Update on Standards for Shotcrete

by Peter C. Tatnall

There have been a number of articles on shotcrete specifications or guidelines since *Shotcrete*'s debut issue in 1999.[1-5] Because this issue's theme is Specifications, I thought it timely to offer an article updating the state of current standards in North America and the ongoing work on shotcrete standards.

As you may know, there are three major groups concerned with shotcrete issues in the U.S.: ACI International, with Committee 506, Shotcreting, and Committee C 660, Shotcrete Nozzleman Certification; ASTM International, with Subcommittee C 09.46, Shotcrete; and, of course, ASA. The first two publish specifications, guidelines, or standards; and, by agreement, ACI International deals with "how to" and design issues, while ASTM International deals with materials specifications, practices, and test methods. Two of the three committees mentioned previously are presently chaired by ASA members—we are working on the third person!—and are required to have a balance of interests of voting members, users, general interest, and suppliers. Documents published by these committees must be approved by oversight committees and sometimes by the entire memberships; thus, they are considered consensus documents in that anyone with an interest may provide input.

ACI International

ACI Committee 506 was organized in 1942 and now consists of approximately 62 members covering diversified interests in shotcrete. Current Chair John H. Pye of the U.S. Nuclear Waste Technical Review Board has divided the committee into subcommittees. This committee has published and is working on the following:

- ACI 506.2-95, "Specification for Shotcrete." Under subcommittee revision.
- ACI 506R-90 (Reapproved 1995), "Guide to Shotcrete." A recent revision has been approved subject to dealing with comments.
- ACI 506.1R-98, "Committee Report on Fiber Reinforced Shotcrete." Under subcommittee revision.
- ACI 506.4R-94, "Guide for the Evaluation of Shotcrete." Balloting for reapproval; under subcommittee revision.
- ACI 506.3R-91, "Guide to Certification of Shotcrete Nozzlemen." Balloting for withdrawal (see ACI C 660).
- A Guide for Shotcrete for Underground Support.
- A Guide to Qualification of Shotcrete Nozzlemen for Specific Projects.
- A Guide on Swimming Pool Construction Practice.

ACI Committee C 660 was established in 1997 and consists of approximately 23 members with diversified interests, chaired by ASA member J.-F. Dufour. Its mission is: "To develop, maintain, and update programs for use in certification of persons performing as shotcrete nozzlemen." This committee has published specific guidelines and requirements for nozzlemen to become ACI certified, and for sponsoring groups to administer the testing required to become ACI certified. ASA acts as a sponsoring group to facilitate ACI certification of nozzlemen throughout North America. ASA also has developed and conducts shotcrete nozzleman training schools for those taking the certification exam as well as for designers, contractors, inspectors, and others seeking more knowledge of shotcrete construction. Specifiers can (and should) require that only ACI-certified shotcrete nozzlemen be allowed to apply shotcrete on a project.

The only ACI document regarding certification that can be incorporated by reference into a project specification is ACI 506.2. If language from any of the other documents is appropriate in the specification, the applicable language should be copied into it.

ASTM International

ASTM International Committee C 09, Concrete and Concrete Aggregates, established Subcommittee C 09.46, Shotcrete, in 1990. I. Leon Glassgold was the founding chair. Glassgold ran the subcommittee for the maximum 10 years, and he established the direction and mission of the subcommittee to complement the efforts of ACI 506. Since 2000, the author has chaired the subcommittee. Presently, the subcommittee has 34 members with a balance of interests from the U.S., Canada, and Mexico. Similarly to the ACI committees, ASTM subcommittees typically meet twice a year to develop new standards, maintain older documents, and resolve comments received on letter ballots. In the ASTM system, every comment received on a ballot item must be addressed and resolved in writing at the subcommittee level, even if the comment is from a non-member of ASTM.

