



Designation: C192/C192M – 13a

# Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory<sup>1</sup>

This standard is issued under the fixed designation C192/C192M; 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 ( $\epsilon$ ) 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 practice covers procedures for making and curing test specimens of concrete in the laboratory under accurate control of materials and test conditions using concrete that can be consolidated by rodding or vibration as described herein.

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 *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 and health practices and determine the applicability of regulatory limitations prior to use. (Warning—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to exposed skin and tissue upon prolonged exposure.<sup>2</sup>)*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

- C70 Test Method for Surface Moisture in Fine Aggregate
- C125 Terminology Relating to Concrete and Concrete Aggregates
- C127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
- C128 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

- C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
  - C143/C143M Test Method for Slump of Hydraulic-Cement Concrete
  - C172/C172M Practice for Sampling Freshly Mixed Concrete
  - C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
  - C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
  - C330/C330M Specification for Lightweight Aggregates for Structural Concrete
  - C403/C403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
  - C470/C470M Specification for Molds for Forming Concrete Test Cylinders Vertically
  - C494/C494M Specification for Chemical Admixtures for Concrete
  - C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
  - C566 Test Method for Total Evaporable Moisture Content of Aggregate by Drying
  - C617/C617M Practice for Capping Cylindrical Concrete Specimens
  - C1064/C1064M Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
  - C1077 Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
- ### 2.2 American Concrete Institute Publications:<sup>4</sup>
- 211.3 Practice for Selecting Proportions for No-Slump Concrete
  - 309R Guide for Consolidation of Concrete

## 3. Significance and Use

3.1 This practice provides standardized requirements for preparation of materials, mixing concrete, and making and curing concrete test specimens under laboratory conditions.

<sup>4</sup> Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, <http://www.aci-int.org>.

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

3.2 If specimen preparation is controlled as stipulated herein, the specimens may be used to develop information for the following purposes:

- 3.2.1 Mixture proportioning for project concrete,
- 3.2.2 Evaluation of different mixtures and materials,
- 3.2.3 Correlation with nondestructive tests, and
- 3.2.4 Providing specimens for research purposes.

NOTE 1—The concrete test results for concrete specimens made and cured using this practice are widely used. They may be the basis for acceptance testing for project concrete, research evaluations, and other studies. Careful and knowledgeable handling of materials, mixing concrete, molding test specimens, and curing test specimens is necessary. Many laboratories performing this important work are independently inspected or accredited. Practice C1077 identifies and defines the duties, responsibilities, and minimum technical qualification requirements of laboratory personnel and the minimum requirements for equipment used in testing concrete and concrete aggregates.

#### 4. Apparatus

4.1 *Molds, General*—Molds for specimens or fastenings thereto in contact with the concrete shall be made of steel, cast iron, or other nonabsorbent material, nonreactive with concrete containing portland or other hydraulic cements. Molds shall conform to the dimensions and tolerances specified in the method for which the specimens are required. Molds shall hold their dimensions and shape under all conditions of use. Watertightness of molds during use shall be judged by their ability to hold water poured into them. Test procedures for watertightness are given in the section on Test Methods for Elongation, Absorption, and Watertightness of Specification C470/C470M. A suitable sealant, such as heavy grease, modeling clay, or microcrystalline wax, shall be used where necessary to prevent leakage through the joints. Positive means shall be provided to hold base plates firmly to the molds. Reusable molds shall be lightly coated with mineral oil or a suitable nonreactive release material before use.

##### 4.2 *Cylinder Molds:*

4.2.1 *Molds for Casting Specimens Vertically* shall conform to the requirements of 4.1 and Specification C470/C470M.

4.2.2 *Horizontal Molds for Creep Test Cylinders* shall conform to the requirements of 4.1 and to the requirements for symmetry and dimensional tolerance in the section on General Requirements except for verticality requirements of Specification C470/C470M. The use of horizontal molds is intended only for creep specimens that contain axially embedded strain gages. Molds for creep cylinders to be filled while supported in a horizontal position shall have a filling slot parallel to the axis of the mold which extends the full length to receive the concrete. The width of the slot shall be one half the diameter of the specimen. If necessary the edges of the slot shall be reinforced to maintain dimensional stability. Unless specimens are to be capped or ground to produce plane ends, the molds shall be provided with two machined metal end plates at least 25 mm [1 in.] thick and the working surfaces shall comply with the requirements for planeness and surface roughness given in the section on Capping Plates of Practice C617/C617M. Provision shall be made for fixing both end plates firmly to the mold. The inside surface of each end plate shall be provided with at least three lugs or studs approximately 25 mm [1 in.]

long, firmly fastened to the plate for embedment in the concrete. One base plate shall be drilled from the inside at an angle to permit the lead wire from the strain gage to exit the specimen through the edge of the plate. Provision shall be made for accurately positioning the strain gage. All necessary holes shall be as small as possible to minimize disturbance to subsequent strain measurements and shall be sealed to prevent leakage.

