

Technical Tips on Shotcrete Finishing

by Denis Beaupré

In this section of the fall issue of ASA's *Shotcrete*, I introduced some aspects of pool finishing. I receive many calls, questions, and comments from people about the new finishing tools. Since this issue is on architectural shotcrete and finishing, I thought it would be interesting to further develop the topic of finishing techniques for shotcrete.

Introduction

Finishing operations are very often an inherent part of shotcrete operations. For many applications, it is necessary to finish the shotcrete, sometimes to the point where the surface needs to be as smooth as cast-in-place concrete. Usually, finishing shotcrete involves more operations than just smoothing the surface (which is also called troweling). This article reviews the different types of shotcrete finishes and explains how they can be achieved.

Types of finish

Different types of shotcrete finishes can be obtained, each of them requiring a certain amount of skill and work. Shotcrete can be left "as shot" (also called natural or gun finish), scratched, troweled or smoothed, carved, exposed, and painted. In all cases, the shotcrete should be cured. Figure 1 shows a typical shotcrete finish obtained with a shotcrete finishing machine.



Figure 1: Typical mechanical shotcrete finish.

Each type of finish, except a "gun finish," requires one or more steps, which are described in the following sections. These steps may include: trimming, cutting, filling-in, scratching, application of a flash coat, troweling, carving, smoothing, curing, and painting. These operations can be done on a free surface that does not require a specific position, or they may have to be done on a surface that is required to be brought to line and grade; that is, to a specific finished position. For example, a cavern in a zoo exhibit is usually a free surface that does not need to be at a precisely determined position, while the surface of a bridge beam (in a repair-type application) must usually be at the same position as the original beam surface.

Obtaining the right line and grade

The use of guides is usually required to bring a surface to the required line and grade. Several types of guides, including wire guides, depth gages, formwork, or temporary forms can be used for this purpose. Figure 2 shows a wire guide line being exposed with the cutting operation.

Very often, shotcrete surfaces are vertical. In this case, the position of the surface and its verticality are often obtained by the combined use of a guide wire (or other positioning device) and the use of a level. This use of a level is referred to as leveling, even though the surface is leveled vertically, not horizontally.

Overhead surfaces are more difficult to finish because it is easier to destabilize the freshly applied shotcrete in that position. The timing and the consistency of shotcrete while performing the cutting operations are very important in this case.



Figure 2: Exposing the wire guide.



Figure 3: Use of a guide line to make the corner shown in Figure 1.

In general, it is recommended to wait between the shooting and finishing operations until the shotcrete has stiffened sufficiently.

Corners are also tricky to get straight. Shooting wires or formwork are very useful in this case (Figure 3). Many craftsmen also use large rulers that they fix at the corner edge after they have finished one face of the corner. They use the ruler as temporary formwork to cut and finish the other face. Usually, they only need to use the ruler on one side of the corner.

Description of finishing operations

This section describes different finishing operations including: leveling, cutting, filling-in, scratching, troweling, flash coat application, and smoothing.

Leveling is an operation done with a hand-held level to bring a vertical surface or corner to the correct grade (Figure 4). The craftsman starts at the top of the wall and slides the level down to make a groove at a proper depth in the fresh shotcrete. He uses some guide at the top and then uses the level to cut a vertical groove as he goes down the wall. Grooves are made approximately 0.5 to 0.8 m (2 to 3 ft) apart or as required by the geometry of the section being shot. A long level, 1.2 m (4 ft), works better than a short one.

When the position of the surface has been determined (with the grooves), the craftsman cuts and scratches the surface until the correct grade is reached. These operations are quite similar: they use the same tools, but in different ways. Cutting (Figure 2) is the operation performed when the craftsman puts his trowel flat on the surface and uses the trowel edge (or the edge of a cutting rod) to cut the fresh shotcrete, usually



Figure 4: Vertical leveling operation and the groove (bottom).

from top to bottom. This operation is usually done so that the craftsman leaves approximately 5 mm (1/4 in.) of shotcrete above the required grade. In cutting vertical surfaces, grooves done during leveling are very useful. The scratching is done with the same tool but with the trowel or cutting rod edge held at a right angle to the surface being scratched (Figure 5).

It often happens during cutting operations that low-profile areas (parts of the surface without



Figure 5: Scratching with the edge of the trowel perpendicular to the surface.

enough shotcrete) are filled with hand-placed material. This operation can be referred to as filling-in. Although this does not produce the best-quality work, it is usually acceptable for small areas, provided the material used for this purpose is taken from the cut material and is free of rebound. Never use rebound to fill holes or any part of the work!

After cutting, the surface is usually scratched. This operation is done with the edge of the trowel (Figure 5), or a cutting rod, held perpendicular to the surface being finished. The edge is used to obtain a flat surface. After scratching, the surface should be at the correct line and grade. The surface can often be left scratched, as is the case for many pools, where the final finish is later completed with hand-applied plaster. In many cases, the scratched surface will be immediately smoothed (by troweling).

