Transparent Ingenuity

Working in the custom swimming pool market requires a keen understanding of how shotcrete can be adapted to complex and challenging structures. The work necessitates creativity on one hand and adherence to ACI and ASA standards and practices on the other. It means being inventive and disciplined at the same time.

By William T. Drakeley

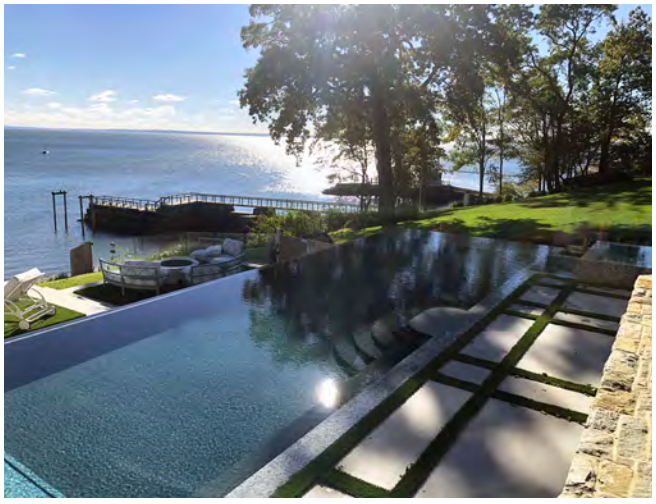
The Sherwood water shape project is something special. It's one of the more creative and challenging residential swimming pool environments we've ever created and I've been humbled by the recognition it's received.

Looking back, I now see it as a prime example of the importance of understanding how all the phases of pool building fit together and support each other. There is a healthy list of takeaways from this challenging and award-winning project. Topping that list stands the importance of understanding shotcrete and the techniques used to place it.

IN SITU

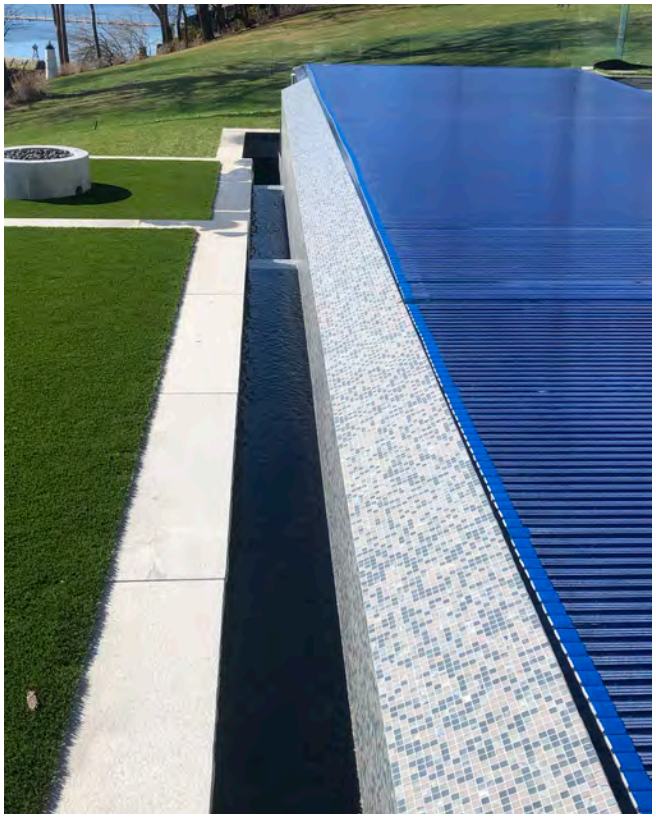
Located on the Connecticut coast overlooking Long Island Sound, the water feature drew its contemporary design from the architecture of the new house, a modern version of the old coastal mansions once built and adorned by the Rockefellers, Morgans, and Vanderbilts.

The house and surrounding architecture and landscape architecture incorporate a contemporary yet strict linear version of hillside old-world construction. It's a spectacular property that warranted an equally eye-catching water shape design.



The house and all its features, including the pool, blend into the modernist property overlooking the ocean. The pool is a reflection of the architecture and the spectacular setting. It's a three-tiered pool, spa, vanishing edge, slot overflow and acrylic panel design with a German Grando cover that rolls out from an automatic shotcrete floor vault and sits onto a shotcrete ledge along both long walls of the pool.

