

Guide to ACI Shotcrete Documents

By Lars Balck

In 1907 Carl Akeley developed a method of shooting a sand and cement mixture. Early promotion of the sand-cement mixture as “Gunitite” by the Cement Gun Company led to use in a variety of concrete applications. By 1950, Gunitite was widely adopted and popular because it produced high-strength concrete and allowed for the economical placement of concrete in difficult locations. Gunitite (now called dry-mix shotcrete) enjoyed success but also, unfortunately, attracted many contractors who didn’t fully understand the materials and process. This lack of knowledge led to many shotcrete projects failing. With the resulting poor reputation many engineers refused to specify shotcrete placement on their projects.

There were no standards or guidance to lead contractors to proper selection of materials, equipment, or placement techniques. The reputation of shotcrete declined and by the late 1940’s, concerned shotcrete companies and consulting engineers asked the American Concrete Institute (ACI) to form a committee to provide an authoritative guide. ACI Committee 506 in 1950, prepared the standard “Proposed Recommended Practice for the Application of Mortar by Pneumatic Pressure”. This document was the first to use the term “shotcrete” as they stated, “To avoid the cumbersome term ‘pneumatically-placed mortar’ the word ‘shotcrete’ is used to refer to this material in the remainder of this report.”

In the 1960’s ACI formed Committee 506 to permanently address shotcrete placement. Their first document was titled “ACI Standard 506-66 Recommended Practice for Shotcreting.” The members of the first ACI 506 committee are a “Who’s Who” of early shotcrete (Fig. 1). The ACI 506-66 document “Recommended Practice” evolved into the “Shotcrete Guide” which is likely the most used shotcrete document today. Since the formation of the ACI 506 committee, many more shotcrete-specific documents have been produced. Below is a brief description of the current ACI 506 shotcrete documents.

ACI PRC-506-22: SHOTCRETE GUIDE

The Shotcrete Guide grew from the committee’s first document ACI 506-66. It uses non-mandatory language and serves as a shotcrete primer. For most in the industry, this is the go-to document for those who want to learn what shotcrete was all about. The Shotcrete Guide has been revised many times. The current version was formatted as a companion document to ACI 506.2 Specification for Shotcrete which uses mandatory language. The section numbering between the Specification and the Shotcrete Guide match, so in effect, the Shotcrete Guide serves as a commentary for the Specification. In addition, the Shotcrete Guide has additional content to cover all facets of shotcrete placement, including equipment, application procedures, crew responsibilities, materials, and testing. Anyone wanting to learn about shotcrete should begin by becoming familiar with the Shotcrete Guide. It is also a great resource for those active in shotcreting to keep a copy as a reference.

ACI SPEC-506.2-13 SPECIFICATION FOR SHOTCRETE

This specification is for contractors. It contains the construction requirements for the application of shotcrete, minimum standards for materials properties, testing and application.

The materials processes, quality control measures and inspections described in the specification should be tested, monitored, or performed as applicable only by individuals holding the appropriate ACI certifications. The mandatory and optional checklists at the back of the Specification will be used by the specifier. Mandatory items should be addressed in the contract documents for specific projects using shotcrete placement. The optional checklist items

