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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 C 42/C 42M; 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 Department of Defense.

1. Scope

1.1 This test method covers obtaining, preparing, and testing (*1*) cores drilled from concrete for length or compressive or splitting tensile strength determinations and (*2*) beams sawed from concrete for flexural 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 may not be exact equivalents, therefore each system must be used independently of the other. Combining values of the two units may result in nonconformance.

1.3 *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:*

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]

C 78 Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)[2]

C 174 Test Method for Measuring Length of Drilled Concrete Cores[2]

C 496 Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens[2]

C 617 Practice for Capping Cylindrical Concrete Specimens[2]

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]

2.2 *ACI Standards:*

318 Building Code Requirements for Reinforced Concrete[3]

3. Significance and Use

3.1 This test method provides standardized procedures for obtaining and testing specimens to determine the compressive, tensile and flexural strength of in-place concrete. Sampling and sample preparation requirements are given to ensure that dimensional requirements are met and that the specimens are comprised of intact sound concrete as free of flaws as the particular structure will allow.

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. Additionally, this method may be used to provide strength information on older structures.

3.3 There is no universal relationship between the compressive strength of a core and the corresponding compressive strength of standard-cured molded cylinders. The relationship is affected by many factors such as the strength level of the concrete, the in-place temperature and moisture history, and the strength gain characteristics of the concrete. Historically, it has been assumed that core strengths are generally 85 % of the corresponding standard-cured cylinder strengths, but this is not applicable to all situations. The acceptance criteria for core strength is to be established by the specifying authority. ACI 318 provides core strength acceptance criteria for new construction.

4. Apparatus

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

4.2 *Saw*, for cutting beam specimens to size for flexural strength tests and to trim ends of cores. The saw shall have a diamond or silicon-carbide cutting edge and shall be capable of cutting specimens which conform to the prescribed dimensions, without excessive heating or shock.

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

[1] This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregatesand is the direct responsibility of Subcommittee C09.61on Testing Concrete for Strength.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

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

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disturbing the bond between the mortar and the coarse aggregate (see Note 1). When preparing strength test specimens from samples of hardened concrete, samples that show defects or samples that have been damaged in the process of removal shall not be used.

5.1.2 Specimens containing embedded reinforcement shall not be used for determining splitting tensile strength and specimens for determining flexural strength shall not be used if reinforcement is embedded in the tensile portion of the specimen.

NOTE 1—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 practical, 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.

5.2 *Core Drilling*—A core specimen taken perpendicular to a horizontal surface shall be located, when possible, so that its axis is perpendicular to the bed of the concrete as originally placed and not near formed joints or obvious edges of a unit of deposit. A specimen taken perpendicular to a vertical surface, or perpendicular to a surface with a batter, shall be taken from near the middle of a unit of deposit when possible and not near formed joints or obvious edges of a unit of deposit.

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

DRILLED CORES

6. Length of Drilled Cores

6.1 Core specimens drilled through a structure for the purpose of measuring structural dimensions shall have a diameter of at least 3.75 in. [95 mm]. Measure the lengths of such cores in accordance with Test Method C 174.

6.2 For cores which are not intended for measuring 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].

7. Cores for Compressive Strength

7.1 *Test Specimen*—The nominal diameter of core specimens for the determination of compressive strength shall be at least 3.75 in. [95 mm]. Core diameters less than 3.75 in. [95mm] are permitted when it is impossible to obtain cores with length to diameter (L/D) ratio ≥ 1 for compressive strength evaluations in cases other than load bearing situations. For concrete with nominal maximum aggregate size greater than 1½ in. [37.5 mm], the nominal diameter should preferably be at least three times the nominal maximum size of the coarse aggregate and must be at least twice the nominal maximum size of the coarse aggregate. The preferred length of the capped specimen is between 1.9 and 2.1 times the diameter. If the ratio of the length to the diameter of the core specimen exceeds 2.1, reduce the length of the specimen so that the ratio is between 2.1 and 1.9. Core specimens with length-to-diameter ratios less than 1.8 require corrections to the measured compressive strength (see 7.7.1). A core having a maximum length of less than 95 % of its diameter before capping or a length less than its diameter after capping shall not be tested.

