

Cliffside Plunge: Rewriting the Rules for Concrete Placement

By William T. Drakeley Jr.

Location, Location, Location

In 2011, Drakeley Pool Company was approached by the Donovans—new clients from Westchester County, NY—whose vision was to build a pool that would blend seamlessly with their home and surrounding landscape.

They imagined a pool nestled against the house in the backyard at basement level, allowing their family to step out onto the pool patio and immediately take advantage of the spectacular views of the lake that abuts the property. Then came the catch: a person could take approximately 10 full steps from the basement door before arriving cliffside, staring down a 200 ft (60 m) slope to the water's edge (refer to Fig. 1).

There was abundant yard space elsewhere on the property—flat, even, and ideal for a pool—but that area was already occupied by the septic tank and other necessities.

The challenge of cliffside construction had been tackled before with the house itself, which was perched sturdily atop a ledge rock point. Drakeley Pool Company was charged with the task of duplicating this process—this time, even closer to the cliff's edge—by working with existing

grade changes and elevations to install a small pool with a strong current the owners could swim against. Bill Drakeley, owner, and Daniel LoRusso, foreman, aimed to create a feeling of expansiveness in the limited space, all the while working to keep the whole operation from tumbling off the cliff.

Designing Against Gravity

The Drakeley design featured three different elevations for water in transit: the top tier was to be a raised spa; the second, a main pool swimming area; and the third, a lower surge trough (Fig. 2). The installation would require the creative use of different techniques, including small cast-in-place concrete footings to stabilize the structures and concrete placed by the shotcrete process to create the bodies of the spa, pool, and surge trough.

The unique topography and geological conditions necessitated the construction of a “keyway” for the bottom of the shotcrete pool. This concrete-filled trough in the natural rock forms a keyway to lock the pool structure into the existing rock ledge and provide horizontal restraint for the structure to keep its position on the very brink of the cliff without movement.



Fig. 1: Dramatic slope bordering construction area

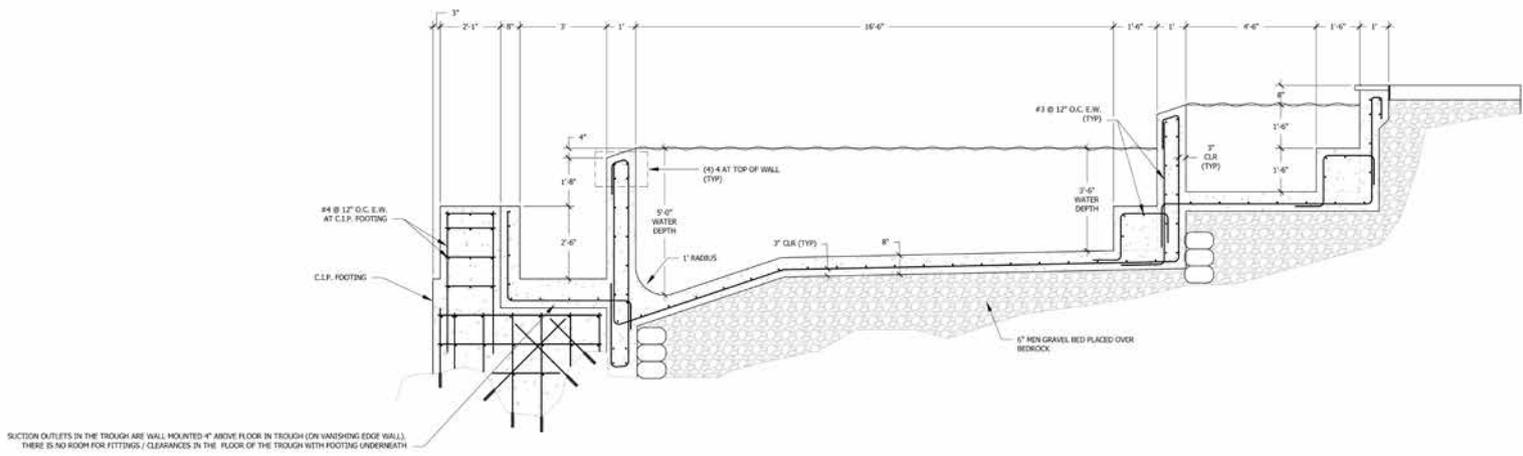


Fig. 2: Three-tier system of spa, main pool swimming area, and surge trough (Note: 1 in. = 25.4 mm)

Angles and Edges

The Donovan home is architecturally contemporary with organic design themes present in both the house's structure and the surrounding landscape. The pool would therefore require both architectural symmetry and fluid continuation of space.