4.3 *Beam and Prism Molds* shall be rectangular in shape (unless otherwise specified) and of the dimensions required to produce the desired specimen size. The inside surfaces of the molds shall be smooth and free from indentations. The sides, bottom, and ends shall be at right angles to each other and shall be straight and true and free of warp. Maximum variation from the nominal cross section shall not exceed 3 mm [ $\frac{1}{8}$  in.] for molds with depth or breadth of 150 mm [6 in.] or more, or 2 mm [ $\frac{1}{16}$  in.] for molds of smaller depth or breadth. Except for flexure specimens, molds shall not vary from the nominal length by more than 2 mm [ $\frac{1}{16}$  in.]. Flexure molds shall not be shorter than 2 mm [ $\frac{1}{16}$  in.] of the required length, but may exceed it by more than that amount.

4.4 *Tamping Rod*—A round, smooth, straight, steel rod with a diameter conforming to the requirements in Table 2. The length of the tamping rod shall be at least 100 mm [4 in.] greater than the depth of the mold in which rodding is being performed, but not greater than 600 mm [24 in.] in overall length (see Note 2). The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

NOTE 2—A rod length of 400 mm [16 in.] to 600 mm [24 in.] meets the requirements of the following: Practice C31/C31M, Test Method C138/C138M, Test Method C143/C143M, Test Method C173/C173M, and Test Method C231/C231M.

4.5 *Mallets*—A mallet with a rubber or rawhide head weighing  $0.6 \pm 0.2$  kg [ $1.25 \pm 0.50$  lb] shall be used.

##### 4.6 *Vibrators:*

4.6.1 *Internal Vibrators*—The vibrator frequency shall be at least 9000 vibrations per minute [150 Hz] while the vibrator is operating in the concrete. The diameter of a round vibrator shall be no more than one fourth the diameter of the cylinder mold or one fourth the width of the beam or prism mold. Other shaped vibrators shall have a perimeter equivalent to the

**TABLE 1 Number of Layers Required for Specimens**

Specimen Type and Size	Mode of Consolidation	Numbers of Layers of Approximate Equal Depth
<b>Cylinders:</b>		
Diameter, mm [in.]		
75 to 100 [3 or 4]	rodding	2
150 [6]	rodding	3
225 [9]	rodding	4
up to 225 [9]	vibration	2
<b>Prisms and horizontal creep Cylinders:</b>		
Depth, mm [in.]		
up to 200 [8]	rodding	2
over 200 [8]	rodding	3 or more
up to 200 [8]	vibration	1
over 200 [8]	vibration	2 or more

**TABLE 2 Diameter of Rod and Number of Roddings to be Used in Molding Test Specimens**

Cylinders		
Diameter of Cylinder, mm [in.]	Diameter of Rod mm [in.]	Number of Strokes/Layer
75 [3] to < 150 [6]	10 ± 2 [ $\frac{3}{8}$ ± $\frac{1}{16}$ ]	25
150 [6]	16 ± 2 [ $\frac{5}{8}$ ± $\frac{1}{16}$ ]	25
200 [8]	16 ± 2 [ $\frac{5}{8}$ ± $\frac{1}{16}$ ]	50
250 [10]	16 ± 2 [ $\frac{5}{8}$ ± $\frac{1}{16}$ ]	75
Beams and Prisms		
Top Surface Area of Specimen, cm <sup>2</sup> [in. <sup>2</sup> ]	Diameter of Rod mm [in.]	Number of Roddings/Layer
160 [25] or less	10 ± 2 [ $\frac{3}{8}$ ± $\frac{1}{16}$ ]	25
165 to 310 [26 to 49]	10 ± 2 [ $\frac{3}{8}$ ± $\frac{1}{16}$ ]	one for each 7 cm <sup>2</sup> [1 in. <sup>2</sup> ] of surface
320 [50] or more	16 ± 2 [ $\frac{5}{8}$ ± $\frac{1}{16}$ ]	one for each 14 cm <sup>2</sup> [2 in. <sup>2</sup> ] of surface
Horizontal Creep Cylinders		
Diameter of Cylinder mm [in.]	Diameter of Rod mm [in.]	Number of Roddings/Layer
150 [6]	16 ± 2 [ $\frac{5}{8}$ ± $\frac{1}{16}$ ]	50 total, 25 along both sides of axis

circumference of an appropriate round vibrator. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 75 mm [3 in.]. The vibrator frequency shall be checked with a vibrating-reed tachometer or other suitable device at least every two years or as recommended by the manufacturer.

