

Curing Pneumatically Applied Concrete

by Ray Schallom III

E-mails are often sent to the ASA website from engineers, contractors, builders/owners, and home owners asking for information on proper methods for curing shotcreted structures. The information in this technical tip provides two considerations to help you choose the appropriate curing method for your next project: water curing and curing compounds.

The shotcrete process, as defined by ACI, is: "A method used to pneumatically project concrete or mortar at a high velocity onto a receiving surface."

Concrete, whether it is pumped, placed, or pneumatically applied by the wet- or dry-mix shotcrete process, requires the same amount of curing time as conventional concrete. Most commercial, industrial, DOT/ministry, and government-funded jobs and utility work will have a job specification outlining the curing requirements for the shotcrete contractor to follow. Residential work or jobs that do not have a curing specification should follow ACI documents ACI 506R-05, "Guide to Shotcrete," ACI 506.2-95, "Specification for Shotcrete" (currently being updated and expanded), ACI 308R, "Guide to Curing Concrete," and ACI 308.1, "Standard Specification for Curing Concrete."

The curing process is designed to prevent the concrete from losing moisture too quickly, thus minimizing shrinkage and cracking. Also, for concrete to achieve its design strength and durability, it must have enough water for the cementitious material to hydrate. These statements are highly stressed to the shotcrete nozzlemen who participate in the ACI Nozzleman Certification Program.

Listed as follows is a general description of curing requirements that may typically be found in job specifications. Depending on the geographical location, some curing specifications may be tailored to accommodate specific or difficult shotcrete projects.

- On completion of the concrete finishing, prevent the shotcrete surface from drying out by moist-curing using fogging, wetting, or maintain a minimum of 95% relative humidity in the area surrounding the shotcrete. (Note:

ACI 506R-05, "Guide to Shotcrete" has lowered the humidity requirement to 85%.)

- Keep the shotcrete continuously wet for a minimum of 7 days. Wet-curing shall be accomplished using one or more of the following procedures:
 - a. Wrap the elements in wet burlap covered with a plastic sheet or a presaturated non-woven synthetic fabric;
 - b. Install sprinklers, soaker hoses, or other devices that will keep the shotcrete continuously wet. Avoid the use of intermittent wetting procedures that will allow the shotcrete to undergo cycles of wetting and drying during the curing process;
 - c. Sheet materials used in conjunction with water curing must comply with (ASTM C 171); and
 - d. If allowed as an alternative to water and burlap curing, apply a liquid membrane-forming curing compound. This compound must be in compliance with ASTM C 309, Types 1 and 1D, Class A & B; ASTM 1315; and AASHTO M-148, Type 1, Class A & B. Compounds being considered shall be low odor, water-based, and solvent free. All compounds must be tested and accepted by the owner prior to usage.

Curing shotcrete surfaces with water is by far the best method for maintaining adequate moisture and controlling shrinkage cracks during the hydration process. Curing vertical and horizontal surfaces with water can be easily accomplished. Water curing overhead surfaces, however, can become a challenge. This author has, however, successfully accomplished overhead water curing off swing stages at the Jefferson Street Bridge (Summer 2003 issue) and hung thousands of feet of sprinkler hose at the George Massey Tunnel, BC, Canada (West Ventilation Tunnel) for overhead water curing. One has to take a look at the impact water curing may create for the job and other subcontractors on the project. Alternative curing methods may have to be considered and should be tested during the preconstruction phase of the contract. If for some reason the primary curing method (water) begins to create excessive

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delays or job site safety issues, alternative methods that can be used without any production delays should be investigated.

The following lists topics for consideration to help when choosing the most appropriate curing method for your next shotcrete project. (Note: your geographical location may require other considerations not mentioned below, for example, in cold temperature conditions, the provision of both warmth and moisture may be needed).

Water Curing and the Use of Burlap

Issues to consider:

A. Environmental

1. Cost for treating the runoff water.
2. How will the water be removed?
3. What permits and government agencies will be regulating the wastewater disposal?
4. Backup pump systems and containment basins.

B. Job schedule slowdowns

1. Subcontractors.
2. Other contract phase work.
3. How many man-hours can be saved and how much time on the contract schedule can be saved by using an alternative curing method?
4. What impact will the shotcrete crew experience with wet curing or what problems will be created if water is sprayed onto the shotcrete surface too soon?

