Designation: ~~C31/C31M – 22~~ C31/C31M – 23

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 U.S. 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 intended for making specimens from concrete not having measurable slump or requiring other sizes or shapes of specimens.

1.3 This practice is not applicable to lightweight insulating concrete or controlled low strength material (CLSM).

NOTE 1—Test Method C495/C495M covers the preparation of specimens and the determination of the compressive strength of lightweight insulating concrete. Test Method D4832 covers procedures for the preparation, curing, transporting and testing of cylindrical test specimens of CLSM.

1.4 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.

1.5 *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.* (**Warning—**Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to exposed skin and tissue upon prolonged exposure.[2])

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

1.7 *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.*

[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.

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C94/C94M Specification for Ready-Mixed Concrete
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/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
C495/C495M Test Method for Compressive Strength of Lightweight Insulating Concrete
C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
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
C1611/C1611M Test Method for Slump Flow of Self-Consolidating Concrete
C1758/C1758M Practice for Fabricating Test Specimens with Self-Consolidating Concrete
D4832 Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Cylindrical Test Specimens

2.2 *American Concrete Institute Publication:*[4]

309R Guide for Consolidation of Concrete

3. Terminology

3.1 ~~For definitions of terms used in this practice, refer to Terminology C125.~~*Definitions:*

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acceptance test specimens, n*—standard-cured test specimens intended for evaluating whether the supplied concrete complies with the specification.

3.2.2 *field-curing, n*—storing test specimens in the field under an environmental temperature and moisture environment similar to the in-place concrete.

3.2.3 *initial-curing, n*—the storage of test specimens in the field after molding and before transporting the specimens to the laboratory.

3.2.3.1 *Discussion*—
Initial curing covers the time period from molding to transporting the test specimens.

3.2.4 *initial standard curing temperature, n*—temperature of the environment surrounding the specimen during initial standard curing.

3.2.4.1 *Discussion*—
The environment surrounding ~~the~~standard-cured test specimens may be air, water, or damp sand. The temperature of the environment surrounding ~~the~~standard-cured test specimen might not be the same as the concrete temperature.

3.2.5 *standard-curing, n*—storing test specimens in an environment of a specified temperature range, and under conditions that control the loss of moisture from the test specimens while the test specimens are in the field and while in the laboratory.

[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.

3.2.5.1 *Discussion—*
Standard-curing is intended to reduce the influence of variations by standardizing the temperature and moisture environment on the strength development of test specimens. Standard-curing includes requirements for the curing environment while the test specimens are in the field (10.1.2) and while the test specimens are in the laboratory (10.1.3).

4. Significance and Use

4.1 This practice provides standardized requirements for making, ~~curing, protecting, and transporting concrete test specimens under field conditions.~~ and curing test specimens in the field. This practice also provides requirements for transporting test specimens to the laboratory, and for curing test specimens in the laboratory. Depending on their purpose, test specimens are either standard-cured, or field-cured.

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~~ Uses of the test results of standard-cured test specimens include the following purposes:

4.2.1 Acceptance testing for specified concrete strength,

NOTE 2—Specification C94/C94M requires compressive-strength test specimens for acceptance to be standard-cured.

4.2.2 Checking adequacy of mixture proportions for concrete 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:~~ Uses of test results of field-cured test specimens include:

4.3.1 ~~Determination of whether a structure is capable of being put in service,~~Estimation of the in place concrete strength,

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.~~requirements, or

4.3.5 Post-tensioning.

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. Cardboard cylinder molds shall not be used for standard-cured specimens.

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 3 mm [1⁄8 in.] for molds with depth or breadth of 150 mm [6 in.] or more. Molds shall produce specimens at least as long but not more than 2 mm [1⁄16 in.] 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

TABLE 1 Tamping Rod Diameter Requirements

Diameter of Cylinder or Width of Beam mm [in.]	Diameter or Rod mm [in.]
<150 [6]	10 ± 2 [3⁄8 ± 1⁄16]
≥150 [6]	16 ± 2 [5⁄8 ± 1⁄16]

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~~3). The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

NOTE 3—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.

5.5 *Vibrators*—Internal vibrators shall be used. The vibrator frequency shall be at least 150 Hz [9000 vibrations per minute] 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 75 mm [3 in.]. The vibrator frequency shall be checked periodically with a vibrating-reed tachometer or other suitable device.