Drakeley Pool Company derived its in-house design of the pool from the school of John Lautner and his mentor, Frank Lloyd Wright. The rectilinear orientation of the pool was intended to echo the angles of the house, while the harnessing of vanishing-edge design would allow the eye to skim effortlessly over the surface of the water and into the vault of trees encompassing the space. The water would flow over the edge and into the surge tank, which was stabilized and locked into the ledge lower on the hillside.



Fig. 3: Rock hammering and ledge removal

Phase 1: Excavation and Footing Installation

The Drakeley team began the project with an extensive period of rock hammering and ledge removal to carve the hillside to a buildable, workable base (Fig. 3 and 4). They then installed three sections of cast-in-place footings and horizontal structural members (Fig. 5). Situated beneath these members was the keyway that anchored the pool structure into the rock. At this point, the Drakeley crews installed drainage mechanisms and subsurface drains necessary to control groundwater that, if left unchecked, could compromise the stability of the hillside pool.

Phase 2: Forming and Steel

The next phase was forming and reinforcement installation (refer to Fig. 6). Forms were one-sided, rough-sawn lumber (2 x 4 in., 1 x 6 in. [50 x 100 mm, 25 x 150 mm]), accompanied by sheets of plywood. Because half of the pool installation was to be an out-of-ground build, intricate



Fig. 4: Rock hammering and ledge removal



Fig. 5: Cast-in-place concrete footing to support pool structure



Fig. 6: Intricate but efficient formwork, steel, and plumbing installation prior to shotcrete placement



Fig. 7: Extensive formwork required for cast-in-place concrete

forming was required. Despite its complexity, the forming phase boasted impressive efficiency when compared to the forming more traditional concrete placement methods would require. Because the formwork did not need to be designed for internal pressures, one-sided forming was used. Drakeley Pool Company recorded approximately 50% labor and material savings over conventional formwork (as is visible in Fig. 7, the small cast-in-place section of the foundation concrete work required as much wood forming as the remainder of the entire pool). Furthermore, the reduction of labor increased the speed of construction by almost 50% because of the reduced (or eliminated) need for two-sided structural forms.

All necessary plumbing was installed in keeping with LEED construction principles, employing low-line velocity technology with large pipe diameters. The steel reinforcement was Grade 60, No.4 (Grade 420, No.13M) bar placed 6 in. (150 mm) on center in the walls and double mat on the vanishing-edge wall. All reinforcing steel was installed with sufficient rigidity to withstand the shotcreting pressures and was kept free from oil, dirt, and other contaminants that could have affected performance.

Phase 3: Shotcrete & Curing

The shotcrete installation took place over a 3-day period. During the first day, Drakeley crews—ACI-certified nozzlemen and other qualified crew members—concentrated on the main pool swimming area and the vanishing-edge wall. The second and third days were designated for focus on the spa and surge trough areas. Despite the relatively unimposing dimensions of the pool, the



Fig. 8: Completed shotcrete structure undergoing 28-day wet cure to achieve high strengths of 6000 to 7000 psi (40 to 48 MPa)

detail work and achievement of key tolerances throughout the installation was critical. Following the 3-day shoot, the pool was water-cured and tank-tested to ensure not only strength gain but also water-tightness (Fig. 8). After a 28-day wet cure, tests revealed strength values between 6000 and 7000 psi (40 and 48 MPa).

