

Formwork in Swimming Pool Construction

by Ron Lacher

One of the great advantages of shotcrete over other forms of concrete placement is that, generally, only a one-sided form is necessary. One of the reasons that shotcrete has become almost universally adopted for construction of concrete swimming pools is that shotcrete can be applied directly against the pool excavation that has been shaped and trimmed to establish the size, contour, and outline of the completed pool. It could be said that a swimming pool shotcreted in this manner would be considered formless. In reality, isn't the earth surface against which the shotcrete is being applied still a form? Shouldn't all the recommended practices for applying shotcrete against forms still apply?

Guidance for applying shotcrete against earth is provided in ACI CCS-4, "Shotcrete for the Craftsman" in Chapter 5, Section 5.1—Earth Surfaces:

"Earth surfaces must be firm and trimmed to the desired lines of the finished shotcrete. A loose or soft subgrade will not provide proper support for the shotcrete. Subgrade lines that differ significantly from the desired finish lines of the shotcrete will require varying thickness of shotcrete; this, in turn, will increase the probability of cracking. It is not unusual for shotcrete to be applied to irregular surfaces, but it is preferable for shotcrete to be applied at a

relatively uniform thickness. Holes or pockets should be filled before application of shotcrete to reduce cracking.

The earth surface should be damp prior to the application of shotcrete so that the subgrade does not absorb water, which is necessary for hydration, from the shotcrete. Whereas proper predampening cannot eliminate all cracking problems in the shotcrete, inadequate predampening will certainly cause cracking. Do not shoot against a frozen subgrade."

There are many situations in swimming pool construction where actual forms are required. Probably the most common is where a spa is adjacent to or within the pool and separated by a shotcrete wall. The wall between the pool and the spa is usually referred to as the spa dam wall. Forms must be placed on one side of the spa dam wall in order for this wall to be shot. Vanishing edge pools are built with a weir wall that is somewhat similar to a spa dam wall except that the weir wall is usually substantially longer and taller. Because of that, proper forming and shooting of a vanishing edge weir wall is even more crucial than a spa dam wall.

Forming may be required for a tractor access ramp into the pool excavation. In some areas of the country, front-end loaders are used for pool excavation and ramps into the pool must be dug for tractor access. After completion of excavation, these ramps must be formed for shotcrete application (Fig. 1).

Another example of formed swimming pool walls can be found in Florida and several areas of the northeastern U.S., where due to high groundwater tables, pools are typically over-excavated because of the likelihood of sloughing of the side walls. In these areas, the entire outer perimeter of the swimming pool is usually formed using a material called steel-tex, a paperbacked wire mesh (Fig. 2).

Forming may also be necessary for shotcrete application when design elements or terrain issues require that pool walls be constructed partially or fully out of grade. It's important to note that walls out of grade may need to be designed and built differently than pool walls within grade and supported by earth. We call these out of grade

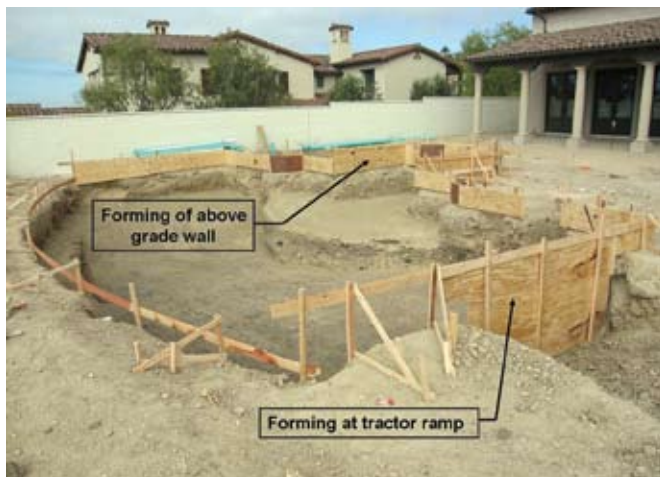


Fig. 1: Shotcrete is typically applied directly against the pool excavation that has been shaped and trimmed to establish the size, contour, and outline of the completed pool. Tractor ramps and walls above grade require forms to shoot against

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walls freestanding walls, which means that they must be designed to withstand the force of outward water pressure.

