
SHOTCRETE EDUCATION AND NOZZLEMEN CERTIFICATION IN NORTH AMERICA

AUSBILDUNG FÜR SPRITZBETONARBEITEN UND DÜSENFÜHRER ZERTIFIZIERUNG IN NORDAMERIKA

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This paper provides an overview of the *American Shotcrete Association* (ASA) shotcrete education programs in parallel with the *American Concrete Institute* (ACI) shotcrete nozzle-men certification program. The complete test procedure of the certification program is described in details, particularly with regards to the standardized test panel that contains reinforcing steel bars with diameters ranging from 15 mm to 25 mm. Recognizing the importance of training and education, the paper also describes the effort put forth by the ASA in their training material; some of the significant changes made to the most recent ACI educational documents recently published are also highlighted.

Dieser Beitrag gibt einen Überblick über das Ausbildungsprogramm für Spritzbetonarbeiten der Amerikanischen Spritzbeton Vereinigung (ASA) und das Zertifizierungsprogramm für Spritzbeton Düsenführer des Amerikanischen Betonvereins (ACI). Der gesamte Prüfungsablauf des Zertifizierungsprogramms wird im Detail beschrieben, speziell auch jener Teil, der die vorgeschriebene Prüfkiste mit Bewehrungsstäben mit Durchmessern von 15 bis 25 mm betrifft. In Anerkennung der Wichtigkeit dieser Ausbildung werden auch die Bemühungen der ASA zur Erstellung ihrer Lehrunterlagen vorgestellt. Außerdem wird auf die bedeutendsten Änderungen in den neuesten ACI Ausbildungsdokumenten eingegangen.

1. Introduction

The American Shotcrete Association (ASA) was founded in 1998 to promote shotcrete with the Vision Statement: “to have the shotcrete process understood and used in every beneficial application”, and the Mission Statement: “to encourage and promote the safe and beneficial use of the shotcrete process”. In the same period, the American Concrete Institute (ACI) was in the initial steps in developing a Shotcrete Nozzleman Certification Program through its certification committee C660.

At this time, the discussion over the importance of shotcrete nozzleman certification in the industry, and the vehicle by which a certification program could be delivered, was debated everywhere. After considerable efforts through 1999 and 2000 by both ASA and ACI members to fast track the launch of the nozzleman certification, the result was a fully tested and proven program that was offered for the first time in January 2001 [1, 2 and 3].

Since then, the ASA has recognized the need for a comprehensive education program for nozzlemen who plan on taking the ACI certification examination. Thus, an early priority of the ASA Education Committee was the development of a Shotcrete Nozzleman Education program. This program was based on development of PowerPoint CD Education modules for

use in classroom instruction, but also included hands-on training in the field in either the wet or dry-mix shotcrete process, or both. As a result, the ASA is the acting Local Sponsoring Group which administers the ACI Nozzleman Certification Program. The ASA also provides Shotcrete Education for nozzleman taking the ACI Certification Examination or for those simply interested in learning correct nozzleman techniques. To put it simply, ASA educates, and ACI certifies.

It should be noted that a 500 hours of practical experience of shotcrete-nozzle-handling is required to qualify for shotcrete nozzleman certification.

2. Education and Certification

The Education and Underground Committees of the American Shotcrete Association have developed a series of Shotcrete Education Modules segmented to best suit the area in which shotcrete education takes place. This ASA Education program consists of concrete/shotcrete related technical modules such as: introduction to shotcrete, history and uses of shotcrete, shotcrete materials and properties, shotcrete mix designs, quality control/quality assurance, shotcrete equipment, preparation for shotcreting, shotcrete nozzling and application techniques, shotcrete finishing and curing procedures, and safety. Modules for shotcrete for swimming pools and spas are also available.

2.1 The Educators & Examiners

Shotcrete education would not be possible without an adequate number of ASA approved Educators. Similarly, the certification program could not be administered without ACI approved Examiners. The detailed requirements to become an ASA Educator or an ACI Examiner (and maintain these statuses) can be found on the respective web sites of the associations (www.shotcrete.org; www.concrete.org); however, the main requirements are quite similar and can be summarized as follow.

