

# Overview of ASA Position Statements on Shotcrete Pool Construction

By Charles Hanskat

**S**hotcrete placement has been used for decades to create high-quality, creatively shaped, durable, water-tight concrete pool shells (Fig 1). Shotcrete has many inherent advantages in pool construction:

- Shotcreted pools are not limited to straight, flat surfaces. We can place concrete to create unique curving walls and radiuses (or even those flat, straight surfaces) when needed.
- Because the final surface of the freshly shotcreted concrete is readily available for finishing, we can provide any finish texture desired—from a simple, cut finish for excellent bond of later-applied plaster or tile, to a smooth trowel finish, to a surface looking exactly like an exposed rock face.
- With the readily available freshly shot concrete surfaces, very close tolerances can be met. This is important for



Fig. 1: Tight tolerances with advanced design facilitated this uniquely curved pool

features like infinity edges that need a uniform elevation for smooth water flow over the edge.

- Shotcrete has low form pressures during placement, so it allows light, easily placed and removed forms using less materials and labor, thus reducing overall construction duration and significantly improving sustainability of the project.
- Shotcrete using properly selected materials, appropriate equipment, and experienced shotcrete crews will create concrete sections with strength, durability, and low permeability that are equal or superior to the hardened properties of traditional form-and-pour concrete.

Though shotcrete's use in the pool industry is widespread, unfortunately, knowledge of proper materials, equipment, and application techniques can vary widely. Our ASA members know that quality shotcrete takes a conscientious and constant effort to pay attention to ALL the details. As Technical Director for ASA, I often get inquiries from pool owners and builders about questionable shotcrete practices on their projects. Reuse of rebound, lack of curing, lack of velocity in placement, inconsistent thicknesses, and issues with excessive porosity crop up frequently. My article "Misconceptions about Shotcrete—True Stories from ASA Technical Inquiries" in the Fall 2016 issue of *Shotcrete* magazine presents many of these, if you would like to see more details.

Why do we have this large spread in quality of shotcrete placement in the pool industry? There is not necessarily a single answer. There are many smaller companies with no ACI-certified nozzle men whose nozzle men just learned by picking up the nozzle. They simply do not understand the basics needed to produce quality shotcrete. There are those companies who, due to the high level of competition in producing pools, feel they need to meet the same price point and quality of the lowest bidder. There are company owners who do not understand the shotcrete process and do not invest in the proper equipment or maintenance to produce quality shotcrete day in and day out.

So, what can ASA do about this lack of knowledge among the owners, designers, and contractors in the growing, and challenging business of creating pools? As Bill Drakeley, Past President of ASA, has repeatedly stated, "We need to raise the bar in the pool industry." ASA's Pool and

Recreational Shotcrete Committee, led by Bill, found there were no clear, specific reference documents that covered shotcrete pools. Though ACI 350, “Code Requirements for Environmental Engineering Concrete Structures,” includes shotcrete and covers all types of liquid-containing concrete structures, it is used predominately in large water, wastewater, and industrial process projects and not in the design of pools. Local building codes also typically did not address the specific needs of shotcrete placement for pool projects.

Thus, the ASA Pool and Recreational Shotcrete Committee decided that a series of position statements, or white papers, on specific, focused issues for shotcrete placement in pool applications was the best way to share the knowledge the committee members had through their long experience with shotcrete pools.

To date, we have developed and had full Board approval on six position statements:

- Compressive (Strength) Values of Pool Shotcrete
- Definitions of Key Shotcrete Terminology
- Sustainability of Shotcrete in the Pool Industry
- Watertight Shotcrete for Swimming Pools
- Monolithic Shotcrete for Swimming Pools (No Cold Joints)
- Forming and Substrates in Pool Shotcrete

Future position statements will address issues such as curing and finishing. The full position statements are freely available at [www.shotcrete.org/resources](http://www.shotcrete.org/resources). The following is an overview of the content in each.

## COMPRESSIVE (STRENGTH) VALUES OF POOL SHOTCRETE (POSITION PAPER #1)

This position paper deals with the specifics on ASA’s recommendation that shotcrete should have a minimum 28-day compressive strength of at least 4000 psi (28 MPa). ACI 318-14, Table 19.3.2.1, for concrete in contact with water where low permeability is required (Exposure Class W1), specifies a minimum compressive strength of 4000 psi and a water-cementitious materials ratio ( $w/cm$ ) of 0.5



Fig. 2: Lightweight, one-sided form is all that is needed when using shotcrete

or less. Shotcrete inherently has a  $w/cm$  of 0.45 or less, and with proper materials, equipment, and placement, can routinely achieve strengths of 4500 to 9000 psi (31 to 62 MPa). Many shotcrete applications see a 4000 psi strength at 7 days.

## DEFINITIONS OF KEY SHOTCRETE TERMINOLOGY (POSITION PAPER #2)

The intent of this paper is to lay the ground work for common terminology when referring to shotcrete and serve as the shotcrete-specific terminology equivalent of ACI’s extensive Concrete Terminology document. The terminology was compiled from ACI CP-60, “Craftsman Workbook for ACI Certification of Shotcrete Nozzlemen”; ACI 506R, “Guide to Shotcrete”; and “ACI Concrete Terminology.” Most terms are applicable to all shotcrete. However, some are more applicable to the pool industry. For example, differentiating between “waterproof” and “watertight”:

**Waterproof:** Completely impervious to water in either liquid or vapor state. (Because nothing can be completely “impervious” to water under infinite pressure over infinite time, this term should not be used.)