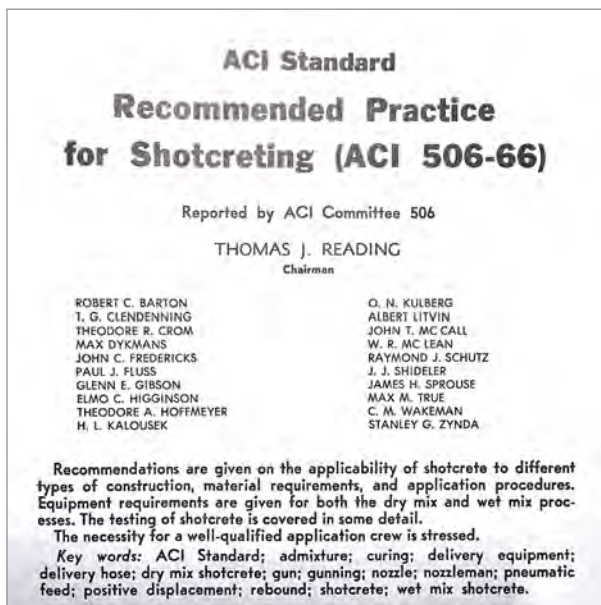


Fig. 1



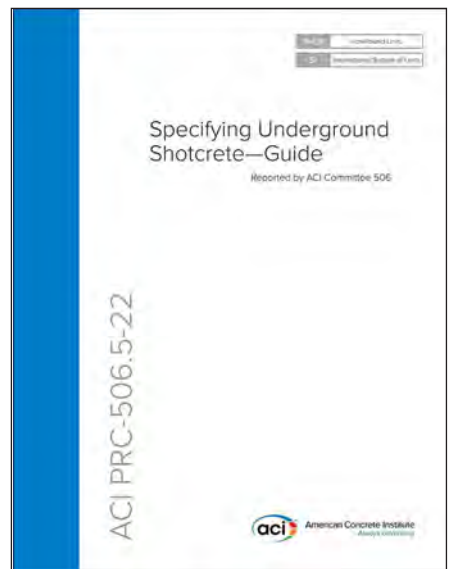
should be reviewed by the specifier to determine whether they are applicable to their specific project. With broader adoption of shotcrete placement, we will see more reference to ACI 506.2 in contract documents. Also, ACI SPEC-301-20: Specifications for Concrete Construction, and ACI SPEC-563-18: Specifications for Repair of Concrete in Buildings refer directly to 506.2 for their shotcrete provisions.

ACI PRC-506.1-21: FIBER-REINFORCED SHOTCRETE - GUIDE

This guide is for anyone involved in fiber-reinforced shotcrete. It describes the technology and applications of fiber-reinforced shotcrete (FRS), focusing on synthetic and steel macrofibers. The guide bridges information between two ACI committees: 506 (Shotcrete) and committee 544 (Fibers). The guide provides proportions of mixtures, application procedures, general performance criteria of FRS and design considerations.

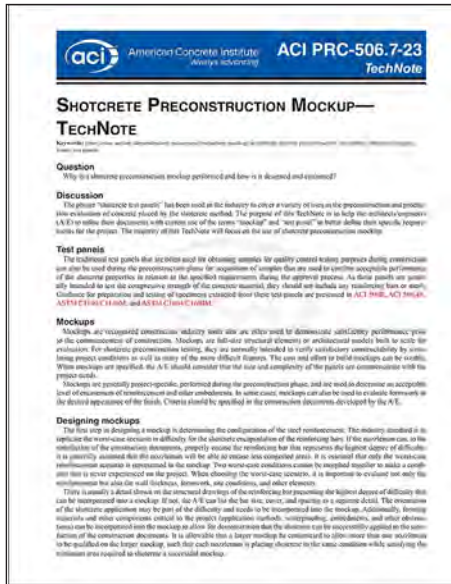
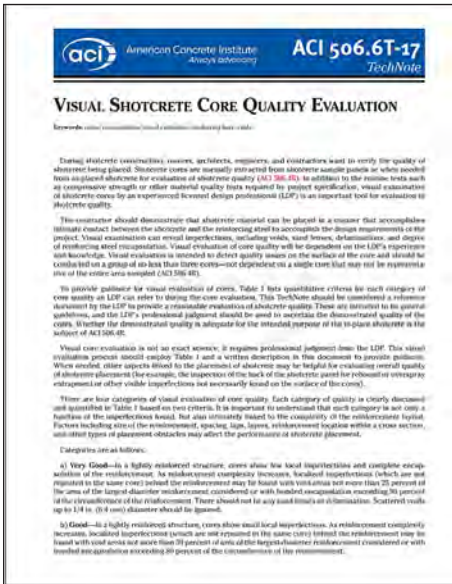
ACI PRC-506.4-19: GUIDE FOR THE EVALUATION OF SHOTCRETE - GUIDE

This guide, as the title explains, presents procedures that can be used to evaluate the quality and properties of shotcrete mixtures and in-place shotcrete. The Guide for Evaluation describes the most relevant test methods applicable to shotcrete along with recommendations for selecting the most appropriate methods and interpreting test results. The guide is divided into 12 chapters, ranging in content from determining mixture proportions to evaluating hardened shotcrete through compressive strength tests or nondestructive testing methods. Efforts have been made not only to present the testing methods available but also to guide the reader on the relevance of each method for a testing program.