To become an ASA Educator or an ACI Examiner, one must document and demonstrate that he or she:

- a. Is knowledgeable about shotcrete and thoroughly familiar with the current applicable reference documents.
- b. Has a total of at least 5 years documented experience in at least two of the following four categories: 1) Testing, inspection, and quality control of shotcrete, 2) Supervision of shotcrete construction work, 3) Design of shotcrete structures 4) Shotcrete-nozzle-operation.
- c. Has sufficient experience to evaluate and judge the qualifications of shotcrete nozzleman applicants and conduct written and performance examinations.
- d. Has, to the satisfaction of the examiners of record, participated in all phases of at least two (2) ACI (ASA) -sanctioned Nozzleman Certification programs for each process for which approval is sought, with different examiners of record for each session. For the first session, the applicant must serve as supplemental examiner. For the second session, the applicant shall serve as supplemental examiner and conduct all phases of the session including written examination, performance examination, and core grading, under direct supervision of the examiner of record.
- e. Has attained a passing grade on the written exam for each process sought.

- f. Has conducted or assisted in at least (3) ACI-sanctioned Nozzleman Certification programs in five (5) years, if not actively participating in committee C660 activities (to maintain status).

2.2 Education session

Unlike ACI certification, it should be noted that attending an ASA Education session does not require any pre-requisite, such as 500 hours of nozzling experience, for the education session to take place. Attending an ASA shotcrete nozzleman education session is a valuable tool for nozzlemen wishing to improve their knowledge and placement skills, and for others who want to learn more about the latest in shotcrete technology and equipment. This program is also a valuable tool for those interested in becoming involved in the shotcrete industry.

The goal of the ASA is to promote shotcrete throughout North America. Further developments are to have fixed certification session locations on a regular basis. ASA has sponsored or overviewed over 450 shotcrete educational sessions to this day. The next task for the ASA Education Committee will be to develop a Shotcrete Inspector’s Education Program for Inspectors involved in the shotcrete industry.

3. ACI Shotcrete Nozzleman Certification Program

In addition to the ASA shotcrete education program, the ACI Shotcrete Nozzleman Certification program provides stringent standards when it comes to shotcrete quality. In addition to good quality, well-proportioned shotcrete mixes and suitable well maintained equipment, qualified and certified shotcrete nozzlemen are a key element to the success of this process. The ACI, through its C660 Committee, is delivering a credible and thorough program with strict policies, guidelines and procedures that respond to the demands of the construction industry [3].

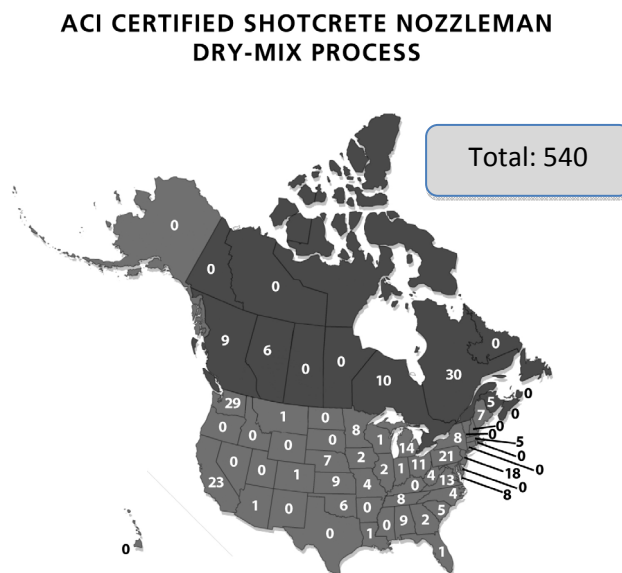


Figure 1: ACI Certified Dry-Mix Shotcrete Nozzlemen in North America (as of September 2011)

The program is continually improving over time, as active ACI shotcrete examiners are also members of the C660 Committee. Since nozzleman certification can be taken place in more

and finishing concrete. A series of detailed illustrations were added to this version of the CP-60 (09).