The weir wall of a vanishing edge pool is an example of an out of grade wall that must be built as freestanding. The weir wall is not backed by earth due to its location between the main pool and the smaller catch pool and is subject to outward water pressure. Therefore, a freestanding design is required. In the Summer 2007 issue of *Shotcrete*, I wrote about the difficult and expensive repair brought about by the lack of secure forming and reinforcement in a vanishing edge weir wall.

The most difficult and complex forming is required when a swimming pool is built completely out of grade, for example, in a steep hillside area (Fig. 3). When a pool is completely out of grade, in addition to all the important forming issues for pool walls, false work that is capable of supporting the empty weight of the pool must be constructed under the pool until the foundation elements and supporting structure are in place and gain sufficient strength to support the pool.

In addition to wood, we commonly see several different materials used as the form including drywall, peg board, and wire mesh or expanded metal lath (Fig. 4). Whatever the material, it must be capable of sufficient rigidity to prevent vibration during shotcrete application. Over the years, there have been many problems with formed walls in swimming pool construction, especially spa dams and vanishing edge dam walls, mainly because of poor practices in the forming, reinforcement installation, and shooting of these walls.

Before we talk about the various problems and poor practices that are frequently observed in swimming pool construction when shooting against forms, especially the spa and vanishing edge dam walls, let's review how it's supposed to be done. In ACI CCS-4, "Shotcrete for the Craftsman," Chapter 5, Section 5.2—Forms, it states:

"Forms must be rigid enough to prevent vibration during shotcrete application. The rigidity and the type of material used in forming for shotcrete should match the desired appearance of the stripped surface. The shotcrete process does not require that the forms resist concrete's hydrostatic pressure. The form, however, needs to resist the shotcrete's impact force. In some situations, forms must be strong enough to carry the shotcrete's weight. Forms must be built to permit the escape of air and rebound. Columns should be formed only on two sides. Shooting shotcrete into narrow holes or deep slots is not recommended."



Fig. 2: In Florida and several areas of the northeastern U.S., the perimeter of swimming pools is often over-excavated then usually formed using steel-tex, a paperback wire mesh



Fig. 3: The most difficult and complex forming is required when a swimming pool is built either partially or completely out of grade



Fig. 4: Another questionable practice: an expanded metal lath is tied directly to the reinforcement and left in place between the inner and outer layer of shotcrete

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The key point is that the form must be rigid enough to prevent vibration and resist the shotcrete's impact force. Let's talk about some of the common but improper practices in forming and shooting walls in swimming pool construction. One of the common practices is the use of drywall as the form material placed directly against the reinforcement without spacers or dobies to establish the correct cover over the reinforcement. How is the drywall form held firmly to prevent movement or vibration? Often a crew member standing in the spa simply holds the drywall in place against the reinforcement as the wall is shot from the outside (Fig. 5). Or, the drywall may be placed on the outside of the reinforcement and be held in place with a single strand of tie wire as the spa wall is shot from the inside (Fig. 6).

Would either of these common practices be considered as holding the forms firmly in place? In my opinion, the answer is no! What is the end result? Lack of a proper bond between the shotcrete and

the reinforcement, poor reinforcing bar encapsulation, and loss of integrity in the shotcrete itself.

In swimming pool construction, the undesirable practice of tying the reinforcement directly to the forms without spacers or dobies is very prevalent; therefore, let's review proper reinforcement practice. In ACI CCS-4, "Shotcrete for the Craftsman," Chapter 3, Section 3.3.1—Reinforcing steel, it states:

"...At all times, reinforcement should be secure and not vibrate during shooting. Vibration of reinforcing steel will create cavities around the steel. Reinforcing steel should be clean and free of set overspray and rebound. Reinforcing steel must be placed so there is adequate coverage and clearance, as required by the contract drawings."

