Designation: C 31 – 91

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

This standard is issued under the fixed designation C 31; 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 practice has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This practice covers procedures for making and curing cylindrical and prismatic specimens using job concrete that can be consolidated by rodding or vibration as described herein.

1.2 The concrete used to make the molded specimens shall have the same levels of slump, air content, and percentage of coarse aggregate as the concrete being placed in the work.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety problems, 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 143 Test Method for Slump of Hydraulic Cement Concrete[2]

C 172 Practice for Sampling Freshly Mixed Concrete[2]

C 173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[2]

C 192 Practice for Making and Curing Concrete Test Specimens in the Laboratory[2]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[2]

C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically[2]

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[2]

C 617 Practice for Capping Cylindrical Concrete Specimens[2]

C 1064 Test Method for Temperature of Freshly Mixed Portland-Cement Concrete[2]

3. Significance and Use

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

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 Checking the adequacy of mixture proportions for strength,

3.2.2 To serve as the basis for comparison with laboratory, field or in-place tests, as the basis for safety and in-structure performance evaluation, and as the basis for form and shoring removal time requirements,

3.2.3 Determination of compliance with strength specifications, and

3.2.4 Determination of time when a structure may be put in service.

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 hold their dimensions and shape under conditions of severe use. Molds shall be watertight during use as judged by their ability to hold water poured into them. Provisions for tests of watertightness are given in the Test Methods for Elongation, Absorption, and Watertightness section of Specification C 470. 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.

4.2 *Cylinder Molds:*

4.2.1 *Molds for Casting Specimens Vertically*—Molds for casting concrete test specimens shall conform to the requirements of Specification C 470.

4.3 *Beam Molds*—Beam molds shall be rectangular in shape and of the dimensions required to produce the specimens stipulated in 5.2. 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. (3.2 mm) for molds with depth or breadth of 6 in. (152 mm) or more. Molds shall produce specimens not more than 1/16 in. (1.6 mm) shorter than the required length in accordance with 5.2, but may exceed it by more than that amount.

---

[1] This practice is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.01 on Methods of Testing Concrete for Strength.

Current edition approved Oct. 15, 1991. Published December 1991. Originally published as C 31 – 20. Last previous edition C 31 – 90a.

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

4.4 *Tamping Rod*—The rod shall be a round, straight steel rod ⅝ in. (16 mm) in diameter and approximately 24 in. (610 mm) long, with the tamping end rounded to a hemispherical tip of the same diameter. Both ends may be rounded, if preferred.

4.5 *Vibrators*—Internal vibrators may have rigid or flexible shafts, preferably powered by electric motors. The frequency or vibration shall be 7000 vibrations per minute or greater while in use. The outside diameter or side dimension of the vibrating element shall be at least 0.75 in. (19 mm) and not greater than 1.50 in. (38 mm). The combined length of the shaft and vibrating element shall exceed the maximum depth of the section being vibrated by at least 3 in. (76 mm). When external vibrators are used, they should be the table or plank type. The frequency of external vibrators shall be at least 3600 vibrations per minute. For both table and plank vibrators, provision shall be made for clamping the mold securely to the apparatus. A vibrating-reed tachometer should be used to check the frequency of vibration.

4.6 *Mallet*—A mallet with a rubber or rawhide head weighing 1.25 ± 0.50 lb (0.57 ± 0.23 kg) shall be used.

4.7 *Small Tools*—Tools and items which may be required are shovels, pails, trowels, wood float, metal float, blunted trowels, straightedge, feeler gage, scoops, and rules.

4.8 *Slump Apparatus*—The apparatus for measurement of slump shall conform to the requirements of Test Method C 143.

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

4.10 *Air Content Apparatus*—The apparatus for measuring air content shall conform to the requirements of Test Methods C 173 or C 231.

5. Test Specimens

5.1 *Compressive Strength Specimens*—Compressive strength specimens shall be cylinders of concrete cast and hardened in an upright position, with a length equal to twice the diameter. The standard specimen shall be the 6 by 12-in. (152 by 305-mm) cylinder when the maximum size of the coarse aggregate does not exceed 2 in. (50 mm). When the maximum size of the coarse aggregate does exceed 2 in. (50 mm), either the concrete sample shall be treated by wet sieving as described in Practice C 172 or the diameter of the cylinder shall be at least three times the nominal maximum size of coarse aggregate in the concrete. Unless required by the project specifications, cylinders smaller than 6 of 12 in. shall not be made in the field.

