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Standard Practice for Making and Curing Concrete Test Specimens in the Field[1]

This standard is issued under the fixed designation C31/C31M; 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 practice covers procedures for making and curing cylinder and beam specimens from representative samples of fresh concrete for a construction project.

1.2 The concrete used to make the molded specimens shall be sampled after all on-site adjustments have been made to the mixture proportions, including the addition of mix water and admixtures. This practice is not satisfactory for making specimens from concrete not having measurable slump or requiring other sizes or shapes of specimens.

1.3 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.

1.4 *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 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.[2])

1.5 The text of this standard references notes which provide explanatory material. These notes shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C125 Terminology Relating to Concrete and Concrete Aggregates
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 Practice for Sampling Freshly Mixed Concrete
C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C330 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
C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C617 Practice for Capping Cylindrical Concrete Specimens
C1064/C1064M Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

2.2 *American Concrete Institute Publication:*[4]

CP-1 Concrete Field Testing Technician, Grade I
309R Guide for Consolidation of Concrete

3. Terminology

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

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[1] This practice 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] See Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol. 04.02.

[3] 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.

[4] 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.**

4. Significance and Use

4.1 This practice provides standardized requirements for making, curing, protecting, and transporting concrete test specimens under field conditions.

4.2 If the specimens are made and standard cured, as stipulated herein, the resulting strength test data when the specimens are tested are able to be used for the following purposes:

4.2.1 Acceptance testing for specified strength,

4.2.2 Checking adequacy of mixture proportions for strength, and

4.2.3 Quality control.

4.3 If the specimens are made and field cured, as stipulated herein, the resulting strength test data when the specimens are tested are able to be used for the following purposes:

4.3.1 Determination of whether a structure is capable of being put in service,

4.3.2 Comparison with test results of standard cured specimens or with test results from various in-place test methods,

4.3.3 Adequacy of curing and protection of concrete in the structure, or

4.3.4 Form or shoring removal time requirements.

5. Apparatus

5.1 *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 hold their dimensions and shape under all conditions of use. Molds shall be watertight during use as judged by their ability to hold water poured into them. Provisions for tests of water leakage are given in the Test Methods for Elongation, Absorption, and Water Leakage section 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 form release material before use.

5.2 *Cylinder Molds*— Molds for casting concrete test specimens shall conform to the requirements of Specification C470/C470M.

5.3 *Beam Molds*—Beam molds shall be of the shape and dimensions required to produce the specimens stipulated in 6.2. The inside surfaces of the molds shall be smooth. The sides, bottom, and ends shall be at right angles to each other and shall be straight and true and free of warpage. Maximum variation from the nominal cross section shall not exceed ⅛ in. [3 mm] for molds with depth or breadth of 6 in. [150 mm] or more. Molds shall produce specimens at least as long but not more than 1⁄16 in. [2 mm] shorter than the required length in 6.2.

5.4 *Tamping Rod*—A round, smooth, straight, steel rod with a diameter conforming to the requirements in Table 1. The length of the tamping rod shall be at least 4 in. [100 mm] greater than the depth of the mold in which rodding is being performed, but not greater than 24 in. [600 mm] in overall length (see Note 1~~). The length tolerance for the tamping rod shall be ± ⅛ in. [4 mm]. The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.~~). The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

NOTE 1—A rod length of 16 in. [400 mm] to 24 in. [600 mm] 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.

TABLE 1 Tamping Rod Diameter Requirements

Diameter of Cylinder or Width of Beam in. [mm]	Diameter or Rod in. [mm]
<6 [150]	⅜ ± 1⁄16 [10 ± 2]
≥6 [150]	⅝ ± 1⁄16 [16 ± 2]

5.5 *Vibrators*—Internal vibrators shall be used. 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 mold. Other shaped vibrators shall have a perimeter equivalent to the 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 3 in. [75 mm]. The vibrator frequency shall be checked periodically with a vibrating-reed tachometer or other suitable device.

NOTE 2—For information on size and frequency of various vibrators and a method to periodically check vibrator frequency see ACI 309R.

5.6 *Mallet*—A mallet with a rubber or rawhide head weighing 1.25 ± 0.50 lb [0.6 ± 0.2 kg] shall be used.