All of this is set on a dramatic slope – there's a 20-ft (6.1 m) drop from the top of the pool area to the bottom of the equipment vault. The soil conditions vary wildly on the property due to the site's many uses dating back to colonial days, meaning the structural design relied heavily on soils analysis and geotechnical engineering.



To effectively execute a project of this complexity, every step in the process is aimed at setting the stage for the next, from the excavation up to the finish materials. The topography and spacing of construction required marrying proven shotcrete methodology into and on top of, a form-and-pour filter vault and supporting lower wall foundation.

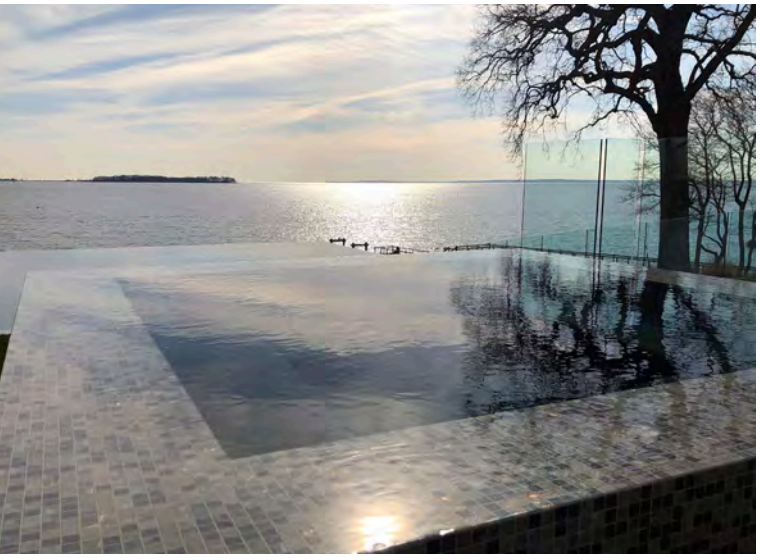
The structure's footprint and position were first established with rock and ledge removal down to a workable and competent substrate. We then cast the supporting foundational walls, footings, and locking mechanisms into the steep vertical slope of the pool area.

A BIG SHOOT

With the new concrete members and the structural foundation in place, we installed additional connecting reinforcing bars that penetrated up and into our shotcreted pool structures.

The next phase was forming and steel reinforcement installation. Unlike the cast concrete substructure, our forms were one-sided, rough-sawed lumber and plywood.

The entire pool installation was above ground, requiring some notably intricate forming. The steel reinforcement was



Grade 60, #4 (#13M) and #5 (#16M) bars, spaced at 6 in. (150 mm) to 12 in. (300 mm) with double or triple layers. All reinforcing steel was securely installed for rigidity, and free of oil and contaminants that can affect performance. In all, we installed 23 tons (21 metric tons) of reinforcing steel.

The shotcrete process took five days. The first three were for the bulk of the main pool shooting and some of the thicker wall-to-floor areas. The last couple of days were focused on the detail and close tolerances of the vanishing edge and all of the spillway lower pools.

The trickiest or most difficult part of the shotcrete placement came with the installation of the pool cover vault and the "rebate," which is the shotcrete locking mechanism or channel for the acrylic panels. Each panel, 7 ft (2 m) high and 7.5 in. (190 mm) thick, was to be recessed 1 ft (0.3 m) down into the rebate channel. The width of the rebate could be no more than 9 in. (230 mm) and must be

Shotcrete Phase

The shotcrete segment of this project was one week's worth of shotcrete placement into the pre-existing formed and reinforced sections for three interconnecting water-in-transit pools. Although it took five days to complete, there are no cold joints, and all interconnecting pools are monolithic and watertight.

There was no expansion or contraction joint, or bonding agent used between concrete connections. There are expansion materials between the acrylic and the shotcreted rebate. All next-day shooting and connecting joints were prepped to a saturated surface-dry (SSD) condition with a roughen bond plane.

We used a total of 210 yd^3 (161 m^3) of concrete.