Examples are presented in the following figures of illustrations incorporated into the new CCS-4 (08) Workbook [4]:

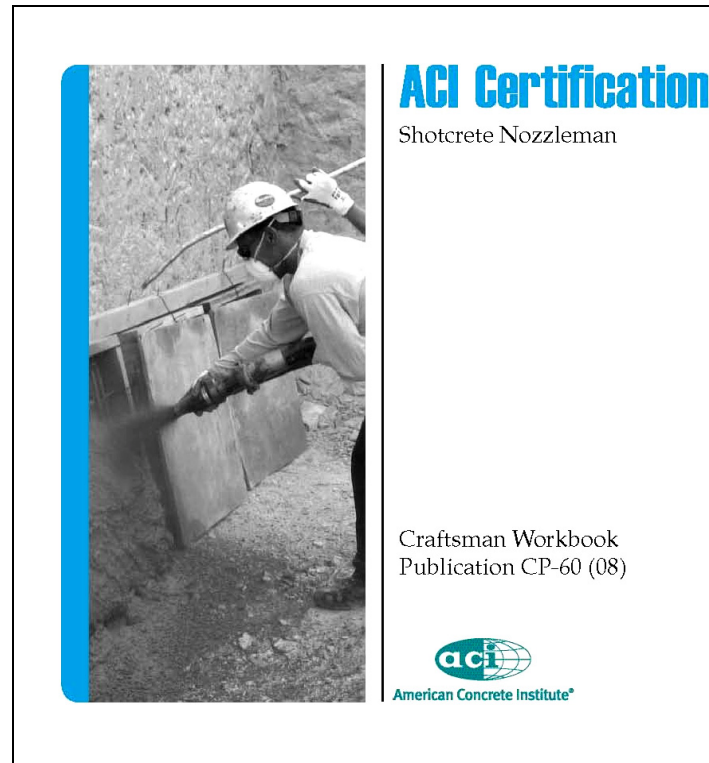


Figure 3: Cover page of the CP-60 (09) Craftsman Workbook for ACI Certification of Shotcrete Nozzleman

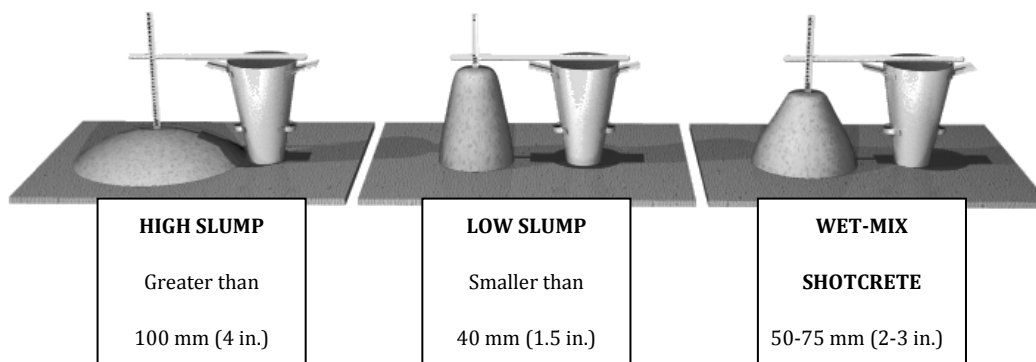


Figure 4: Measure of Workability of Wet-Mix Shotcrete.