7.2 *End Preparation*—The ends of core specimens to be tested in compression shall be essentially smooth, perpendicular to the longitudinal axis, and of the same diameter as the body of the specimen. If necessary, saw the ends of the specimens until the following requirements are met:

7.2.1 Projections, if any, shall not extend more than 0.2 in. [5 mm] above the end surfaces,

7.2.2 The end surfaces shall not depart from perpendicularity to the longitudinal axis by more than 0.5°, and

7.2.3 The diameters of the ends shall not depart more than 0.1 in. [2.5 mm] from the mean diameter of the specimen.

7.3 *Moisture Conditioning*—Test specimens shall be tested in a moisture condition representative of the in-place concrete or as directed by the specifying authority.

7.3.1 Compressive strength test results are usually used for the evaluation of the in-place concrete strength; therefore, the cores shall be conditioned in a moisture condition most representative of the in-place strength. If the concrete service condition is dry, the cores can be tested in either an “as received condition” after allowing the drilling moisture to evaporate in accordance with 7.3.2 or tested in a “dry condition” where the cores are air dried in a temperature range of 60 to 80°F [16 to 27°C] at a relative humidity less than 60 % for seven days, as directed by the specifying authority.

7.3.2 The following procedure is used to bring the cores to the “as received condition.” After drilling, transport the cores to the testing laboratory within 24 h. Dry the cores for 12 to 24 h in air at a temperature between 60 and 80° [16 to 27°C] and at less than 50 % relative humidity. Cap or grind the cores, and test them within 48 h of receipt.

7.3.3 When the specifying authority so directs, cores shall be tested in a moisture condition other than achieved by conditioning according to 7.3.1 or 7.3.2.

7.3.4 Further guidance for core strength evaluation considerations is found in ACI 318, Chapter 5.

7.4 *Capping*—The ends of the cores shall conform to the tolerance requirements of Test Method C 39. The ends shall be sawed or ground to tolerance or capped in accordance with capping procedures for hardened concrete specimens of Practice C 617.

NOTE 2—Prior to capping, the density of a core may be determined by weighing it and dividing it by the volume calculated from the average diameter and length, or by any other standard method for determining density.

7.5 *Measurement*—Prior to testing, measure the length of the capped specimen to the nearest 0.1 in. [2.0 mm] and use this length to compute the length-to-diameter ratio. Determine the average diameter by averaging two measurements taken at right angles to each other about the midheight of the specimen. Measure core diameters to the nearest 0.01 in. [0.2 mm] whenever possible, but at least to the nearest 0.1 in. [2.0 mm].

7.6 *Testing*—Test the specimens in accordance with the applicable provisions of Test Method C 39.

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7.7 *Calculation*—Calculate the compressive strength of each specimen using the computed cross-sectional area based on the average diameter of the specimen.

7.7.1 If the ratio of length to diameter (L/D) of the specimen is 1.75 or less, correct the result obtained in 7.7 by multiplying by the appropriate correction factors shown in the following table (see Note 3):

Ratio of Length to Diameter (L/D)	Strength Correction Factor
1.75	0.98
1.50	0.96
1.25	0.93
1.00	0.87

Use interpolation to determine correction factors for L/D values not given in the table.

NOTE 3—Correction factors depend on various conditions such as moisture condition, strength level, and elastic modulus. Average values are given in the table. These correction factors apply to lightweight concrete weighing between 100 and 120 lb/ft^3[1600 and 1990 kg/m^3] and to normal weight concrete. They are applicable to both dry and wet concrete for strengths between 2000 and 6000 psi [14 to 42 MPa]. For strengths above 10000 psi [70 MPa], test data on cores show that the correction factors may be larger than the values listed above. Thus, these factors should be applied to high-strength concrete with caution.