5.7 *Placement Tools*—of a size large enough so each amount of concrete obtained from the sampling receptacle is representative and small enough so concrete is not spilled during placement in the mold. For placing concrete in a cylinder mold, the acceptable tool is a scoop. For placing concrete in a beam mold, either a shovel or scoop is permitted.

5.8 *Finishing Tools*—a handheld float or a trowel.

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

5.10 *Sampling Receptacle*—The receptacle shall be a suitable heavy gauge metal pan, wheelbarrow, or flat, clean nonabsorbent board of sufficient capacity to allow easy remixing of the entire sample with a shovel or trowel.

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

5.12 *Temperature Measuring Devices*—The temperature measuring devices shall conform to the applicable requirements of Test Method C1064/C1064M.

6. Testing Requirements

6.1 *Cylindrical Specimens*—Compressive or splitting tensile strength specimens shall be cylinders cast and allowed to set in an upright position. The number and size of cylinders cast shall be as directed by the specifier of the tests. In addition, the length shall be twice the diameter and the cylinder diameter shall be at least 3 times the nominal maximum size of the coarse aggregate. When the nominal maximum size of the coarse aggregate exceeds 2 in. [50 mm], the concrete sample shall be treated by wet sieving through a 2-in. [50-mm] sieve as described in Practice C172. For acceptance testing for specified compressive strength, cylinders shall be 6 by 12 in. [150 by 300 mm] or 4 × 8 in. [100 × 200 mm] (Note 3).

NOTE 3—When molds in SI units are required and not available, equivalent inch-pound unit size mold should be permitted.

6.2 *Beam Specimens*— Flexural strength specimens shall be beams of concrete cast and hardened in the horizontal position. The number of beams cast shall be as directed by the specifier of the tests. The length shall be at least 2 in. [50 mm] greater than three times the depth as tested. The ratio of width to depth as molded shall not exceed 1.5. The standard beam shall be 6 by 6 in. [150 by 150 mm] in cross section, and shall be used for concrete with nominal maximum size coarse aggregate up to 2 in. [50 mm]. When the nominal maximum size of the coarse aggregate exceeds 2 in. [50 mm], the smaller cross sectional dimension of the beam shall be at least three times the nominal maximum size of the coarse aggregate. Unless required by project specifications, beams made in the field shall not have a width or depth of less than 6 in. [150 mm].

6.3 *Field Technicians*—The field technicians making and curing specimens for acceptance testing shall be certified ACI Field Testing Technicians, Grade I or equivalent. Equivalent personnel certification programs shall include both written and performance examinations, as outlined in ACI CP-1.

7. Sampling Concrete

7.1 The samples used to fabricate test specimens under this standard shall be obtained in accordance with Practice C172 unless an alternative procedure has been approved.

7.2 Record the identification of the sample with respect to the location of the concrete represented and the time of casting.

8. Slump, Air Content, and Temperature

8.1 *Slump*—Measure and record the slump of each batch of concrete from which specimens are made immediately after remixing in the receptacle, as required in Test Method C143/C143M.

8.2 *Air Content*— Determine and record the air content in accordance with either Test Method C173/C173M or Test Method C231. The concrete used in performing the air content test shall not be used in fabricating test specimens.

8.3 *Temperature*— Determine and record the temperature in accordance with Test Method C1064/C1064M.

NOTE 4—Some specifications may require the measurement of the unit weight of concrete. The volume of concrete produced per batch may be desired on some projects. Also, additional information on the air content measurements may be desired. Test Method C138/C138M is used to measure the unit weight, yield, and gravimetric air content of freshly mixed concrete.

9. Molding Specimens

9.1 *Place of Molding*— Mold specimens promptly on a level, rigid surface, free of vibration and other disturbances, at a place as near as practicable to the location where they are to be stored.

9.2 *Casting Cylinders*—Select the proper tamping rod from 5.4 and Table 1 or the proper vibrator from 5.5. Determine the method of consolidation from Table 2, unless another method is specified. If the method of consolidation is rodding, determine molding requirements from Table 3. If the method of consolidation is vibration, determine molding requirements from Table 4. Select a scoop of the size described in 5.7. While placing the concrete in the mold, move the scoop around the perimeter of the mold opening to ensure an even distribution of the concrete with minimal segregation. Each layer of concrete shall be consolidated as required. In placing the final layer, add an amount of concrete that will fill the mold after consolidation.