NOTE 1—The maximum size is the smallest sieve opening through which the entire amount of aggregate is required to pass.

5.2 *Flexural Strength Specimens*—Flexural strength specimens shall be rectangular beams of concrete cast and hardened with long axes horizontal. 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. (152 by 152 mm) in cross section, and shall be used for concrete with 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.

6. Sampling Concrete

6.1 The samples used to fabricate test specimens under this standard shall be obtained in accordance with Practice C 172 unless an alternative procedure has been approved.

6.2 Record the identity of the sample with respect to the location of the concrete represented and the time of casting.

7. Slump, Air Content, and Temperature

7.1 *Slump*—Measure the slump of each batch of concrete, from which specimens are made, immediately after remixing in the receptacle, as required in Test Method C 143.

7.2 *Air Content*—Determine the air content in accordance with either Test Method C 173 or Test Method C 231. The concrete used in performing the air content test shall not be used in fabricating test specimens.

7.3 *Temperature*—Determine the temperature in accordance with Test Method C 1064.

8. Molding Specimens

8.1 *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.

8.2 *Placing the Concrete*—Place the concrete in the molds using a scoop, blunted trowel, or shovel. Select each scoopful, trowelful, or shovelful of concrete from the mixing pan to ensure that it is representative of the batch. Remix the concrete in the mixing pan with a shovel or trowel to prevent segregation during the molding of specimens. Move the scoop, trowel, or shovel around the perimeter of the mold opening when adding concrete to ensure an even distribution of the concrete and minimize segregation. Further distribute the concrete by use of a tamping rod prior to the start of consolidation. In placing the final layer the operator shall attempt to add an amount of concrete that will exactly fill the mold after compaction. Do not add nonrepresentative concrete to an underfilled mold.

8.2.1 *Number of Layers*—Make specimens in layers as indicated in Table 1.

8.3 *Consolidation:*

8.3.1 *Methods of Consolidation*—Preparation of satisfactory specimens requires different methods of consolidation. The methods of consolidation are rodding, and internal or external vibration. Base the selection of the method of consolidation on the slump, unless the method is stated in the specifications under which the work is being performed. Rod concretes with a slump greater than 3 in. (75 mm). Rod or vibrate concretes with slump of 1 to 3 in. (25 to 75 mm). Vibrate concretes with slump of less than 1 in. (25 mm). Concretes of such low water content that they cannot be properly consolidated by the methods described herein, or requiring other sizes and shapes of specimens to represent the product or structure, are not covered by this method. Specimens for such concretes shall be made in accordance with the requirements of Practice C 192 with regard to

TABLE 1 Number of Layers Required for Specimens

Specimen Type and Size, or Depth, in. (mm)	Mode of Compaction	Number of Layers	Approximate Depth of Layer, in. (mm)
Cylinders:			
12 (305)	rodding	3 equal	4 (100)
Over 12 (305)	rodding	as required	4 (100)
12 (305) to 18 (460)	vibration	2 equal	half depth of specimens
Over 18 (460)	vibration	3 or more	8 (200) as near as practicable
Beams:			
6 (152) to 8 (200)	rodding	2 equal	half depth of specimen
Over 8 (200)	rodding	3 or more	4 (100)
6 (152) to 8 (200)	vibration	1	depth of specimen
Over 8 (200)	vibration	2 or more	8 (200) as near as practicable

TABLE 2 Number of Roddings to be Used in Molding Cylinder Specimens

Diameter of Cylinder, in. (mm)	Number of Strokes/Layer
6 (152)	25
8 (200)	50
10 (250)	75

specimen size and shape and method of consolidation.

8.3.2 *Rodding*—Place the concrete in the mold, in the required number of layers of approximately equal volume. For cylinders, rod each layer with the rounded end of the rod using the number of strokes specified in Table 2. The number of roddings per layer required for beams is one for each 2-in.^{2} (13-cm^2) top surface area of the specimen. Rod the bottom layer throughout its depth. Distribute the strokes uniformly over the cross section of the mold and for each upper layer allow the rod to penetrate about ½ in. (12 mm) into the underlying layer when the depth of the layer is less than 4 in. (100 mm), and about 1 in. (25 mm) when the depth is 4 in. or more. 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-gage single-use molds which are susceptible to damage if tapped with a mallet. After tapping, spade the concrete along the sides and ends of beam molds with a trowel or other suitable tool.