7.8 *Report*—Report the results as required by Test Method C 39 with the addition of the following information:

7.8.1 Length of test specimen before and after capping,

7.8.2 Compressive strength to the nearest 10 psi [0.1 MPa] when the diameter is measured to the nearest 0.01 in. [0.20 mm] and to the nearest 50 psi [0.5 MPa] when the diameter is measured to the nearest 0.1 in. [2.0 mm], after correction for length-diameter ratio when required,

7.8.3 Direction of application of the load on the specimen with respect to the horizontal plane of the concrete as placed,

7.8.4 The moisture condition at the time of testing, and

7.8.5 Nominal maximum size of concrete aggregate.

7.9 *Precision:*[4]

7.9.1 The single-operator coefficient of variation on cores has been found to be 3.2 %[5]for a range of compressive strength between 4500 [32.0 MPa] and 7000 [48.3 MPa] psi. Therefore, results of two properly conducted tests of single cores by the same operator on the same sample of material should not differ from each other by more than 9 %[5]of their average.

7.9.2 The multi-laboratory coefficient of variation on cores has been found to be 4.7 %[5]for a range of compressive strength between 4500 [32.0 MPa] and 7000 [48.3 MPa] psi. Therefore, results of two properly conducted tests on cores sampled from the same hardened concrete (where a single test is defined as the average of two observations (cores), each made on separate adjacent drilled 4 in. [100 mm] diameter cores), and tested by two different laboratories should not differ from each other by more than 13 %[5]of their average.

7.10 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in this test method, no statement on bias is being made.

8. Cores for Tensile Splitting Strength

8.1 *Test Specimens*—The specimens shall conform to the dimensional requirements in 7.1, 7.2.1, and 7.2.2. Ends are not to be capped.

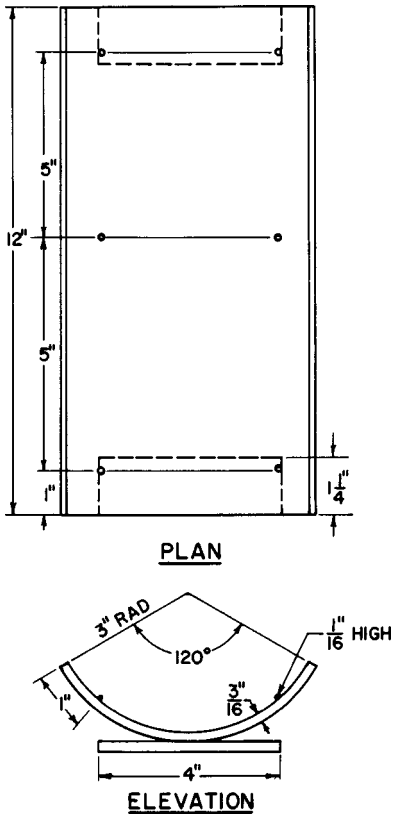
8.2 *Moisture Conditioning*—Prior to testing condition the specimens as described in 7.3.

8.3 *Bearing Surfaces*—The line of contact between the specimen and each bearing strip shall be straight and free of any projections or depressions higher or deeper than 0.01 in. [0.2 mm]. When the line of contact is not straight or contains projections or depressions having heights or depths greater than 0.01 in., grind or cap the specimen so as to produce bearing lines meeting these requirements. Do not use specimens with projections or depressions greater than 0.1 in. [2.0 mm]. When capping is employed the caps shall be as thin as practicable and shall be formed of high-strength gypsum plaster.

NOTE 4—Fig. 1 illustrates a device suitable for applying caps to 6-in. (150-mm) diameter specimens.

8.4 *Testing*—Test the specimens in accordance with the applicable provisions of Test Method C 496.

