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Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete[1]

This standard is issued under the fixed designation C42/C42M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers obtaining, preparing, and testing cores drilled from concrete for length or compressive strength or splitting tensile strength determinations. This test method is not applicable to cores from shotcrete.

NOTE 1—Test Method C1604/C1604M is applicable for obtaining, preparing, and testing cores from shotcrete.

NOTE 2—Appendix X1 provides recommendations for obtaining and testing sawed beams for flexural performance.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance 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 all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C78/C78M Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

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/C617M Practice for Capping Cylindrical Concrete Specimens

C642 Test Method for Density, Absorption, and Voids in Hardened Concrete

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C823/C823M Practice for Examination and Sampling of Hardened Concrete in Constructions

C1231/C1231M Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Cylindrical Concrete Specimens

C1542/C1542M Test Method for Measuring Length of Concrete Cores

C1604/C1604M Test Method for Obtaining and Testing Drilled Cores of Shotcrete

3. Significance and Use

3.1 This test method provides standardized procedures for obtaining and testing specimens to determine the compressive, splitting tensile, and flexural strength of in-place concrete.

3.2 Generally, test specimens are obtained when doubt exists about the in-place concrete quality due either to low strength test results during construction or signs of distress in the structure. Another use of this method is to provide strength information on older structures.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.61 on Testing for Strength.

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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.

***A Summary of Changes section appears at the end of this standard**

3.3 Concrete strength is affected by the location of the concrete in a structural element, with the concrete at the bottom tending to be stronger than the concrete at the top. Core strength is also affected by core orientation relative to the horizontal plane of the concrete as placed, with strength tending to be lower when measured parallel to the horizontal plane.[3] These factors shall be considered in planning the locations for obtaining concrete samples and in comparing strength test results.

3.4 The strength of concrete measured by tests of cores is affected by the amount and distribution of moisture in the specimen at the time of test. There is no standard procedure to condition a specimen that will ensure that, at the time of test, it will be in the identical moisture condition as concrete in the structure. The moisture conditioning procedures in this test method are intended to provide reproducible moisture conditions that minimize within-laboratory and between-laboratory variations and to reduce the effects of moisture introduced during specimen preparation.

3.5 The measured compressive strength of a core will generally be less than that of a corresponding properly molded and cured standard cylinder tested at the same age. For a given concrete, however, there is no unique relationship between the strengths of these two types of specimens (see Note 3). The relationship is affected by many factors such as the strength level of the concrete, the in-place temperature and moisture histories, the degree of consolidation, batch-to-batch variability, the strength-gain characteristics of the concrete, the condition of the coring apparatus, and the care used in removing cores.

NOTE 3—A procedure is available for estimating the equivalent cylinder strength from a measured core strength.[4]

NOTE 4—In the absence of core strength requirements of an applicable building code or of other contractual or legal documents that may govern the project, the specifier of tests should establish in the project specifications the acceptance criteria for core strengths. An example of acceptance criteria for core strength is provided in ACI 318,[5] which are used to evaluate cores taken to investigate low strength test results of standard-cured cylinder during construction. According to ACI 318, the concrete represented by the cores is considered structurally adequate if the average strength of three cores is at least 85 % of the specified strength and no single core strength is less than 75 % of the specified strength.

3.6 The "specifier of the tests" referenced in this test method is the individual responsible for analysis or review and acceptance of core test results.

NOTE 5—For investigation of low strength test results, ACI 318 defines the specifier of the tests as the licensed design professional.

3.7 The apparent compressive strength of concrete as measured by a core is affected by the length-diameter ratio (L/D) of the core as tested and this must be considered in preparing core specimens and evaluating test results.

4. Apparatus

4.1 *Core Drill,* for obtaining cylindrical core specimens with diamond impregnated bits attached to a core barrel.

4.2 *Saw,* for trimming ends of cores. The saw shall have a diamond or silicon-carbide cutting edge and shall be capable of cutting cores without introducing cracks or dislodging aggregate particles.

4.3 *Balance,* accurate to at least 5 g [0.01 lb].