8.3.3 *Vibration*—Maintain a uniform time period for 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. Continue vibration only long enough to achieve proper consolidation of the concrete. Overvibration may cause segregation. 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. When placing the final layer, avoid overfilling by more than ¼ in. (6 mm). Finish the surface either during or after vibration where external vibration is used. Finish the surface after vibration when internal vibration is used. When the finish is applied after vibration, add only enough concrete with a trowel to overfill the mold about ⅛ in. (3 mm). Work it into the surface and then strike it off.

8.3.3.1 *Internal Vibration*—The diameter of the vibrating element, or thickness of a square vibrating element, shall be in accordance with the requirements of 4.5. For beams, the vibrating element shall not exceed ⅓ of the width of the mold. For cylinders, the ratio of the diameter of the cylinder to the diameter of the vibrating element shall be 4.0 or higher. In compacting the specimen the vibrator shall not be allowed to rest on the bottom or sides of the mold. Carefully withdraw the vibrator in such a manner that no air pockets are left in the specimen.

8.3.3.2 *Cylinders*—Use three insertions of the vibrator at different points for each layer. Allow the vibrator to penetrate through the layer being vibrated, and into the layer below, approximately 1 in. (25 mm). After each layer is vibrated, tap the outsides of the mold lightly 10 to 15 times with the mallet, to close any holes that remain and to release any large air bubbles that may have been trapped. Use an open hand to tap light-gage single-use molds which are susceptible to damage if tapped with a mallet.

8.3.3.3 *Beam*—Insert the vibrator at intervals not exceeding 6 in. (150 mm) along the center line of the long dimension of the specimen. For specimens wider than 6 in., use alternating insertions along two lines. Allow the shaft of the vibrator to penetrate into the bottom layer approximately 1 in. (25 mm). After each layer is vibrated, tap the outsides of the mold lightly 10 to 15 times with the mallet to close any holes left by vibrating and to release any large air bubbles that may have been trapped.

8.3.4 *External Vibration*—When external vibration is used, take care to ensure that the mold is rigidly attached to or securely held against the vibrating element or vibrating surface.

8.4 *Finishing*—After consolidation, unless the finishing has been performed during the vibration (8.3.3), strike off the surface of the concrete and float or trowel it as required. 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 ⅛ in. (3.2 mm).

8.4.1 *Cylinders*—After consolidation, finish the top surfaces by striking them off with the tamping rod where the consistency of the concrete permits or with a wood float or trowel. If desired, cap the top surface of freshly made cylinders with a thin layer of stiff portland cement paste which is permitted to harden and cure with the specimen. See section on Capping Materials of Practice C 617.

8.4.2 *Beams*—After consolidation of the concrete, strike off the top surface to the required tolerance to produce a flat

even surface. A wood float may be used.

8.5 Mark the specimens to positively identify them and the concrete they represent. Use a method that will not alter the top surface of the concrete. Do not mark the removable caps. Upon removal of the molds, mark the test specimens to retain their identities.

8.6 *Initial Storage*—Immediately after being struck off, the specimens shall be moved to the storage place where they will remain undisturbed for the initial curing period. If specimens made in single use molds are moved, lift and support the specimens from the bottom of the molds with a large trowel or similar device.

9. Curing

9.1 *Covering After Finishing*—Immediately after finishing, precautions shall be taken to prevent evaporation and loss of water from the specimens. Protect the outside surfaces of cardboard molds from contact with wet burlap or other sources of water. Cardboard molds may expand and damage specimens at an early age if the outside of the mold absorbs water. Cover specimens with a nonabsorbent, nonreactive plate or sheet of impervious plastic. Wet burlap may be used over the plate or plastic sheet to help retard evaporation, but the burlap must not be in contact with the surface of the concrete.