NOTE 3—For information on size and frequency of various vibrators and method to check vibrator frequency, see ACI 309R.

4.6.2 *External Vibrators*—The two types of external vibrators permitted are either table or plank. The external vibrator frequency shall be 3600 vibrations per minute (60 Hz) or higher.

4.6.3 Provisions shall be made for clamping the mold securely to the apparatus for both types of vibrators.

NOTE 4—Vibratory impulses are frequently imparted to a table or plank vibrator through electromagnet means, or by use of an eccentric weight on the shaft of an electric motor or on a separate shaft driven by a motor.

4.7 *Small Tools*—Tools and items such as shovels, pails, trowels, wood float, blunted trowels, straightedge, feeler gage, scoops, rulers, rubber gloves, and metal mixing bowls shall be provided.

4.8 *Slump Apparatus*—The apparatus for measurement of slump shall conform to the requirements of Test Method C143/C143M.

4.9 *Sampling and Mixing Pan*—The pan shall be flat-bottom and of heavy-gage metal, watertight, of convenient depth, and of sufficient capacity to allow easy mixing by shovel or trowel of the entire batch; or, if mixing is by machine, to receive the entire batch on discharge of the mixer and allow remixing in the pan by trowel or shovel.

4.10 *Wet-Sieving Equipment*—If wet-sieving is required, the equipment shall conform to the requirements of Practice C172/C172M.

4.11 *Air Content Apparatus*—The apparatus for measuring air content shall conform to the requirements of either Test Methods C231/C231M or C173/C173M.

4.12 *Scales*—Scales for determining the mass of batches of materials and concrete shall be accurate within 0.3 % of the test load at any point within the range of use.

NOTE 5—In general the mass of small quantities should not be determined on large capacity scales. In many applications the smallest mass determined on a scale should be greater than about 10 % of the

maximum capacity of the scale; however, this will vary with the performance characteristics of the scale and the required accuracy of the determination. Acceptable scales used for determining the mass for concrete materials preferably should determine mass accurately to about 0.1 % of total capacity and the foregoing precaution is applicable. However, certain analytical and precision balances are exceptions to this rule and should weigh accurately to 0.001 %. Particular care must be exercised in measuring small quantities of material by determining the difference between two much larger masses.

4.13 *Temperature Measuring Device*—The temperature measuring device shall conform to the requirements of Test Method C1064/C1064M.

4.14 *Concrete Mixer*—A power-driven concrete mixer shall be a revolving drum, tilting mixer, or suitable revolving pan or revolving-paddle mixer capable of thoroughly mixing batches of the prescribed sizes at the required slump.

NOTE 6—A pan mixer is usually more suitable for mixing concrete with less than 25 mm [1 in.] slump than a revolving drum mixer. The rate of rotation, degree of tilt, and rated capacity of tilting mixers are not always suitable for laboratory mixed concrete. It may be found desirable to reduce the rate of rotation, decrease the angle of tilt from the horizontal, and use the mixer at somewhat less than the manufacturer's rated capacity.

## 5. Specimens

5.1 *Cylindrical Specimens*—Cylinder dimensions shall be as stipulated in the specification, test method or practice for the laboratory studies being performed and shall meet the requirements of 5.4. If dimensions are not stipulated in a specification, test method, or practice, the specimen selected shall have a length that is twice the diameter and meet the requirements of 5.4.

NOTE 7—The same cylinder size should be used for the reference (control) concrete mixture and test concrete mixtures when conducting comparative studies such as those required in Specification C494/C494M. For mixture proportioning of project concrete, it is preferable for the cylinder size in the laboratory to be the same as that specified for acceptance testing.

NOTE 8—When molds in SI units are required and not available, equivalent inch-pound unit size mold should be permitted.

5.1.1 Cylindrical specimens for tests other than creep shall be molded and allowed to harden with the axis of the cylinder vertical.

5.1.2 Cylindrical creep specimens may be cast with the cylindrical axis either vertical or horizontal and allowed to harden in the position in which cast.



5.2 *Prismatic Specimens*—Beams for flexural strength, prisms for freezing and thawing, bond, length change, volume change, etc., shall be formed with their long axes horizontal, unless otherwise required by the method of test in question, and shall conform in dimension to the requirements of the specific test method.

5.3 *Other Specimens*—Other shapes and sizes of specimens for particular tests may be molded as desired following the general procedures set forth in this practice.

5.4 *Specimen Size versus Aggregate Size*—The diameter of a cylindrical specimen or minimum cross-sectional dimension of a rectangular section shall be at least three times the nominal maximum size of the coarse aggregate in the concrete as defined in Terminology **C125**. When the nominal maximum size of the coarse aggregate exceeds 50 mm [2 in.], the sample shall be treated by wet sieving through a 50-mm [2-in.] sieve as described in Practice **C172/C172M**, unless otherwise stipulated.

