of a given concrete to permit liquids or gases to pass through. All watershapes should be impermeable!

While it is true that all concrete is permeable to some extent, in 4,000 psi concrete the permeability is low enough that water flowing through the pool shell is not a problem. When you deviate from that standard and accept some lower compression strength, then it is very likely you'll have concrete that will allow water to permeate through it. One of the arguments you hear from some mail-order engineers is that the concrete matrix is inconsistent and there will inevitably be areas of higher porosity than others. Again, that is simply not true. With proper mixing and application techniques, concrete is relatively uniform.

In conclusion, engineers who support cutting corners and work outside of established and accepted industry standards are not worthy of your trust. Caveat emptor. Let the buyer (you, the builder) beware.

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