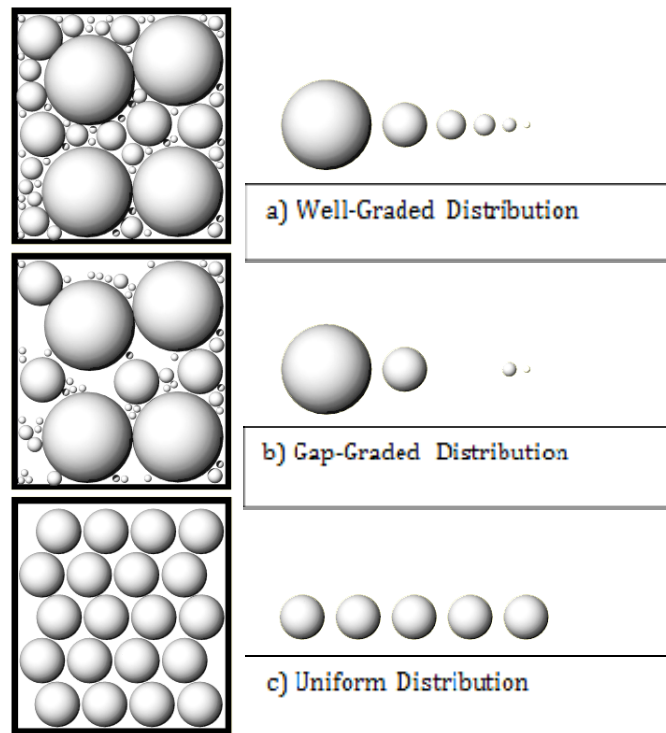


Figure 5: Illustration of different aggregate size distributions: a) well-graded distribution, b) gap-graded distribution, and c) uniform distribution

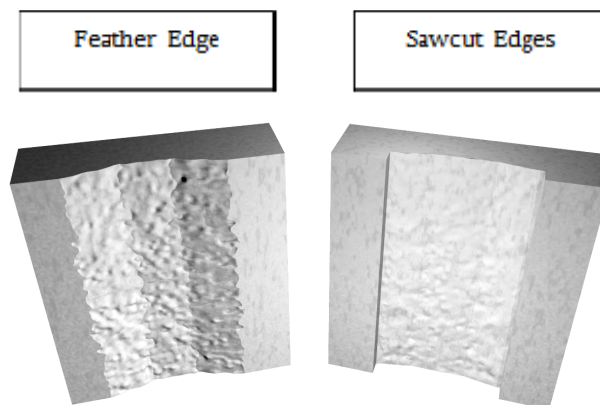


Figure 6: Concrete Surface Preparation - Feathered vs. Sawcut Edges

This recent workbook document, CP-60 (09) Craftsman Workbook for ACI Shotcrete Nozzleman Certification, is the official document that is handed to the nozzleman before an education/certification session. It is comprised of the following:

- Program Information,
- Education modules,
- Appendices.

The ACI Committee C660 has also recently reviewed the written examination questions based on the new literature. This international certification program and its supporting literature (Workbooks, written examination, etc.) are also available in three languages: English, Spanish and French.

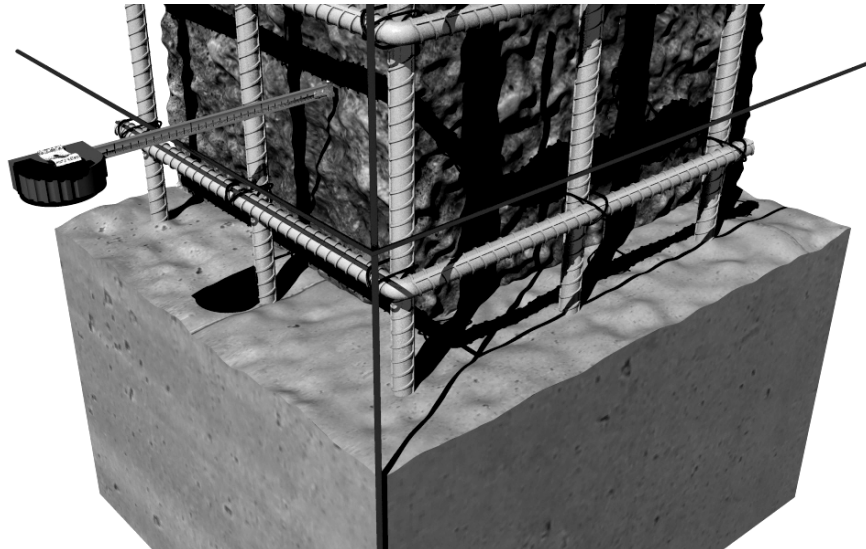


Figure 7: Guide wires installed vertically and horizontally. Wires strung along to the finished grade line provide a visual guide for the nozzleman and finishers.