9.2 *Curing Specimens for Checking the Adequacy of Mixture Proportions for Strength or as the Basis for Acceptance or Quality Control:*

9.2.1 *Initial Curing*—After molding, the specimens shall be stored in a temperature range between 60 to 80°F (16 to 27°C) and in a moist environment preventing any loss of moisture up to 48 h (Note 2). At all times the temperature in and between specimens shall be controlled by shielding from direct rays of the sun and radiant heating devices. Specimens that are to be transported to the laboratory for standard curing (see 9.2.2) before 48 h shall remain in the molds in a moist environment, until they are received in the laboratory, demolded and placed in standard curing. If specimens are not transported within 48 h, the molds shall be removed within 24 ± 8 h and standard curing used until transported (see 10.1).

NOTE 2—It may be necessary to create an environment during initial curing to provide satisfactory moisture and to control the temperature. The specimens may be immersed immediately in saturated limewater, and/or stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap, or in heavyweight closed plastic bags. Immersing in saturated limewater is not acceptable for specimens in cardboard or other molds that expand when immersed in water. Other suitable methods may be used provided the foregoing requirements limiting specimen temperature and moisture loss are met. The temperature may be controlled by ventilation, or thermostatically controlled cooling devices, or by heating devices such as stoves, light bulbs, or thermostatically controlled heating elements. Temperature record of the specimens may be established by means of maximum-minimum thermometers. Early age results may be lower when stored near 60°F (16°C) and higher when stored near 80°F (27°C).

9.2.2 *Standard Curing:*

9.2.2.1 *Cylinders*—Upon completion of initial curing and within 30 min after removing the molds, store specimens in a moist condition with free water maintained on their surfaces at all times at a temperature of 73.4 ± 3°F (23 ± 1.7°C). Temperatures between 68 and 86°F (20 and 30°C) are permitted for a period not to exceed 3 h immediately prior to test if free moisture is maintained on the surfaces of the specimen at all times, except when capping with sulfur mortar capping compound. When capping with this material, the ends of the cylinder will be dried as described in Practice C 617. Specimens shall not be exposed to dripping or running water. The required moist storage can be obtained by immersion in saturated limewater and may be obtained by storage in a moist room or cabinet meeting the requirements of Specification C 511.

9.2.2.2 *Beams*—Beams are to be cured the same as cylinders (see 9.2.2.1) except for a minimum of 20 h prior to testing, they shall be stored in saturated limewater at 73.4 ± 3°F (23 ± 1.7°C). Drying of the surfaces of the beam shall be prevented between removal from limewater and completion of testing.

NOTE 3—Relatively small amounts of surface drying of flexural specimens can induce tensile stresses in the extreme fibers that will markedly reduce the indicated flexural strength.

9.3 *Curing for Determining Form Removal Time or When a Structure May be Put into Service:*

9.3.1 *Cylinders*—Store cylinders in or on the structure as near to the point of deposit of the concrete represented as possible. Protect all surfaces of the cylinders from the elements in as near as possible the same way as the formed work. Provide the cylinders with the same temperature and moisture environment as the structural work. Test the specimens in the moisture condition resulting from the specified curing treatment. To meet these conditions, specimens made for the purpose of determining when a structure may be put in service shall be removed from the molds at the time of removal of form work.

9.3.2 *Beams*—As nearly as practicable, cure beams in the same manner as the concrete in the structure. At the end of 48 ± 4 h after molding, take the molded specimens to the storage location and remove from the molds. Store specimens representing pavements of slabs on grade by placing them on the ground as molded, with their top surfaces up. Bank the sides and ends of the specimens with earth or sand that shall be kept damp, leaving the top surfaces exposed to the specified curing treatment. Store specimens representing structure concrete as near the point in the structure they represent as possible, and afford them the same temperature protection and moisture environment as the structure. At the end of the curing period leave the specimens in place exposed to the weather in the same manner as the structure. Remove all beam specimens from field storage and store in limewater at 73.4 ± 3°F (23 ± 1.7°C) for 24 ± 4 h immediately before time of testing to ensure uniform moisture condition from specimen to specimen. Observe the precautions given in 9.2.2.2 to guard against drying between time of removal from curing to testing.

10. Transportation of Specimens to Laboratory

10.1 Prior to transporting, specimens shall be cured and protected as required in Section 9. During transportation, the specimens must be protected with suitable cushioning mate-

rial to prevent damage from jarring and from freezing temperatures, or moisture loss. Moisture loss may be prevented by wrapping the specimens in plastic or surrounding them with wet sand or wet saw dust. Transportation shall not exceed 4 h.