Subcommittee C 09.46 maintains the following standards:

- C 1140-03a, "Practice for Preparing and Testing Specimens from Shotcrete Test Panels."
- C 1141-01, "Specification for Admixtures for Shotcrete."
- C 1385-98, "Practice for Sampling Materials for Shotcrete." Will ballot for reapproval Fall 2003.
- C 1398-98$^{\varepsilon 1}$, "Test Method for the Laboratory Determination of the Time of Setting of Hydraulic-Cement Mortars Containing Additives for Shotcrete." Gathering data for a Precision and Bias statement required to update the standard.
- C 1436-99, "Specification for Materials for Shotcrete." Will ballot for reapproval in Fall 2003.
- C 1480-00, "Specification for Packaged, Pre-blended, Dry, Combined Materials for Use in Wet or Dry Shotcrete

Applications." This standard was developed in cooperation with Subcommittee C 09.43, Prepackaged Materials.

After establishing the C 1398 test method for determining time of setting of the mortar fraction of shotcrete mixtures, C 1102 and C 1117, which considered the paste only, were withdrawn (which means they will no longer be published). The C 1398 test is a laboratory test and should not be used in project specifications as an acceptance test method on project sites.

In addition to the previous standards, the subcommittee will ballot this fall on a new document, "Test Method for Obtaining and Testing Drilled Cores of Shotcrete." Because many shotcrete applications involve thin sections, the established test methods (ASTM C 42) do not adequately address the smaller cores required. Additionally, because determining compressive strength of shotcrete should always involve specimens cored or sawn from shotcrete panels or in-place sections, the application of correction factors to correlate the results to cast cylinder test results is not appropriate.

The Shotcrete subcommittee also works closely with Subcommittee C 09.42, Fiber-Reinforced Concrete, where some standards under their control apply to fiber-reinforced shotcrete as well. Examples are:

- C 1018-97, "Test Method for Flexural Toughness and First-Crack Strength of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading)."
- C 1116-02, "Specification for Fiber-Reinforced Concrete and Shotcrete."
- C 1399-01, "Test Method for Obtaining Average Residual Strength of Fiber-Reinforced Concrete."
- C 1550-03, "Test Method for Flexural Toughness of Fiber-Reinforced Concrete (Using Centrally Loaded Round Panel)."

The C 1018 test method has been used for many years for specifying the performance required for fiber-reinforced shotcrete projects, particularly ground support applications. This test method has been revised extensively and the proposed revisions will be out for ballot this fall. The new round panel test method (C 1550-03) has been used for many years in Australia to specify and control fiber-reinforced shotcrete, and is being introduced in North America. Subcommittee C 09.42, in cooperation with the Shotcrete subcommittee, is developing a practice for preparing and curing round panels for use in the C 1550 test method.

Rusty Morgan[4] provides a thorough overview of the use of some of these standards in project specifications, as well as a bibliography and comments on some of the efforts on standards around the world. These include efforts by the European Federation of Producers and Applicators of Specialist Products for Structures (EFNARC), the Austrian Concrete Society, and the Concrete Institute of Australia. Many of the European efforts are being consolidated by the European Committee for Standardization (CEN) to eventually become European Community standards.

As shotcrete technology advances rapidly, the standards-writing community is making every effort to keep up. These joint efforts will help keep owners, designers, and builders at the forefront of the technological advances being made in this exciting, dynamic industry. Specification writers must ensure they are working with the latest revisions of the standards used.

Documents and articles previously cited can be obtained from the various organizations as shown in the References section. They can also be secured online as follows:

ACI documents: www.concrete.org
ASTM documents: www.astm.org
ASA articles: www.shotcrete.org

References

ACI International
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ASTM standards cited can be found in the *Annual Book of ASTM Standards*, V. 04.02

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1. Bernard, S., "Release of New ASTM Round Panel Test," *Shotcrete*, V. 5, No. 2, Spring 2003, pp. 20-23.
2. Chan C.; Heere R.; and Morgan, D. R., "Shotcrete for Ground Support: Current Practices in Western Canada," *Shotcrete*, V. 4, No. 1, Winter 2002, pp. 14-19.
3. Glassgold, I. L., "Shotcrete Specification And Testing," *Shotcrete*, V. 3, No. 3, Summer 2001, pp. 6-7.
4. Morgan, D. R., "Shotcrete Guides and Specifications," *Shotcrete*, V. 2, No. 4, Fall 2000, pp. 8-12.
5. Papworth, F., "Design Guidelines for the Use of Fiber-Reinforced Shotcrete in Ground Support," *Shotcrete*, V. 4, No. 2, Spring 2002, pp. 16-21.

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