5.5 *Number of Specimens*—The number of specimens and the number of test batches are dependent on established practice and the nature of the test program. Guidance is usually given in the test method or specification for which the specimens are made. Usually three or more specimens are molded for each test age and test condition unless otherwise specified (**Note 9**). Specimens involving a given variable should be made from three separate batches mixed on different days. An equal number of specimens for each variable should be made on any given day. When it is impossible to make at least one specimen for each variable on a given day, the mixing of the entire series of specimens should be completed in as few days as possible, and one of the mixtures should be repeated each day as a standard of comparison.

**NOTE 9**—Test ages often used are 7 and 28 days for compressive strength tests, or 14 and 28 days for flexural strength tests. Specimens containing Type III cement are often tested at 1, 3, 7, and 28 days. For later test ages, 3 months, 6 months, and 1 year are often used for both compressive and flexural strength tests. Other test ages may be required for other types of specimens.

## 6. Preparation of Materials

6.1 *Temperature*—Before mixing the concrete, bring the concrete materials to room temperature in the range from 20 to 30 °C [68 to 86 °F], except when the temperature of the concrete is stipulated. When a concrete temperature is stipulated, the method proposed to obtain the concrete temperature needs approval of the stipulator.

6.2 *Cement*—Store the cement in a dry place, in moisture-proof containers, preferably made of metal. The cement shall be thoroughly mixed to provide a uniform supply throughout the tests. It shall be passed through a 850- $\mu$ m (No. 20) or finer sieve to remove all lumps, remixed on a plastic sheet, and returned to sample containers.

6.3 *Aggregates*—In order to preclude segregation of a coarse aggregate, separate into individual size fractions and for each batch recombine in the proper proportions to produce the desired grading.

**NOTE 10**—Only rarely is a coarse aggregate batched as a single size

fraction. The number of size fractions will generally be between 2 and 5 for aggregate smaller than 60 mm [2½ in.]. When a size fraction to be batched is present in amounts in excess of 10 %, the ratio of the opening of the larger to the smaller sieve should not exceed 2.0. More closely sized groups are sometimes advisable.

6.3.1 Unless fine aggregate is separated into individual size fractions, maintain it in a damp condition or restore to a damp condition until use, to prevent segregation, unless material uniformly graded is subdivided into batch size lots using a sample splitter with proper size openings. If unusual gradings are being studied, the fine aggregate may need to be dried and separated into individual sizes. In this instance, if the total quantity of fine aggregate required is larger than can be efficiently blended in a single unit, then the individual size fractions should be determined in a mass required for each individual batch. When the total quantity of fine aggregate needed for the complete investigation is such that it can be thoroughly mixed, blended, and maintained in a damp condition, then it should be handled in that manner. Determine the specific gravity and absorption of aggregates in accordance with either Test Methods **C127** or **C128**.

6.3.2 Before incorporating in concrete, prepare the aggregate to ensure a definite and uniform condition of moisture. Determine the weight of aggregate to be used in the batch by one of the following procedures:

6.3.2.1 Determine the mass of low-absorption aggregates (absorption less than 1.0 %) in the room-dry condition with allowance made for the amount of water that will be absorbed from the unset concrete (**Note 11**). This procedure is particularly useful for coarse aggregate which must be batched as individual sizes; because of the danger of segregation it can be used for fine aggregate only when the fine aggregate is separated into individual size fractions.

**NOTE 11**—When using aggregates with low absorption in room-dry condition the amount of water that will be absorbed by the aggregates before the concrete sets may be assumed to be 80 % of the difference between the 24-h absorption of the aggregates determined by Test Methods **C127** or **C128**, and the amount of water in the pores of the aggregates in their room-dry state, as determined by Test Method **C566**.

6.3.2.2 Individual size fractions of aggregate may be weighed separately, recombined into a tared container in the amounts required for the batch, and immersed in water for 24 h prior to use. After immersion the excess water is decanted and the combined weight of aggregate and mixing water determined. Allowance shall be made for the amount of water absorbed by the aggregate. The moisture content of the aggregates may be determined in accordance with Test Methods **C70** and **C566**.

6.3.2.3 The aggregate may be brought to and maintained in a saturated condition, with surface moisture contained in sufficiently small amounts to preclude loss by draining, at least 24 h prior to use. When this method is used, the moisture content of the aggregate must be determined to permit calculation of proper quantities of the damp aggregate. The quantity of surface moisture present must be counted as a part of the required amount of mixing water. Surface moisture in fine aggregate may be determined in accordance with Test Methods **C70** and **C566**, making due allowance for the amount of water absorbed. The method outlined here (moisture content slightly