Mixture Design

Cement (ASTM C150 Type I/II) – 750 lbs (340 kg)
Fly Ash (ASTM C618 Class C) – 50 lbs (23 kg)
Sand (ASTM C-33) – 2020 lbs (920 kg)
ASTM No. 8 (3/8 in.) – 600 lbs (270 kg)
Water – 358 lbs (162 kg)
Air Mix 250 – 1.0-2.0 oz (30 – 60 ml)
Water Reducer – 2.0 oz
Entrained Air Content – 8%-10%
Slump – 1-3 in. (25 – 75 mm)
w/c Ratio – 0.44

Equipment Used: Schwing BP500 Wet Mix Shotcrete Pump, Ingersoll Rand #375 CFM Air Compressor

Economies of Shotcrete

Benefits on this project include:

- Approximately 50% labor and material savings over conventional form-and-pour formwork
- Our formwork did not need to be designed for internal liquid concrete pressures, and thus only needed one-sided forming.
- The speed of labor increased by almost 50% because of the reduced need for overall forms in relationship to reinforcement.
- The restricted work area and its elevated accessibility could not have been completed economically or timely by any other means than the shotcrete process.
- The cost savings with materials and manpower is evident when compared to the cost of the formed foundation on this same job.

Materials Palette

The project included the installation of a variety of beautiful finish materials:

- Native stone veneer (chosen to match the home's foundational color scheme)
- Italian glass time by Bisazza
- Bluestone treads and caps from Pennsylvania Select
- Fiberglass safety grating
- Stainless (Grade 316) steel slot perimeter overflow earth supports
- Exposed aggregate plaster finish

level and square. Shooting this in an elevated condition above a shotcrete vanishing edge trough that's another 8 ft (2.4 m) deep is no day at the beach (more on the panel installation below).

The cover vault was the first shotcreted application of the pool. It sits under the pool floor and acts as a foundation for the rest of the pool with a tolerance requirement of ½ in (13 mm). For the cover lid to operate, we had to take precautions in the form of a prep or leveling coat of cementitious materials, which needed to be added to the roughened bond plane after we shot the vault. As I said, it was tricky and the tolerances in the detail work were critical.

After the concrete placement with wet-mix shotcrete, the concrete was water cured to ensure not only strength gain but also give reduced permeability and enhanced

water-tightness. Compressive values after a 28-day wet cure were between 6,000 and 7,500 psi (41 MPa and 52 MPa). For more shotcrete details, see the sidebars.

THE BIG FIT

The marquee achievement on this project was the way we married two water-retaining materials. Specifically, the design included perpendicular massive acrylic panels that constitute the above-grade southwest corner of the pool. It's a daring design, to say the least. Aesthetically the concept is to visually link the beautiful interior of the pool with the scenic setting. Technically speaking, it required creative problem solving, custom fabrication and ultra-precise installation.

The concise explanation is that the acrylic panels had to connect, bond, and function as one structural vessel. Making that happen pushed our existing norms to a new level.

Turns out that creating a fused L-shaped panel in our climate is far more challenging than we imagined. We had to create a watertight connection between the acrylic and the shotcrete, while allowing for differing thermal expansion and contraction in an area known for both very cold and very hot weather.

Through painstaking investigation, we determined that joining massive panels at corners like this requires a special caulk joint supported by a structure known as a mullion, a common fenestration term referring to vertical supports in window treatments. In this case, we were looking at what might rightfully be considered a mullion on steroids.

We had never tried this before, so we brought in our friend and colleague, Rick Chafey from Red Rock Pools & Spas in Chandler, AZ, who had experience in this type of challenging application.

We designed the mullion with Chafey's guidance and design input. It was fabricated from ¾ in. and 1 in. (19 and 25 mm) stainless steel fin-shaped plates that buttressed the joint in both directions. The idea was to create a support structure for the loading and push of the interior water.

The mullion was set into the concrete with ¾ in. threaded rods. The bottom and sides of the panels were set 10 in. (250 mm) into a channel in the concrete, with caulking around both sides of the panel. The force of the water acts to make the ends of the walls lift, so we also used stainless steel panels on the tops of the walls, finishing them with Bisazza glass tile.

We knew we'd have to closely monitor the structure during the first winter and determine how to service it for the next. We wanted to collect data to get this down to a science as there was no previous experience to support the performance characteristics of two 7 in. (180 mm) thick, acrylic panels joined together in a swimming pool here in the northeast climate.

This completed water shape is proof positive that the shotcrete process not only creates a watertight bond to support vastly different surfaces, but it is also well-suited for

use in projects featuring leading architecture and design. The experience and creativity of a quality shotcrete can be an integral part of creating meaningful architectural works that stand the test of time.

William T. 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.*