**Watertight:** Impermeable to water except when under hydrostatic pressure sufficient to produce structural failure.

## SUSTAINABILITY OF SHOTCRETE IN THE POOL INDUSTRY (POSITION PAPER #3)

Shotcrete inherently has many sustainability advantages. We use less formwork. Sometimes we do not use any formwork. When formwork is used, it is lighter and is made with less material and labor than with form-and-pour equivalents (Fig. 2). The position paper also discusses shotcrete’s inherent sustainable advantages in creating complex and efficient shapes, creating better bond, speeding construction, adaptability to varying shapes and thicknesses in repair, and facilitating access to restricted or hard to reach areas (Fig. 3).



Fig. 3: Overview of a pool with extensive curves typifying shotcrete’s flexibility

## WATERTIGHT SHOTCRETE FOR SWIMMING POOLS (POSITION PAPER #4)

Concrete is a relatively impermeable material. I have seen cast concrete walls 35 ft (11 m) with a full water head on the inside that are completely dry on the outside. To create



Fig. 4(a) and (b): Shotcrete on top of cast floor

these functionally watertight walls, one needs to properly detail the design (movement joints, reinforcing, etc.), use a high-quality concrete mixture, and fully consolidate ALL the concrete. This can be routinely accomplished by shotcrete placement, as we use high-strength concrete (4000 psi minimum), with a low  $w/cm$  (0.32 to 0.45) and provide complete consolidation by high-velocity impact. Further, the quality of placement is readily visible in all areas during placement. It is not hidden at the bottom of an enclosed two-sided form. This position paper explains in greater detail why shotcrete meets and exceeds requirements from ACI 350. Further, it proves that a quality shotcrete pool shell should be functionally watertight, and subsequently applied plaster or tile are not what makes the pool watertight.

## MONOLITHIC SHOTCRETE FOR SWIMMING POOLS (NO COLD JOINTS) (POSITION PAPER #5)

This position paper focuses on the ability of shotcrete to form monolithic concrete sections even when shot in layers. This is an industry-specific adaptation of the article “Shotcrete Placed in Multiple Layers does NOT Create Cold Joints” that can be found in our website magazine archive ([www.Shotcrete.org/ArchiveSearch](http://www.Shotcrete.org/ArchiveSearch)). There have been specifiers who insist the entire wall of a pool be shot at one time due to fear there would be a “cold joint.” But cold joints simply do not happen in shotcrete when the interfaces between layers are properly prepared, quality materials and equipment are used, and shotcrete is placed with experienced nozzle men (Fig. 4). The paper goes into more detail about construction joints, and an explanation of how shotcrete can facilitate creating sections that act monolithically at these joints. Also, we explain why bonding agents are never recommended with shotcrete applications.

## FORMING AND SUBSTRATES IN POOL SHOTCRETE (POSITION PAPER #6)

This position paper explains the wide variety of forming options available in shotcrete pools. There is discussion



Fig. 5: Lightweight curved form with steel reinforcing for radius steps

of the soil conditions in the subgrade and excavated sides of the pool, and how that may impact forming or wall thicknesses. The paper further details formwork considerations such as rigidity needed for shotcrete placement, different materials available, and the impact weather and delays may play (Fig. 5). Overall, the shotcrete contractor must verify that: the formed or natural surface being shotcreted upon is stable, rigid, and nonvibrating; the forms define and maintain the desired thickness and shape; and they fully support any attached reinforcement during shotcreting.

## IN CLOSING

When going to our Shotcrete Resources webpage, you will also see our “Board Position Paper on Shotcrete Contractor and Crew Qualifications.” This paper explains why a contractor offering to place quality shotcrete must have specific knowledge, equipment, training, and hands-on experience of the entire construction team—from company management through the field crew—to truly be considered a Shotcrete Contractor. The paper details typical shotcrete

crew duties and qualifications and concludes with a Shotcrete Contractor Qualification Evaluation Checklist that proves useful for owners or specifiers to qualify their shotcrete contractor on a specific project.

We expect these Pool Position Papers to be a continuing series that will bring expanded knowledge from successful and experienced members in the shotcrete pool industry to the public domain. Your comments are welcome. If you would like to share your experience with the ASA Pool and Recreation Committee in developing future papers, consider attending an upcoming meeting. All our ASA committee meetings are open to the public ([www.Shotcrete.org/Calendar](http://www.Shotcrete.org/Calendar)).



**Charles Hanskat** is the current ASA Executive Director. He received his BS and MS in civil engineering from the University of Florida, Gainesville, FL. Hanskat is a licensed professional engineer in several states. He has been involved in the design, construction, and evaluation of environmental concrete and shotcrete structures for over 35 years. Hanskat is also a member of ACI Committees 301, Specifications for Structural Concrete; 350, Environmental Engineering Concrete Structures; 371, Elevated Tanks with Concrete Pedestals; 372, Tanks Wrapped with Wire or Strand; 376, Concrete Structures for Refrigerated Liquefied Gas Containment; 506, Shotcreting; and Joint ACI-ASCE Committee 334, Concrete Shell Design and Construction. Hanskat's service to the American Society of Civil Engineers (ASCE), the National Society of Professional Engineers (NSPE), and the Florida Engineering Society (FES) in over 50 committee and officer positions at the national, state, and local levels was highlighted when he served as State President of FES and then as National Director of NSPE. He served as a District Director of Tau Beta Pi from 1977 to 2002. He is a Fellow of ACI, ASCE, and FES and a member of ACI, NSPE, ASTM International, AREMA, ICRI, and ASCC.