NOTE 4—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 0.6 kg ± 0.2 kg [1.25 lb ± 0.50 lb] 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/C231M.

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~~ 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~~ The length of the cylinder shall be twice the diameter of the cylinder. If the nominal maximum

TABLE 2 Minimum Cross-Sectional Dimension of Beams

Nominal Maximum Aggregate Size (NMAS)	Minimum Cross-Sectional Dimension
≤ 25 mm [1 in.]	100 mm by 100 mm [4 in. by 4 in.]
25 mm [1 in.] < NMAS ≤ 50 mm [2 in.]	150 mm by 150 mm [6 in. by 6 in.]

size of the ~~coarse aggregate exceeds 50 mm [2~~aggregate is 37.5 mm [1½ ~~in.], the concrete sample shall be treated by wet sieving through a 50 mm [2 in.] sieve as described in Practice~~ in.] or larger, acceptance test specimens for compressive strength shall be 150 mm by 300 mm [6 in. by 12 in.] cylinders. If the nominal maximum ~~C172/C172M. For~~ size of the aggregate is less than 37.5 mm [1½~~acceptance testing for specified compressive strength, cylinders shall be 150 mm~~ in.], acceptance test specimens for compressive strength shall be either 150 mm by 300 mm ~~[6 in.~~ [6 in. by 12 in.] cylinders or 100 ~~mm~~ by 200 mm ~~[4 in.~~ [4 in. by 8 in.] ~~(~~cylinders.~~Note 4)~~.

NOTE 5—See 7.2 for concrete containing coarse aggregate larger than 50 mm [2 in.] nominal maximum size.

NOTE 6—~~When~~If molds in SI units are required and not available, ~~equivalent inch-pound unit size mold~~ molds of equivalent size in inch-pound units should be permitted. If molds in inch-pound units are required and not available, molds of equivalent size in SI units should be permitted.

6.2 *Beam Specimens*—Flexural strength specimens shall be beams of concrete cast and hardened in the horizontal position. The length shall be at least 50 mm [2 in.] greater than three times the depth as tested. The ratio of width to depth as molded shall not exceed 1.5.

6.2.1 The minimum cross-sectional dimension of the beam shall be as stated in Table 2. Unless otherwise specified by the specifier of tests, the standard beam shall be ~~150~~150 mm by 150 mm ~~[6~~[6 in. by 6 in.] in cross section.

6.2.2 When the nominal maximum size of the coarse aggregate exceeds 50 mm [2 in.], the concrete sample shall be treated by wet sieving through a ~~50-mm [2-in.]~~50 mm [2 in.] sieve as described in Practice C172/C172M.

6.2.3 The specifier of tests shall specify the specimen size and the number of specimens to be tested to obtain an average test result (Note ~~5~~7). The same specimen size shall be used when comparing results and for mixture qualification and acceptance testing.

NOTE 7—The modulus of rupture can be determined using different specimen sizes. However, measured modulus of rupture generally increases as specimen size decreases.[5,6] The strength ratio for beams of different sizes depends primarily on the maximum size of aggregate.[7] Experimental data obtained in two different studies have shown that for maximum aggregate size between 19.0 mm and 25.0 mm [¾ in. and 1 in.], the ratio between the modulus of rupture determined with a 150 mm by 150 mm [6 in. by 6 in.] and a 100 mm by 100 mm [4 in. by 4 in.] may vary from 0.90 to 1.07[5] and for maximum aggregate size between 9.5 mm and 37.5 mm [⅜ in. and 1½ in.], the ratio between the modulus of rupture determined with a 150 mm by 150 mm [6 in. by 6 in.] and a 115 mm by 115 mm [4.5 in. by 4.5 in.] may vary from 0.86 to 1.00.[6]

6.3 *Field Technicians*—The field technicians making and curing specimens for acceptance testing shall meet the personnel qualification requirements of Practice C1077.

7. Sampling Concrete

7.1 ~~The samples used to fabricate test specimens under this standard shall be obtained~~ Sample the concrete in accordance with Practice C172/C172M ~~unless an alternative procedure has been approved.~~ after all adjustments, including water and admixture additions, have been made.

7.2 If the nominal maximum size of the coarse aggregate exceeds 50 mm [2 in.], wet sieve the concrete sample through a 50 mm [2 in.] sieve as described in Practice C172/C172M.