5. Test Panel and Performance Exam

The use of shotcrete core grading to quantify the quality of shotcrete cores has been over-used for years and, in the past, was included in many ACI shotcrete related documents. With the exception of the nozzleman certification program, core grading has been discontinued. Industry experts felt that it was risky to propose such a subjective tool to members of the engineering and construction industries with very little experience in the field of shotcrete (problem related to its misuse). The core grades example displayed in the appendix document did not necessarily represent nor cover all the structure configurations where shotcrete is applied, and therefore, made it irrelevant.

Core grading however is an appropriate means to evaluate the skills of nozzlemen with respect to shotcrete consolidation and rebar encapsulation. Although it is still a subjective method, it allows consistent grading amongst ACI Examiners. Therefore, each of the test panels shot by the nozzleman-examinee is cored and inspected for reinforcement encapsulation and rebound control. The size (length and diameter) of the cores, the five (5) core locations in the panel, the size and configuration of the reinforcing steel and the size of the panels are consistent parameters important for a standardized certification program (Fig. 8).

It should be noted that a total of five cores are graded using these criteria at specific locations per test panel. A test panel with any single core grade exceeding core grade No. 3, or with more than two of the five cores having a core grade No. 3 is declared a failure. Averaging of core grades is not permitted. Definitions of core grades No. 1 to 5 are provided in the Program Policy [5].