ACI PRC-506.5-22: SPECIFYING UNDERGROUND SHOTCRETE - GUIDE

This document provides a guide for owners, designers, specifiers, and inspection organizations developing specifications for projects using shotcrete placement for underground excavation support. The guide specification provides general information for the selection of constituent materials, and methods to proportion shotcrete. Typical methods of batching, mixing, and handling of proportioned shotcrete materials are detailed along with shotcrete placement methods and equipment. The guide briefly discusses the concept of composite ground support—the combination of shotcrete and other support elements used to provide early and effective tunnel support. The guide is not a comprehensive treatise on the design of these systems but is intended to provide sufficient background to understand how the combination and sequencing of ground support elements can influence the performance, application, inspection, and testing of shotcrete.



ACI PRC-506.6-17: VISUAL SHOTCRETE CORE QUALITY EVALUATION - TECHNOTE

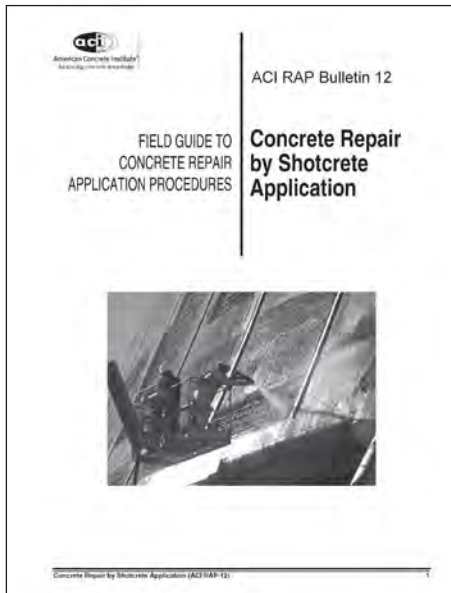
This tech note was developed to give a rational basis for owners, architects, engineers, and contractors to verify the quality of shotcrete placement. Shotcrete cores are normally extracted from shotcrete mockup panels or when needed from as-placed shotcrete for evaluation of shotcrete quality (ACI 506.4R). In addition to the routine tests such as compressive strength or other material quality tests required by project specification, visual examination of shotcrete cores by an experienced licensed design professional (LDP) is an important tool for evaluation of shotcrete quality.

ACI PRC-506.7-23: SHOTCRETE PRECONSTRUCTION MOCKUP - TECHNOTE

The phrase “shotcrete test panels” has been used in the industry to cover a variety of uses in the preconstruction and production evaluation of shotcrete placement of concrete. The purpose of this technote is to help the architects and engineers to use the terminology “mockup” and “test panel” to better define their specific requirements on a shotcrete project. The majority of the technote focuses on the use of shotcrete preconstruction mockup panels for evaluating materials, equipment and shotcreter (formerly nozzleman) competence.

ACI PRC-506.X CONSTRUCTION OF POOLS USING SHOTCRETE - GUIDE

This document has not yet been published as of Spring 2024. This document is intended for use by owners and



pool builders who are building shotcreted pool shells. It does not include specific design requirements. It does include recommendations for aspects of planning, design, and construction that are needed for quality shotcrete placement with the goal of producing pools that have the long-term durability and serviceability owners should expect. Though other ACI 506 documents, like the Shotcrete Guide cover shotcrete placement in general this document focuses on the specific needs of shotcreted pool shells.

ACI RAP-12 - CONCRETE REPAIR BY SHOTCRETE APPLICATION

The ACI Education Committee has produced a set of field guides to concrete repair application procedures. The RAP documents are freely available from ACI and cover a wide variety of concrete repair topics. RAP-12 provides a short overview of the shotcrete process as typically used to restore structural integrity, increase concrete cover over reinforcement, or both. It addresses the reduced forming requirements and presents another repair tool in the designer’s and contractor’s tool kits.

SHOTCRETER (FORMERLY NOZZLEMAN) EDUCATION DOCUMENTS

SHOTCRETER CERTIFICATION

Engineers and contractors for years have recognized that the shotcreter has more influence on the in-place quality of shotcreted concrete than craftsmen who form-and-pour concrete. In 2000, ASA and ACI 506 committee members worked with ACI Certification to develop a Shotcrete Nozzleman certification program to certify shotcrete nozzlemen. The engineers and specifiers recognized the benefit of having shotcreter certification and began specifying that only ACI-Certified Shotcreters place shotcrete on their jobs. Now most commercial shotcrete projects require current ACI Shotcreter certification. The ACI-Certified Shotcreter program currently has 2091 shotcreters worldwide. With specifiers having confidence in the credentials provided by the internationally recognized ACI certification program, use of shotcrete in concrete projects has increased substantially.



