



Designation: C1604/C1604M – 05

Standard Test Method for Obtaining and Testing Drilled Cores of Shotcrete¹

This standard is issued under the fixed designation C1604/C1604M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers obtaining, preparing, and testing cores drilled from shotcrete for length, compressive strength, or splitting tensile strength determinations.

1.2 The values stated in either inch-pound units or SI units shall be regarded separately as standard. SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3 The text of this standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *This standard does not purport to address the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

- C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
- C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- C125 Terminology Relating to Concrete and Concrete Aggregates
- C174/C174M Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
- C496/C496M Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
- C617 Practice for Capping Cylindrical Concrete Specimens

¹ This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.46 Shotcrete.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- C823 Practice for Examination and Sampling of Hardened Concrete in Constructions
- C1140 Practice for Preparing and Testing Specimens from Shotcrete Test Panels
- C1231/C1231M Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders
- 2.2 *ACI Standards:*³
 - 318 Building Code Requirements for Structural Concrete
 - 506.2 Specification for Shotcreting
 - 506.4R Guide for the Evaluation of Shotcrete

3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminology C125.

4. Significance and Use

4.1 This test method provides standardized procedures for obtaining cored specimens to determine the compressive strength and splitting tensile strength of shotcrete during pre-construction, during construction, and from older shotcrete structures.

4.2 Generally, test specimens are obtained *in situ* when doubt exists about the in-place shotcrete quality due either to low strength test results during construction or signs of distress in the structure. Other uses of this method are to provide specimens for acceptance testing, construction control and to assess the condition, quality and uniformity of the shotcrete in accordance with Practice C823 (see Note 1).

4.3 Specimens obtained by this method are used to verify the thickness of shotcrete and aid in the visual assessment of the shotcrete quality, workmanship, defects, shotcrete-to-substrate bond and the condition of any reinforcement used in the shotcrete⁴.

³ Available from American Concrete Institute, P.O. Box 9094, Farmington Hills, MI 48333

⁴ Bartlett, F.M. and MacGregor, J.G., "Effect of Core Diameter on Concrete Core Strengths," *ACI Materials Journal*, Vol. 91, No. 5, September-October 1994, pp. 460-470.

4.4 Shotcrete strength is affected by the location of the shotcrete in a structure. Vertical, sub-horizontal and overhead elements of the shotcrete structure may show variability. Core strength is affected by core orientation relative to direction of shotcrete application. These factors shall be considered in planning the locations for obtaining shotcrete samples and in interpreting strength test results.

4.5 Shotcrete is applied in single or multiple layers, as plain shotcrete, reinforced shotcrete, or fiber-reinforced shotcrete. Core samples containing wire-mesh and reinforcing bars shall not be used for compressive strength testing.

4.6 The strength of shotcrete is affected by moisture content, the specified moisture conditioning procedure for cores is intended to provide test specimens with reproducible moisture contents that minimize within-laboratory and between-laboratory variations.

4.7 Sample acquisition may require a combination of core-drilling, sawing, and grinding that may have the potential to adversely affect the sample condition if care is not taken during sampling and testing.

4.8 A sampling plan shall be established that indicates the number of samples and their locations (see **Note 1**). The acceptance criteria for shotcrete core strengths shall be established by the specifier of tests (see **Note 2**).

NOTE 1—Practice **C823** provides guidance on the development of a sampling plan for concrete in constructions. A number of methods that supplement the examination of hardened shotcrete by means of representative core samples and testing are discussed in ACI 506.4R.

NOTE 2—The core strength acceptance criteria cited in ACI 318 are based on a comparison of molded cylinder specimens and cores. Shotcrete strengths are always based on core specimens, therefore the 85 % factor used in core to cylinder comparisons is not relevant to the evaluation of shotcrete core strengths. A typical shotcrete specification reflecting standard industry practice is contained in ACI 506.2.