It is also possible to use a mechanical device that will cut and scratch the shotcrete in one operation. Figure 6 shows a mechanical scratching device being used. Note the grooves made during leveling in the non-scratched section. The surface on the right (cut and scratched) is ready for troweling or smoothing.

After scratching is completed, the finisher uses the flat edge of a trowel (wood, rubber, steel, sponge, or other material) to obtain a smooth surface. Using a circular motion and a slight angle, he will first try to push the coarse aggregate into the shotcrete. He will then continue troweling until the surface is free of voids and is smooth. It is difficult at this point to remove any waves on the surface: the straight surface is obtained during scratching, not during smoothing. To remove the

waves, the finisher will have to scratch the surface again where needed. Troweling can be performed by hand or by using a mechanical device called a shotcrete finishing machine. The texture of the shotcrete will be affected by the trowel type. A wood trowel will leave a rougher surface than a steel trowel.

Troweling may have important implications with respect to cracking. This has been especially observed to full effect in a training project in the United Arab Emirates where very severe drying conditions were present. It was observed that when final troweling was performed on a very soft (wet) surface, lots of cracks developed. If troweling was done after a waiting period long enough to allow cracks to develop on the scratched surface, however, the final cracking was much less pronounced. Even if no crack density measurement was performed, it was obvious that this latter procedure was very effective in reducing cracking. Of course, manual troweling was more difficult because of the stiffer surface at the time of troweling, but mechanical trowels were used for easy smoothing. In this case, the waiting period has allowed some cracks to appear on the scratched surface (Figure 7), and the delayed smoothing allowed filling of these cracks with “grout,” resulting in much less cracking being evident after drying. Under severe drying conditions, early troweling or smoothing of wet surfaces usually results in more cracking.

If for some reason it is difficult to smooth the surface (dry-process shotcrete shot too dry or with too long a waiting period between scratching and smoothing), it is possible to apply a flash coat. A flash coat is a new shotcrete application usually done after scratching to ease troweling (flash coat finishes can also be performed to get a smoother



Figure 6: Use of mechanical screeder to do the cutting and the screeding.

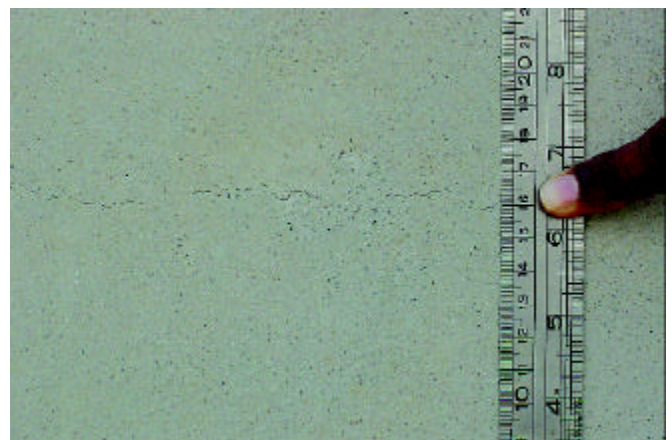


Figure 7: Example of crack that can be filled and “heal” from a delayed smoothing with a mechanical finishing machine.

Technical Tip



Figure 8: Carving of shotcrete requires artistic skills.

gun finish). In all cases, the goal of using a flash coat is to apply a thin layer of mortar. To do that, the nozzleman sprays the material from a greater distance while moving the nozzle quickly over the surface. Since the receiving surface is stiff (too stiff to be easily finished), the rebound rate will be very high, and this will leave a thin layer of fine mortar on the surface. In the case of dry shotcrete, the nozzleman usually adds a bit more water than usual; the receiving surface absorbs some water and the flash coat will be easier to finish.

Carving (Figure 8) is usually performed on a free surface to make a sculpture, or to imitate different textures. Among the most popular kinds of carving, artificial rock landscaping for zoo exhibits is certainly the most common. This operation is often made by craftsman who view themselves as artists instead of construction workers.

Curing is not part of finishing operations but must be performed soon after the completion of the finishing operation. Although curing is important for the development of the mechanical properties of the shotcrete, the main reason to perform curing is to prevent cracking and enhance durability. With respect to cracking reduction, the timing of the start of curing is more important



Figure 9: Exposed aggregate shotcrete wall repair in Quebec City.

than the length of the curing period, although a longer curing period is always better.

After finishing operations, the material is usually fresh and quite weak, so it is not difficult for cracks to develop. Later, however, after a few days, as the tensile strength of shotcrete increases, it is more difficult to create new cracks. The material's usual response is a widening of existing cracks instead of the creation of new ones. To help prevent crack initiation, look for as short a delay as possible between finishing and curing.

It is also possible to obtain exposed aggregate-type finishes with shotcrete. One way of doing this is through the use of a set-retarding admixture applied on the finished shotcrete surface. This way of using wet-process shotcrete to produce an exposed aggregate finish was presented in the February 2000 issue of *Shotcrete*. Figure 9 shows a picture of a shotcrete wall with an exposed aggregate finish.



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