ACI CCS-4(20) – SHOTCRETE FOR THE CRAFTSMAN

This document provides the shotcreter an understanding of basic concrete technology, shotcrete equipment, surface preparation, shotcrete placement techniques, finishing, curing and protection of shotcreted concrete. It also covers the impact of weather conditions on shotcrete place-

ment, safety and testing. This material is also duplicated in ACI CP-60 (see next).

ACI CP-60 – CRAFTSMAN WORKBOOK FOR ACI CERTIFICATION OF SHOTCRETE NOZZLEMEN

This workbook contains all the shotcrete information from ACI CCS-4 as that is covered in the certification written exam. It also includes sample questions at the end of each chapter for the shotcreter to review, a sample of the perfor-

mance exam and the certification panel layout and evaluation. The format is spiral bound in a larger 8.5 x 11 in. (215 x 275 mm) format conducive to letting the shotcreter take notes in the book during education classes. The ACI Shotcreter certification written exam verifies that the shotcreter candidates have the basic shotcrete knowledge contained in the CP-60.





ACI CP-61PACK - SHOTCRETE INSPECTOR REFERENCE PACKAGE

This package of documents included in a notebook-style binder includes program information for the ACI Shotcrete Inspector Certification program, a sample exam, and reprints of ACI and ASA technical resource materi-

als covered by the program. The collection is intended for those candidates taking the Shotcrete Inspector open book written exam, however it is a very cost-effective way to purchase these ACI and ASA documents and keep together as a ready reference on shotcrete in the office or field:

- ACI 305R-10, Guide to Hot Weather Concreting
- ACI 305.1-14, Specification for Hot Weather Concreting
- ACI 306R-16, Guide to Cold Weather Concreting
- ACI 306.1-90(02), Standard Specification for Cold Weather Concreting
- ACI 506R-16, Guide to Shotcrete
- ACI 506.1R-08, Guide to Fiber-Reinforced Shotcrete
- ACI 506.2-13, Specification for Shotcrete
- ACI 506.4R-94(04), Guide for the Evaluation of Shotcrete
- ACI 506.6T-17, Visual Shotcrete Core Quality Evaluation
- ACI CCS-4(08), Shotcrete for the Craftsman
- ASA, Safety Guidelines for Shotcrete

WRAPPING UP

A note of caution for contractors. While ACI provides excellent documents about concrete and shotcrete, the contractor is legally required by contract to comply with the specific project specifications and build the structure

to meet the project specifications even though the project specification may conflict with provisions in the referenced ACI documents. The Shotcrete Guide has been erroneously referenced in contract documents with wording such as “Shotcrete work shall be as documented in ACI PRC 506-22 Shotcrete Guide”. This has led to legal disputes since the Shotcrete Guide does not use mandatory language and thus is not strictly enforceable from a legal perspective. Specifiers are encouraged to use the mandatory ACI 506.2 in their contract documents or include modified language from the Shotcrete Guide to make the project requirements mandatory.

Though shotcrete has been around for over 100 years many architects and engineers are not familiar with the variety of shotcrete documents produced by ACI over the last 74 years. My advice to contractors is to get copies and become familiar with the above documents. If the project specification conflicts with ACI documents the contractor who is familiar with ACI documents can potentially head off a conflict by discussing the potential conflict with the specifier.



Lars Balck is a Concrete Consultant and ASA/ACI Nozzleman Examiner. He recently retired from CROM, LLC, as a Senior Vice President. He has been involved in the design and construction of prestressed concrete tanks built with shotcrete for over 40 years. He received his bachelor's degree in civil engineering from the University of Florida and served with the U.S. Army as First Lieutenant in Vietnam as a Combat Engineer. Balck is a Past President of ASA. He is Chair of ACI Subcommittee 506-C, Shotcreting Guide; a past Chair and current member of ACI Committee 506, Shotcreting; and a member of ACI Committees 376, Concrete Structures for Refrigerated Liquefied Gas Containment; 563, Specifications for Repair of Structural Concrete in Buildings; and C660, Shotcrete Nozzleman Certification.