

Abrams' Law As It Applies to Pool Finish - Part I

By Rob Blake, POOLCORP Product Manager, Pool Finish & Decorative Concrete

Duff A. Abrams, an American professor and researcher, who dedicated his career to pursuing a deeper understanding and knowledge of the science of concrete, published (inhale) “*Design of Concrete Mixtures, Bulletin 1, Structural Materials Research Laboratory, Lewis Institute, Chicago, 1918*” (exhale). Not the most catchy title for a book, but groundbreaking nonetheless.

Thankfully, through Abrams' dedication to understanding the science behind water to cement ratio, we now have a concrete (yes, I went there) formula as to the importance of the impact of water to the compressive strength of concrete. The following summarizes his findings:

- **Less than 50% weight of water to weight of cement produces the strongest concrete.**
- **The optimal range for this is 44% - 47%.**

Understanding Abrams Law

“Jerry, do you know that the human head weighs eight pounds. Do you know what else weighs approximately eight pounds? A gallon of water.” This is a classic line from “*Seinfeld*” that should not be forgotten for anyone working with concrete. But to be more precise, a gallon of water weighs 8.33 lbs. You need to know this in order to use and understand Abrams' law. Specifically, Abrams' law states:

“For a mixture of workable consistency, the strength of the concrete is determined by the ratio of water to cement. As the water content increases, the strength decreases. Less than 50% water to cement is ideal, with 44-47% being optimal.”

It's important to keep in mind that concrete is very similar to any cement-based pool finish (a.k.a. cementitious pool finish). Both are comprised of aggregates, which are held together by a binder (in this case, Portland cement paste). When water is added to Portland cement, it goes through a chemical process called *hydration* where it hardens into a stone-like mass.

Abrams law created a standard for everyone to use to maximize the strength and performance of concrete in various forms. We can apply this standard to our NPT branded pool finishes. Abrams law falls into what are known as “best practices”. When working with cement, it's important to take a well thought out systematic approach to every aspect of the process. We've all seen what pool finishes can look like when too much water is used in the mix design. If Abrams' law was utilized, this would not happen. This is especially true for applicators that are mixing in small vessels and dumping or wheel barrowing the material into the pool. (More on that later.)

Abrams' Law
Cement to Water Ratio

In civil engineering, Abrams' law states that in concrete materials, for a mixture of workable consistency the strength of concrete is determined by the ratio of water to cement. As the water content increases the strength decreases

Optimum Ratio makes for stronger pool finishes → 50% < Ideal 44-47% optimal

Equation: weight of water divided by weight of cement

a gallon of water weighs 8.33 lbs. a full 5 gallon bucket of water weighs 41 lbs.

Note: Local environmental conditions may dictate changes to the standard water to cement ratio.

Water: Balance is the Key

What a crazy year we're having across the country. There is too much water in Texas – with devastating consequences – and not enough water in California, with a different degree of devastating consequences. 96.5% of all of the water on earth is held in the oceans. As an avid surfer, I'm a huge fan of the oceans and water in general. Even though we don't sell it, water is the single most essential component of every NPT branded pool finish. Water brings the pool finish to life, and without it, it would be impossible to have NPT pool finishes. The biggest challenge we have with water (as it relates to our pool finishes) is the fact that the vast majority of our customers do not weigh the water that they use to mix the pool finish components together to create the pool finish. Without a systematic approach to the adding of water to the mix design, it's extremely difficult to get the proper water-to-cement ratio for the particular pool finish. In most cases, an excessive amount of water is being added.

The NPC's Perspective – Optimal Mix Design:

From the National Plasterers Council Technical Manual Seventh Edition, section 2.1:

Water content is typically governed by three primary factors: weather conditions (water evaporation), the substrate conditions (water absorption), and the application conditions (workability). The water content will vary from job to job based on these three factors. Under certain environmental conditions, it is critical that supplemental (re-temper) water be added during mixing, to ensure that:

1. Pumping, placing, and finishing of the cementitious surface coating is facilitated.
2. The cementitious surfaced coating does not dry before it sets.