TABLE 2 Method of Consolidation Requirements

Slump in. [mm]	Method of Consolidation
≥ 1 [25]	rodding or vibration
< 1 [25]	vibration

TABLE 3 Molding Requirements by Rodding

Specimen Type and Size	Number of Layers of Approximately Equal Depth	Number of Roddings per Layer
Cylinders:		
Diameter, in. [mm]		
4 [100]	2	25
6 [150]	3	25
9 [225]	4	50
Beams:		
Width, in. [mm]		
6 [150] to 8 [200]	2	see 9.3
>8 [200]	3 or more equal depths, each not to exceed 6 in. [150 mm].	see 9.3

TABLE 4 Molding Requirements by Vibration

Specimen Type and Size	Number of Layers	Number of Vibrator Insertions per Layer	Approximate Depth of Layer, in. [mm]
Cylinders:			
Diameter, in. [mm]			
4 [100]	2	1	one-half depth of specimen
6 [150]	2	2	one-half depth of specimen
9 [225]	2	4	one-half depth of specimen
Beams:			
Width, in. [mm]			
6 [150] to 8 [200]	1	see 9.4.2	depth of specimen
over 8 [200]	2 or more	see 9.4.2	8 [200] as near as practicable

9.3 *Casting Beams*— Select the proper tamping rod from 5.4 and Table 1 or proper vibrator from 5.5. Determine the method of consolidation from Table 2, unless another method is specified. If the method of consolidation is rodding, determine the molding requirements from Table 3. If the method of consolidation is vibration, determine the molding requirements from Table 4. Determine the number of roddings per layer, one for each 2 in.^{2} [14 cm^2] of the top surface area of the beam. Select a placement tool as described in 5.7. Using the scoop or shovel, place the concrete in the mold to the height required for each layer. Place the concrete so that it is uniformly distributed within each layer with minimal segregation. Each layer shall be consolidated as required. In placing the final layer, add an amount of concrete that will fill the mold after consolidation.

9.4 *Consolidation*— The methods of consolidation for this practice are rodding or internal vibration.

9.4.1 *Rodding*—Place the concrete in the mold in the required number of layers of approximately equal volume. Rod each layer uniformly over the cross section with the rounded end of the rod using the required number of strokes. Rod the bottom layer throughout its depth. In rodding this layer, use care not to damage the bottom of the mold. For each upper layer, allow the rod to penetrate through the layer being rodded and into the layer below approximately 1 in. [25 mm]. After each layer is rodded, tap the outsides of the mold lightly 10 to 15 times with the mallet to close any holes left by rodding and to release any large air bubbles that may have been trapped. Use an open hand to tap light-gauge single-use cylinder molds which are susceptible to damage if tapped with a mallet. After tapping, spade each layer of the concrete along the sides and ends of beam molds with a trowel or other suitable tool. Underfilled molds shall be adjusted with representative concrete during consolidation of the top layer. Overfilled molds shall have excess concrete removed.

9.4.2 *Vibration*—Maintain a uniform duration of vibration for the particular kind of concrete, vibrator, and specimen mold involved. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Usually sufficient vibration has been applied as soon as the surface of the concrete has become relatively smooth and large air bubbles cease to break through the top surface. Continue vibration only long enough to achieve proper consolidation of the concrete (see Note 5). Fill the molds and vibrate in the required number of approximately equal layers. Place all the concrete for each layer in the mold before starting vibration of that layer. In compacting the specimen, insert the vibrator slowly and do not allow it to rest on the bottom or sides of the mold. Slowly withdraw the vibrator so that no large air pockets are left in the specimen. When placing the final layer, avoid overfilling by more than ¼ in. [6 mm].

NOTE 5—Generally, no more than 5 s of vibration should be required for each insertion to adequately consolidate concrete with a slump greater than 3 in. [75 mm]. Longer times may be required for lower slump concrete, but the vibration time should rarely have to exceed 10 s per insertion.

9.4.2.1 *Cylinders*—The number of insertions of the vibrator per layer is given in Table 4. When more than one insertion per layer is required distribute the insertion uniformly within each layer. Allow the vibrator to penetrate through the layer being