An example of properly constructed formwork and fixed reinforcing can be seen in Fig. 7.

Clearly, the practice of tying the reinforcement directly to the forms without spacers or dobies is in violation of every sound practice in shotcrete placement as well as concrete placement.

What happens when this so-called formwork that was tied directly to the reinforcement is removed? The end result will usually have exposed reinforcement and trapped rebound and overspray (Fig. 8). To make matters worse, this surface now becomes the receiving surface for the application of shotcrete on the alternate side (Fig. 9). But, what happens to the integrity of the freshly shot inner wall when additional material is shot on the alternate side with the momentum from shotcrete hitting the receiving surface at 200 to 300 miles/hour (320 to 480 km/hour)? What about the necessary preparation work to remove any overspray or rebound that was trapped in the first application? Or, the exposing of 1 in. (25 mm) clear around all of the exposed reinforcing bar and piping to assure proper reinforcing bar encapsulation and to make sure no voids are left in the wall? My experience in swimming pool construction is that these unsuitable surfaces are often shot over without the appropriate surface preparation.

Another unacceptable practice is when spa dam walls are taken apart for repair and material used as the form has been left between the inner and outer layer of shotcrete (Fig. 10). Because of the previously discussed practices, it is no wonder that formed and shot walls in swimming pool construction have been the source of so many problems and subsequent repairs.

Shotcrete crews are not using these practices with the knowledge that problems will result



Fig. 5: Unacceptable practice: drywall form held directly against reinforcement by crew member without dobies or spacers to establish the cover over the reinforcement



Fig. 6: Drywall form often placed on the outside of the reinforcement and the wall shot from the inside. Only tie wire on the outer face is holding the drywall in place

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Fig. 7: Example of secure dam wall forming braced to resist vibration and the impact force of the shotcrete. Reinforcement tied to forms with dobies to resist vibration and provide proper coverage



Fig. 9: After the forms are stripped, this becomes the receiving surface for shotcrete on the alternate side. Results in questionable bond and reinforcing bar encapsulation



Fig. 8: Delamination occurred when forms were stripped. The surface against the form contained sand lenses and trapped overspray and rebound



Fig. 10: It's not uncommon to find drywall left between the inner and outer layer of shotcrete when spa walls are taken apart for repair

down the road. It's more likely that these practices occur from a lack of knowledge about proper practices. How can these poor practices that are so widely observed in the swimming pool industry be eliminated? The answer is education, training, and certification. In the meantime, the basic rules for forming in swimming pool construction are simple:

1. Forms must be rigid enough to prevent vibration during shotcrete application and resist the shotcrete's impact force;
2. Reinforcement must be secure and not vibrate during shooting; and
3. Reinforcement must be placed to provide the specified coverage and clearance.



Ron Lacher, PE, CBP, is a well-known speaker, educator, and author on proper trade practices and structural engineering in swimming pool construction. His firm, Pool Engineering, Inc., provided the structural designs for over 16,000 pools in 2006. With experience from prior ownership of a swimming pool construction company, he has completed over 300 forensic investigations on problem pools. He is a member of the Advisory Board of the National Pool Industry Research Center at California State Polytechnic University, San Luis Obispo, CA, and is also a member of the American Shotcrete Association (ASA), a member of the ASA Pool & Spa Committee, and an ASA Educator. Lacher graduated from California State Polytechnic University with a degree in civil engineering and is a licensed Professional Engineer in the state of California.

Tom Norman, ASA member and Chair of ASA's Pool and Spa Committee, wants your input. Your comments, suggestions, and the topics you'd like to see covered are welcome. Perhaps you'd like to become a contributing author to Pool & Spa Corner: Norman and the ASA staff encourage you to contact ASA with your questions and comments at: info@shotcrete.org.