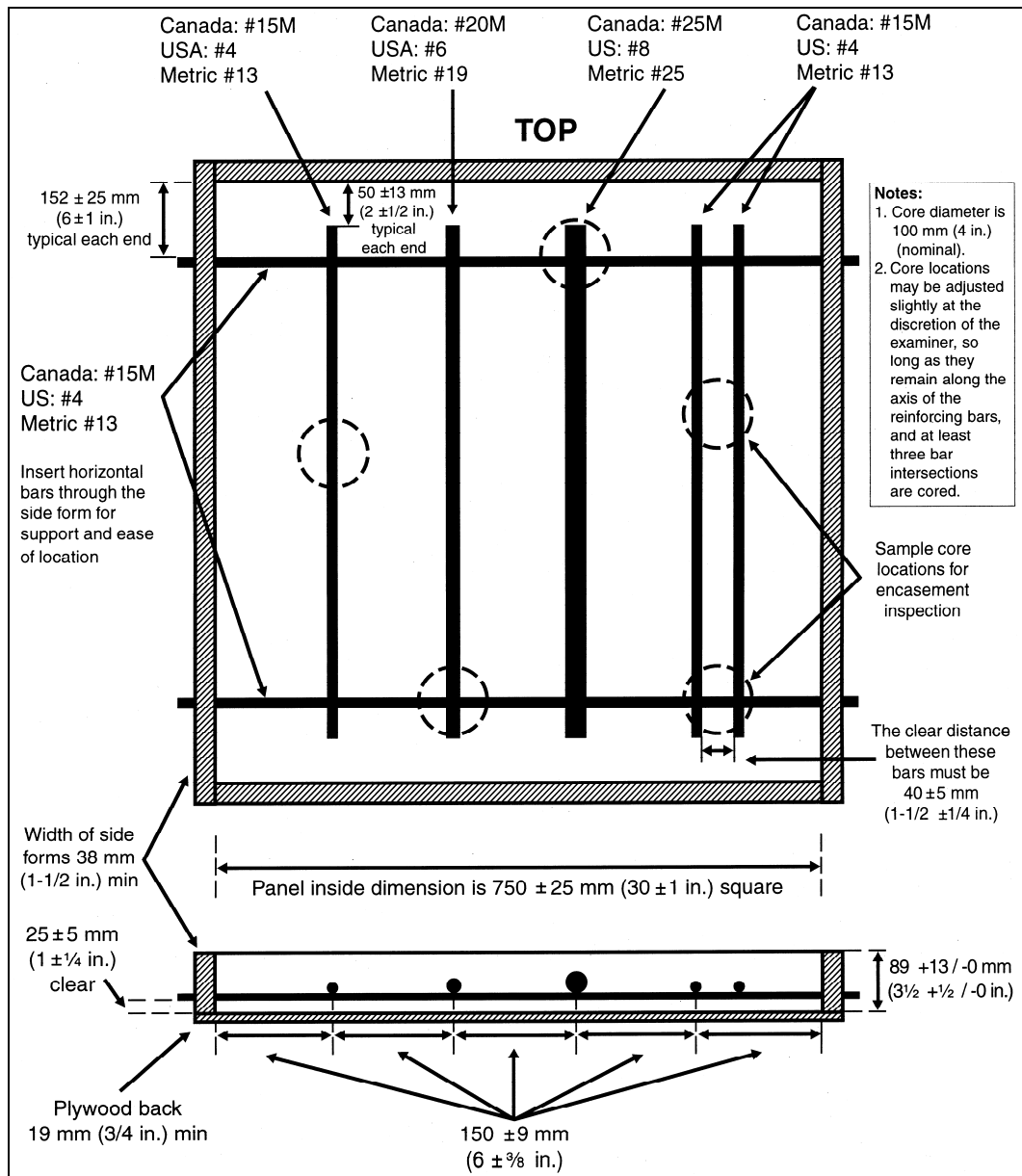


Figure 8: Standard ACI Shotcrete Nozzleman Certification Panel (2009).

A new Task Group has been recently formed to evaluate and improve the current core grading appendix. While the current system only addresses rebar encapsulation, it often does not address properly other defects within the cores. The objective is to describe potential defects and their position (adjacent or not to the rebar), including evidence and size of sand lenses, pockets and voids in order to provide better analysis in the examiner's reports to ACI.

As an example, a core grade #3 can be hard to evaluate and display different defect patterns (Fig.9). This new document will be used as guidance to improve accuracy and consistency during the visual examination, and to help all ACI examiners coming from different locations throughout North America. This document is under review by ACI Committee C660 (as of March 2011).

CORE GRADE 3



Dry-mix shotcrete, #4 bar, sand lenses.



Dry-mix shotcrete, #8 bar, one important void directly behind rebar, smaller than 1/4 dept and 3/4 in long.



Dry-mix shotcrete, intersection #4 bars, mid size void too large to be a Core Grade #2.



Dry-mix shotcrete, intersection #4 bars, linear defect from bar extending to back of panel. No interconnection detected or void against panel.

Core Grade 3: Shotcrete specimens shall have no more than two laminations or sandy areas with dimensions exceeding 3/16 in. thick by 1 1/4 in. long, or one major void, sand pocket, or lamination containing loosely bonded sand not to exceed 5/8 in. thick and 1 1/4 in. in width. The surface against the form or bond plane may be sandy with voids containing overspray to a depth of 1/16 in.

Figure 9: Suggested Core Grade Document – ACI Shotcrete Nozzleman Certification (Currently under review by ACI Committee C660 as of March 2011)

6. Shotcrete Nozzleman Education and Certification around the World

Shotcrete education and nozzleman certification is not only limited to North America. A wet-mix shotcrete nozzleman certification session recently took place in Singapore for more than 10 nozzlemen! A series of articles illustrating available nozzleman education and certification programs in Europe, South Africa, South America, and Australia have been published and presented at previous conferences [6, 7 and 8]. Recently, computer based virtual environment have even been developed to further improve the training and understanding of underground shotcrete nozzlemen [8].

The quality of shotcrete is highly dependent on the skill of the Nozzleman. Excellent education and certification programs around the world are available to continually improve

the quality of shotcrete placement leading to better quality work. Regardless of the industry type (civil, repair, structural work, tunneling, mining, pool and spa construction, etc), we shall all use these available tools to improve knowledge and awareness of the shotcrete process. As an industry, we have set the bar high, but collectively, we can raise it even higher!

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