5. Sampling

5.1 *General:*

5.1.1 Samples of hardened concrete for use in the preparation of strength test specimens shall not be taken until the concrete is strong enough to permit sample removal without disturbing the bond between the mortar and the coarse aggregate (see Note 6 and Note 7). When preparing strength test specimens from samples of hardened concrete, samples that have been damaged during removal shall not be used unless the damaged portion(s) are removed and the lengths of resulting test specimens satisfy the minimum length-diameter ratio requirement in 7.2. Samples of defective or damaged concrete that cannot be tested shall be reported along with the reason that prohibits use of the sample for preparing strength test specimens.

NOTE 6—Practice C823/C823M provides guidance on the development of a sampling plan for concrete in constructions.

NOTE 7—It is not possible to specify a minimum age when concrete is strong enough to withstand damage during removal, because the strength at any age depends on the curing history and strength grade of the concrete. If time permits, the concrete should not be removed before it is 14 days old. If this is not practicable, removal of concrete can proceed if the cut surfaces do not display erosion of the mortar and the exposed coarse aggregate particles are embedded firmly in the mortar. In-place test methods may be used to estimate the level of strength development prior to attempting removal of concrete samples.

5.1.2 Except as provided in 5.1.3, cores containing embedded reinforcement, excluding fibers, or other embedded objects shall not be used for determining strength of concrete.

5.1.3 If it is not possible to prepare a test specimen that meets the requirements of 7.1 and 7.2 and that is free of embedded reinforcement or other metal, the specifier of the tests is permitted to allow testing of cores with embedded metal (see Note 8). If a core tested for strength contains embedded metal, the size, shape, and location of the metal within the core shall be documented in the test report.

NOTE 8—The presence of steel reinforcement, other than fibers, or other embedded metal in a core can affect the measured strength.[6,7] There are insufficient data to derive reliable correction factors that can be applied to the measured strength to account for embedded reinforcement perpendicular to the core axis. If testing of cores containing embedded reinforcement is permitted, engineering judgment is required to assess the significance of the results. The specifier of the tests should not permit a core to be tested for strength if bar reinforcement, or other elongated embedded metal

[3] Neville, A., "Core Tests: Easy to Perform, Not Easy to Interpret," *Concrete International*, Vol 23, No. 11, November 2001, pp. 59–68.

[4] "Guide for Obtaining Cores and Interpreting Compressive Strength Results," ACI 214.4R, American Concrete Institute, P.O. Box 9094, Farmington Hills, MI 48333, www.concrete.org.

[5] "Building Code Requirements for Structural Concrete and Commentary," ACI 318, American Concrete Institute, P.O. Box 9094, Farmington Hills, MI 48333, www.concrete.org.

[6] Gaynor, R. D., "Effect of Horizontal Reinforcing Steel on the Strength of Molded Cylinders," Problems and Practices in *Journal of the American Concrete Institute, Proceedings*, Vol 62, No. 7, July 1965, pp. 837–840.

[7] Concrete Society Working Party, "Concrete Core Testing for Strength," Concrete Society Technical Report No. 11, The Concrete Society, England, May 1976.

object, is oriented close to parallel to the core axis.

5.2 *Core Drilling*—When a core will be tested to measure concrete strength, the core shall be drilled perpendicular to the surface and at least 150 mm [6 in.] away from formed joints or obvious edges of a unit of deposit (see Note 9). This minimum distance does not apply to the formed boundaries of structural members. Record the approximate angle between the longitudinal axis of the drilled core and the horizontal plane of the concrete as placed. A specimen drilled perpendicular to a vertical surface, or perpendicular to a sloping surface, shall be taken from near the middle of a unit of deposit when possible. If cores are obtained for purposes other than determination of strength, drill cores in accordance with the instructions provided by the specifier of the tests. Record the date core was drilled. If known, record the date when concrete was placed.

NOTE 9—The intent is to avoid drilling cores in non-representative concrete that may exist near formed joints or the boundary of a unit of placement.

5.3 *Slab Removal*—Remove a slab sufficiently large to secure the desired test specimens without the inclusion of any concrete that has been cracked, spalled, undercut, or otherwise damaged.