5. Apparatus

5.1 *Core Drill*, for obtaining cylindrical core specimens with diamond impregnated bits attached to a core barrel. The core drill shall have a rigid mounting base and be capable of being operated in any orientation normal to the shotcrete structure that is being sampled. The core drill shall be free from excessive vibration when in operation and shall have sufficient torque and consistent rotational speed to sustain uniform rates of penetration of the core drill. The core barrel shall be cooled and core cuttings flushed with water during operation.

5.2 *Saw*, for cutting core specimens to size for compressive strength. The saw shall have a diamond or silicon carbide cutting edge and shall be capable of cutting plain and reinforced specimens in a single pass that conform with the prescribed dimensions, without excessive heating or shock.

5.3 *Grinding wheel*, to trim and clean plain and fiber-reinforced shotcrete specimens that conform to prescribed tolerances without significantly disturbing the aggregates, matrix or fiber-reinforcement.

6. Sampling

6.1 General:

6.1.1 Sampling shall be planned in accordance with the applicable provisions of Practice **C823**. The number of samples, sample locations and sampling procedures shall be established in the plan.

6.1.2 Shotcrete samples obtained from test panels shall be in accordance with the applicable provisions of Practice **C1140**.

6.1.3 Samples of hardened shotcrete for use in the preparation of strength test specimens shall not be taken until the shotcrete is strong enough to permit sample removal without disturbing the bond between the mortar, coarse aggregate (see **Note 3**) and fiber-reinforcement. When preparing strength test specimens from samples of hardened shotcrete, samples that have been damaged in the process of removal shall not be used. Specimens of defective shotcrete that cannot be tested shall be reported as such if the defects are representative of the in-place condition of the shotcrete (see ACI 506.4R).

NOTE 3—It is not possible to specify a minimum age when shotcrete is strong enough to withstand damage during removal, because the strength at any age depends on the strength grade and curing of the shotcrete. If accelerating admixtures are used during shotcrete application, core specimens may be obtained for testing at approximately 6 h. If this is not practical, removal of shotcrete can proceed if cored or cut surfaces do not display erosion of the mortar and the exposed coarse aggregate particles are embedded firmly in the mortar. Nondestructive test methods may be used to estimate level of in-place strength development prior to attempting removal of shotcrete core samples (see ACI 506.4R).

6.1.4 Specimens containing embedded reinforcement shall not be used for determining compressive or splitting tensile strength.

6.2 *Core Drilling*—Drill core specimens perpendicular to the surface and avoid drilling near formed joints or edge placement. Record the approximate angle between the drilled core axis and the plane of the shotcrete as placed.

7. Measuring the Length of Drilled Cores

7.1 Cores for determining the thickness of shotcrete layers or other structural elements shall have a diameter of at least 3.0 in. [75 mm] when the lengths of such cores are to be measured in accordance with Test Method **C174/C174M**.

7.2 For cores that are not intended for determining structural dimensions, measure the longest and shortest lengths on the cut surface along lines parallel to the core axis. Record the average length to the nearest ¼ in. [5 mm].

8. Cores for Compressive Strength

8.1 *Diameter*—The diameter of core specimens for the determination of compressive strength in load bearing structural members shall be at least 3.0 in. [75 mm] (see **Note 4**). Core diameters less than 3.0 in. [75 mm] shall be permitted as directed by the specifier of the tests.

NOTE 4—The compressive strengths of 2-in [50-mm] diameter cores are known to be somewhat lower and more variable than those of 3-in. [75-mm] diameter cores. In addition, smaller diameter cores appear to be more sensitive to the effect of the length-diameter ratio⁴.

8.2 *Length*—The preferred length of the capped or ground specimen is nominally two times the diameter.

8.2.1 If the ratio of the length to the diameter (L/D) of the core exceeds 2.1, reduce the length of the core so that the ratio of the capped or ground specimen is between 1.9 and 2.1. Core