For Bill Drakeley, an expert in concrete materials and application who specializes in the shotcrete process, the significance of the use of shotcrete in the Donovan project cannot be overstated. With the limited space for maneuvering at the cliff side, the flexibility of the concrete installation was paramount. Given that all formwork, steel, and concrete installations were basically out of the ground and extended outward over an edge, the shotcrete process allowed Drakeley Pool Company to complete this installation in the exact spot that the owner designated without any derivation from the original vision. Using other concrete installation types for the shells of the spa, pool, and surge trough would have greatly increased both difficulty and cost. Drakeley further notes that, despite the flexibility of concrete placement through the shotcrete process, compressive values and overall structural strength were not compromised in the least. “With shotcrete,” he notes, “you don’t sacrifice performance just because of difficult or challenging site conditions.”

Phase 4: Masonry and Start-Up

In homage to the natural features of the surrounding New England topography, native stone

matching the existing house foundation stone was used as coping and veneer material (Fig. 9). Select Pennsylvania bluestone made up all treads and caps. Glass tile covered the weir wall and the vanishing edge (Fig. 10), while Vermont slate tile was placed at the water line. Finally, a standard gray plaster finish was applied to the interior of all three shells, allowing for maximum sharp reflection at the water’s surface (Fig. 11).

The pool was filled, all systems started up, and the project was turned over to a smiling client.

A Final Anecdote

Before ground was even broken, the project faced significant obstacles. Given the unprecedented nature of the proposed installation, the town building department was understandably skeptical regarding the ultimate reliability of the structure. The idea that the pool could be installed without some type of eventual flexural movement or differential settlement was considered unlikely at best. It was believed that some type of exceptional storm may have adverse effects on the project, implying legal repercussions for those involved in approving the plans.

To keep the wheels of the painstaking construction process moving according to the client’s needs, Drakeley pressed on, hopeful that the quality of the installation would speak for itself, resulting in ultimate approval and a new precedent set for both the town and surrounding contractors.



Fig. 9: Native stone in harmony with house and surrounding landscape



Fig. 10: Glass tile applied to weir wall and vanishing edge



Fig. 11: Three-tier system complete and running

As perverse luck would have it, the local area was wracked by a hurricane, a tropical storm, an earthquake, a tornado, and a freak October blizzard that knocked the power out for 7 days. After this brutal round of foul weather (and with an unmoved, sound installation), Bill Drakeley humbly inquired if the shotcrete structure required further testing and verification. It didn't. The project was approved, albeit a bit later than hoped.

The Outstanding Pool & Recreational Project

Project Name
Donovan Residence

Project Location
Armonk, NY

Shotcrete Contractor
Drakeley Pool Co., LLC*

General Contractor
Drakeley Pool Co., LLC*

Architect/Engineer
Drakeley Pool Co., LLC*

Material Supplier/Manufacturer
Putzmeister Shotcrete Technology*

Project Owner
Joe & Judy Donovan

*Corporate Member of the
American Shotcrete Association



William T. Drakeley Jr. is President of Drakeley Industries and W. Drakeley Swimming Pool Company. Drakeley Industries is a shotcrete consulting firm that is dedicated to the training and implementation of the shotcrete process in regard

to building water-retaining structures, ground support, and underground shotcrete application. Drakeley Pool Company is a design-build construction and service firm specializing in in-ground, high-end commercial and residential pools. Drakeley is an active member of ACI Committee 506, Shotcreting. He is the first ACI-Certified Shotcrete Examiner from the pool industry nationwide. Drakeley is also an ACI Certified Nozzleman, ASA Technical Advisor, Chair of the ASA Pool & Recreational Shotcrete Committee, and serves as Treasurer to the ASA Executive Committee. His writings have been published in national and international trade magazines, including Shotcrete, Watershapes, Pool and Spa, and Luxury Pools magazines. In addition, Drakeley is a Platinum Member of the Genesis 3 Group, a licensed member of the Society of Water Shape Designers, and a member of the Association of Pool and Spa Professionals (APSP). He is also the Concrete/Shotcrete Instructor at the Genesis 3 Pool Construction Schools and NESPA Region 1 Show in Atlantic City. As an instructor and trainer, Drakeley has given lectures on shotcrete applications for various pool trade shows and for World of Concrete. Drakeley is an expert witness regarding shotcrete applications for the swimming pool industry.