8.5 *Calculation and Report*—Calculate the splitting tensile strength and report the results as required in Test Method C 496. When grinding or capping of the bearing surfaces is



Metric Equivalents

in.	1/16	3/16	1	1 1/4	3	4	5	12
mm.	1.6	4.8	25	32	76	102	127	305

FIG. 1 Suitable Capping Device for Splitting Tensile Strength Test

[4] "Development of Precision and Bias Statements for Testing Drilled Cores in Accordance with ASTM C 42," by Glenn E. Bollin, *ASTM Journal of Cement, Concrete, and Aggregates*, Vol 15, No. 1, 1993.

[5] These numbers represent, respectively, the (1s %) and (d2s %) limits as described in ASTM Practice C 670.

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required, measure the diameter between the finished surfaces. Indicate that the specimen was a core and state its moisture condition at the time of testing.

8.6 *Precision:*[6]

8.6.1 The within laboratory single operator coefficient of variation for splitting tensile strength between 520 psi [3.6 MPa] and 590 psi [4.1 MPa] of cores has been found to be 5.3 %[7]. Therefore, results of two properly conducted tests by the same operator in the same laboratory on the same sample of material should not differ by more than 14.9 %[7] of their average.

8.6.2 The multi-laboratory coefficient of variation for splitting tensile strength between 520 psi [3.6 MPa] and 590 psi [4.1 MPa] of cores has been found to be 15.0 %[7]. Therefore, results of two properly conducted tests on the same sample of material of hardened concrete and tested by two different laboratories should not differ from each other by more than 42.3 %[7] of their average.

8.7 *Bias*—Since there is no accepted reference materials suitable for determining the bias for the procedure in this test method, no statement on bias is being made.

BEAMS FOR FLEXURAL TESTING

9. Flexural Strength

9.1 *Test Specimens*—A beam specimen for the determination of flexural strength shall in general have a cross section of 6 by 6 in. [150 by 150 mm] (Note 5). The specimen shall be at least 21 in. [530 mm] in length, but when two tests for flexural strength are to be made in one beam specimen, it shall be at least 33 in. [840 mm] in length. Perform the sawing operation so that the concrete will not be weakened by shock or by heating. The sawed surfaces shall be smooth, plane, parallel, and free from steps, ridges, and grooves. Take care in handling sawed beam specimens to avoid chipping or cracking.

NOTE 5—In many cases, particularly with prisms cut from pavement slabs, the width will be governed by the size of the coarse aggregate and the depth by the thickness of the slab.

9.2 *Moisture Conditioning*—Submerge the test specimens in lime-saturated water at 73.5 ± 3.5°F [23.0± 2.0°C] for at least 40 h immediately prior to the flexure test. Test the specimens promptly after removal from water storage. During the period between removal from water storage and testing, keep the specimens moist by covering with a wet blanket of burlap or other suitable absorbent fabric.

9.2.1 When the specifying authority for the project so directs, beams shall be tested in a moisture condition other than that achieved by conditioning in accordance with 9.2. Relatively small amounts of drying of the surface of flexural specimens induce tensile stresses in the extreme fibers that will markedly reduce the indicated flexural strength.

9.3 *Testing*—Test the specimens in accordance with the applicable provisions of Test Method C 78.

NOTE 6—Sawing may greatly reduce the indicated flexural strength; beams shall, therefore, be tested with a molded surface in tension whenever possible. The location of the tension face with respect to the position of the concrete as placed and the position of the sawed surfaces should be reported.

9.4 *Report*—Report the results in accordance with the applicable provisions of Test Method C 78 and the requirements of this test method, including the moisture condition at the time of testing. Identify orientation of the specimen's finished, sawed, and tension faces with respect to their positions in the test apparatus.

10. Keywords

10.1 compressive strength; concrete; concrete coring; concrete sawing; flexural strength; splitting tensile strength

[6] "Portland Cement Concrete Core Proficiency Sample Program" by G.W. Steele, Strategic Highway Research Program, SHRP-P-636, National Research Council, Washington, D.C., 1993.

[7] These numbers represent, respectively, the (1s%) and (d2s%) limits as described in Practice C 670.

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