DRILLED CORES

6. Measuring the Length of Drilled Cores

6.1 Cores for determining the thickness of pavements, slabs, walls or other structural elements shall have a diameter of at least 94 mm [3.70 in.] when the lengths of such cores are stipulated to be measured in accordance with Test Method C174/C174M. When core length for determining the thickness of a member is not required to be measured in accordance with Test Method C174/C174M, core diameter shall be as directed by specifier of tests.

6.2 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 5 mm [¼ in.].

7. Cores for Compressive Strength

7.1 *Diameter:*

7.1.1 Except as provided in 7.1.2, the diameter of core specimens for the determination of compressive strength shall be at least 94 mm [3.70 in.] or at least two times the nominal maximum size of the coarse aggregate, whichever is larger.

7.1.2 If limited member thickness makes it impossible to obtain cores with length-diameter ratio (L/D) of at least 1.0 or if clear distance between reinforcement is limited, core diameters less than 94 mm [3.70 in.] are not prohibited. If a core diameter less than 94 mm [3.70 in.] is used, report the reason.

NOTE 10—The compressive strengths of nominal 50-mm [2-in.] diameter cores are known to be somewhat lower and more variable than those of nominal 100-mm [4-in.] diameter cores. In addition, smaller diameter cores appear to be more sensitive to the effect of the length-diameter ratio.[8]

[8] 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.

7.2 *Length*

7.2.1 Except as provided in 7.2.2, the preferred length of the capped or ground specimen is between 1.9 and 2.1 times the diameter. 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 specimens with length-diameter ratios equal to or less than 1.75 require corrections to the measured compressive strength (see 7.9.1). A strength correction factor is not required for L/D greater than 1.75. A core having a maximum length of less than 95 % of its diameter before capping or a length less than its diameter after capping, trimming, or end grinding shall not be tested.

7.2.2 If the compressive strengths of cores are to be compared with specified strengths based on standard concrete cubes, cores shall be tested with L/D, after end preparation, in the range of 1.00 to 1.05 unless otherwise directed by the specifier of the tests. If the strengths of cores with L/D =1 are to be compared with specified concrete cube strength, do not apply the correction factor in 7.9.1.

7.3 *Moisture Conditioning*—Test cores after moisture conditioning as specified in this test method or as directed by the specifier of the tests. The moisture conditioning procedures specified in this test method are intended to preserve the moisture of the drilled core and to provide a reproducible moisture condition that minimizes the effects of moisture gradients introduced by wetting during drilling and specimen preparation.

7.3.1 After cores have been drilled, wipe off surface drill water and allow remaining surface moisture to evaporate. When surfaces appear dry, but not later than 1 h after drilling, place cores in separate plastic bags or nonabsorbent containers and seal to prevent moisture loss. Maintain cores at ambient temperature, and protect cores from exposure to direct sunlight. Transport the cores to the testing laboratory as soon as possible. Keep cores in the sealed plastic bags or nonabsorbent containers at all times except during end preparation and for a maximum time of 2 h to permit capping before testing.

7.3.2 If water is used during sawing or grinding of core ends, complete these operations as soon as possible, but no later than 2 days after drilling of cores unless stipulated otherwise by the specifier of tests. After completing end preparation, wipe off surface moisture, allow the surfaces to dry, and place the cores in sealed plastic bags or nonabsorbent containers. Minimize the duration of exposure to water during end preparation.

7.3.3 Allow the cores to remain in the sealed plastic bags or nonabsorbent containers for at least 5 days after last being wetted and before testing, unless stipulated otherwise by the specifier of tests.

NOTE 11—The waiting period of at least 5 days is intended to reduce moisture gradients introduced when the core is drilled or wetted during sawing or grinding.

7.3.4 When direction is given to test cores in a moisture condition other than achieved by conditioning according to 7.3.1, 7.3.2, and 7.3.3, report the alternative procedure.

7.4 *Sawing of Ends*—The ends of core specimens to be tested in compression shall be flat, and perpendicular to the