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

8. Fresh Concrete Tests

8.1 Perform the following tests for each sample of concrete from which specimens are made for acceptance testing for strength:

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[5] ~~Tanesi, J; Ardani, A. Leavitt, J. "Reducing the Specimen Size of Concrete Flexural Strength Test (AASHTO T97) for Safety and Ease of Handling," *Transportation Research Record: Journal of the Transportation Research Board*, No. 2342, Transportation Research Board of National Academies, Washington, D.C., 2013.~~Tanesi, J; Ardani, A. Leavitt, J. "Reducing the Specimen Size of Concrete Flexural Strength Test (AASHTO T97) for Safety and Ease of Handling," *Transportation Research Record: Journal of the Transportation Research Board,* No. 2342, Transportation Research Board of National Academies, Washington, D.C., Carrasquillo, P.M. and Carrasquillo, R. L "Improved Concrete Quality Control Procedures Using Third Point Loading", *Research Report 119-1F*, Project 3-9-87-1119, Center for Transportation Research, The University of Texas at Austin, November 1987.

[6] Carrasquillo, P.M. and Carrasquillo, R. L "Improved Concrete Quality Control Procedures Using Third Point Loading", *Research Report 119-1F*, Project 3-9-87-1119, Center for Transportation Research, The University of Texas at Austin, November 1987.

[7] Bazant, Z. and Novak, D. "Proposal for Standard Test of Modulus of Rupture of Concrete with its Size Dependence," *ACI Materials Journal*, January-February 2001.

8.1.1 *Slump or Slump Flow*—After remixing the sample in the receptacle, measure and record the slump or slump flow in accordance with Test Method C143/C143M or Test Method C1611/C1611M, respectively.

8.1.2 *Air Content*—Determine and record the air content in accordance with either Test Method C173/C173M or Test Method C231/C231M. The concrete used in performing the air content test shall not be used in fabricating test specimens.

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

NOTE 8—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 3, unless another method is specified. If the method of consolidation is rodding, determine molding requirements from Table 4. If the method of consolidation is vibration, determine molding requirements from Table 5. 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.

9.2.1 *Self-Consolidating Concrete*—If casting cylinders of self-consolidating concrete, use the mold filling procedures in Practice C1758/C1758M instead of the procedure in 9.2. After filling the mold, finish the cylinders in accordance with 9.5, without further consolidation.

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 3, unless another method is specified. If the method of consolidation is rodding, determine the molding requirements from Table 4. If the method of consolidation is vibration, determine the molding requirements from Table 5. Determine the number of roddings per layer, one for each 14 cm^2 [2 $in.^2$] 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.

9.3.1 *Self-Consolidating Concrete*—If casting beams of self-consolidating concrete, use the mold filling procedures in Practice C1758/C1758M instead of the procedure in 9.3. After filling the mold, finish the beams in accordance with 9.5, without further 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 25 mm [1 in.]. 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 cylinder molds that are susceptible to denting or other permanent distortion 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.

TABLE 3 Method of Consolidation Requirements

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

TABLE 4 Molding Requirements by Rodding

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

TABLE 5 Molding Requirements by Vibration

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

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 ~~7~~9). 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 6 mm [¼ in.].

NOTE 9—Generally, no more than 5 s of vibration should be required for each insertion to adequately consolidate concrete with a slump greater than 75 mm [3 in.]. 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 5. 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 vibrated, and into the layer below, about 25 mm [1 in.]. After each layer is vibrated, tap the outsides of the mold at least 10 times with the mallet, to close holes that remain and to release entrapped air voids. Use an open hand to tap molds that are susceptible to denting or other permanent distortion if tapped with a mallet.

9.4.2.2 *Beams*—Insert the vibrator at intervals not exceeding 150 mm [6 in.] along the center line of the long dimension of the specimen. For specimens wider than 150 mm [6 in.], use alternating insertions along two lines. Allow the shaft of the vibrator to penetrate into the bottom layer about 25 mm [1 in.]. After each layer is vibrated, tap the outsides of the mold sharply at least 10 times with the mallet to close holes left by vibrating and to release entrapped air voids.

9.5 *Finishing*—Perform all finishing with the minimum manipulation necessary to produce a flat even surface that is level with the rim or edge of the mold and that has no depressions or projections larger than 3.3 mm [⅛ in.].