Important Questions:

- How much water should I be recommending to my customers?
- How much water is too much?
- Does it really matter how much water goes into the mixer?

Remember that the cement ratio for “optimal conditions” is 44% - 47%, but let's bring that to life.



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Science, Not Fiction

Every NPT branded pool finish has a corresponding batch formula card that clearly states the amount of cement specified for each color. As a general rule, the type of aggregate or pool finish determines the amount of cement in the batch – the larger the aggregate, the higher the percentage of cement in the batch. This is designed to facilitate the mixing, pumping, and placement of the larger aggregate pool finishes (like JewelScapes® and StoneScapes®).

In reality, a large portion of the added cement will be washed away during the application/exposure process. That's what slurry pumps, sponge rollers, plastic sheeting, and slurry containment are used for.

Here are some interesting facts:

- It's not uncommon to have 600-900 lbs of water, cement paste, pigment, and aggregate removed during a normal StoneScapes application.
- JewelScapes formulas have 470 lbs of cement per 986 lbs batch.
- StoneScapes formulas have 564 lbs of cement per 1,164 lbs batch.
- QuartzScapes® has two different batch sizes: one has 296 lbs of cement and the other has 390 lbs.
- The difference in the weight of cement between a standard QuartzScapes batch and a StoneScapes batch is 268 lbs or 47%.

When you understand these facts, it becomes clear that if you told your customer to use the same amount of water for different products, you would be in big trouble. This is because the recommended formula is almost *twice* as much water as was needed for the proper mix design in *optimal conditions*.

NPT® Pool Finishes		Abrams' Law Water to Cement Ratio 
Recommended Water Addition Amounts <i>Forget water to cement ratio. 64 - 67%.</i>		
JewelScapes®	470 lbs of cement per batch 25-28 gallons of water optimal	
QuartzScapes®	308 lbs of cement per batch 17-18 gallons of water optimal	
QuartzScapes® Super Blue	402 lbs of cement per batch 21-24 gallons of water optimal	
StoneScapes®	564 lbs of cement per batch 30-33 gallons of water optimal	

*Under Optimal Environmental Conditions

By using this quick reference guide for the addition of water when mixing NPT pool finishes, the guess work is replaced by science and a standardized professional guideline. The term “**optimal environmental conditions**” is crucial to remember.

If your customer is working in challenging environmental conditions like extremes in humidity, wind, sun, and/or ambient air temperature, this will have a tremendous impact on the proper amount of water needed to create the best pool finish matrix (stronger, less susceptible to chemical degradation, with a longer service life) and application process.

Breaking the Law

The main goal is to create a pool finish matrix that's mixed thoroughly enough that *all* the material is wetted out properly, but not too wet to make the material weak. This is a delicate balance. Some plaster crews think that wetter material (a.k.a. *mud*) is easier to mix, move, and trowel. In reality, the opposite is true most of the time. A good example of this is when you see the finisher push the pool finish material back up the side of the pool wall repeatedly because the material is too wet to stay up or stick or when a mixer says that the hoses will plug if they don't make the material super wet.

Often, plaster hoses will pack because the mixer did not mix the material long enough for all of the material to wet out in the mixer before it was pumped through the hose. Plaster material will expand in the plaster hose as it seeks water. *Thoroughly wetted and properly mixed material will not do that.*

I've witnessed customers in South Florida mix our pool finish products in a plastic drum in the bottom of a pool, then simply tip the drum over and pour the pool finish material out. They then used a rubber squeegee to spread the material around. If the mixer had used the proper amount of water, the material would have been too stiff to flow out of the drum and they would not have been able to use this application technique. This creates a pool finish that is weaker and more susceptible to cracking – especially craze cracking – spot etching, and delamination. None of these circumstances are typically covered under the warranty program.

To help you fully realize just how crucial the water/cement ratio is to the strength and longevity of our pool finish brands and the importance of knowing, understanding, and using Abrams' law while installing/applying NPT pool finishes, we'll share more “real life” stories from our customers around the country in our next issue. ♦