C. Economical

1. Extra manpower to watch over the wet-curing process and disposal of curing water.
2. Water curing versus the alternative.
3. Water supply.
4. Cost of water hoses, sprinklers, and sprinkler hoses.
5. Hose repair costs.
6. Locating supply sources that stock needed items in the off season.

D. Rebound removal

1. Methods, equipment, and alternative dump sites for curing water, saturated wet rebound, sand, and cement slurry.
2. Extra equipment maintenance.
3. Backup cleanup equipment.

E. Crew, pedestrian, and subcontractor personnel safety

1. Tripping and sliding hazards.
2. Wind conditions.
3. Electrical hazards (lighting systems).
4. If the temperature drops, what structural and safety issues will be created?
5. Job site security issues.



Cracking as a result of shotcrete not properly cured

6. Securing the burlap to the surface in windy conditions.

F. Pedestrian and vehicle traffic

1. What problems can be expected if the water pumps fail?
2. Costs for extra road closures due to high water levels.
3. Extra clean-up costs.
4. Vehicle cleaning—concrete slurry.

Liquid Curing Compounds

A. Material supplier

1. Find a distributor that carries low odor, solvent-free, water-based curing compounds.
2. Check the manufacturer's MSDS sheets.
3. Call the manufacturer directly for additional information and a list of past projects that have used the curing compound in similar applications.
4. Have samples of the products shipped for testing purposes.

B. Environmental

1. What protection will be needed if used?
2. Spray equipment cleanup.
3. Wind conditions.

C. Economical

1. What will be the impact on cost and production compared to water curing?
2. What other job testing will be required if the alternative curing method is used?
3. What additional liability will be added for using the alternative?
4. What additional surface preparation will be required before applying the next layer of shotcrete?
5. Will protection need to be installed during spraying of curing compound?

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- D. Choosing the right spraying system
 - 1. Handheld versus engine-powered drum sprayers.
 - E. Produce test panels
 - 1. Check how long the surface stays opaque until the curing compound surface turns clear.
 - 2. Apply the compound on the freshly placed surface to see if any reactions take place.
 - 3. Apply the compound at twice the manufacturer's recommended application rate (ACI 506R-05 recommendation).
 - F. Choose the right equipment for removing the curing compound when required
 - 1. Abrasive blasting versus high-pressure water blasting (5000 psi) (34.47 MPa).
 - G. Clean off the dried curing compound before applying more shotcrete
 - 1. The membrane film may interfere with the bonding of future layers of shotcrete.
 - H. Apply curing compound to second shotcrete layer
 - I. Test the panel
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- 1. Test the shotcrete for compressive strength.
- 2. Compare compressive strengths between water cured shotcrete and shotcrete cured with curing compound.
- 3. Test the bond strength between shotcrete layers. (Note: have an experienced testing lab perform these tests).

The above-mentioned steps are for both the water/burlap and liquid-curing compound alternatives that are usually specified. Some shotcrete projects may not have specifications or preconstruction testing. In this case, the owner or engineer should require documentation from the contractor regarding the curing method they are planning on using. In addition, the contractor should also furnish a list of completed projects, along with reference phone numbers that can be used to verify the performance of the curing system being considered. A little research by the owner or engineer prior to the start up of the project will help provide a level of comfort as to how the proposed curing system will perform.

Remember concrete has to be cured for 7 continuous days to prevent moisture loss and minimize the potential for development of shrinkage cracks. Proper curing methods cannot be over-emphasized in producing a good quality in-place shotcrete.



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He is a Past President of ASA, and currently serves as Vice Chair of the ASA Underground Committee as well as being an active member of the Publications, Education, and Pool & Spa committees. He is also a member of ACI Committees 506, Shotcreting, and C 660, Shotcrete Nozzleman Certification. With over 28 years of shotcrete nozzling experience in wet- and dry-mix handheld and robotic applications, Schallom is an ACI Certified Nozzleman in the wet- and dry-mix processes, as well as an ASA-approved shotcrete trainer and an ACI-approved shotcrete examiner. He is also a member of ASTM Committee C09, Concrete and Concrete Aggregates, as well as Subcommittee C09.46, Shotcrete.