Standard Test Method for Making, Accelerated Curing, and Testing Concrete Compression Test Specimens[1]

This standard is issued under the fixed designation C 684; 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.

1. Scope

1.1 This test method covers four procedures for making, curing, and testing specimens of concrete stored under conditions intended to accelerate the development of strength. The four procedures are: Procedure A—Warm Water Method, Procedure B—Boiling Water Method, Procedure C—Autogenous Curing Method, and Procedure D—High Temperature and Pressure Method.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are provided for information purposes only.

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.* See Section 9 and Note 9 and Note 14 for specific warnings and precautions.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 31/C 31M Practice for Making and Curing Concrete Test Specimens in the Field

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens

C 172 Practice for Sampling Freshly Mixed Concrete

C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

C 192/C 192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically

C 617 Practice for Capping Cylindrical Concrete Specimens

C 1231 Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

D 3665 Practice for Random Sampling of Construction Materials

E 105 Practice for Probability Sampling of Materials

E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for Characteristics of a Lot or Process

E 141 Practice for Acceptance of Evidence Based on the Results of Probability Sampling

3. Terminology

3.1 There are no terms in this standard that require new or other than dictionary definitions.

4. Summary of Test Method

4.1 Concrete specimens are exposed to accelerated curing conditions that permit the specimens to develop a significant portion of their ultimate strength within a time period ranging from 5 to 49 h, depending upon the procedure that is used. Procedures A and B utilize storage of specimens in heated water at elevated curing temperatures without moisture loss. The primary function of the moderately heated water used in Procedure A is to serve as insulation to conserve the heat generated by hydration. The temperature level employed in Procedure B provides thermal acceleration. Procedure C involves storage of specimens in insulated curing containers in which the elevated curing temperature is obtained from heat of hydration of the cement. The sealed containers also prevent moisture loss. Procedure D involves simultaneous application of elevated temperature and pressure to the concrete using special containers. Sampling and testing procedures are the same as for normally cured specimens (see Practice C 172 and Test Method C 39, respectively).

---

[1] This test method 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.

Current edition approved Nov. 10, 1999. Published February 2000. Originally approved in 1971. Last previous edition approved in 1999 as C 684 – 99.

[2] 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.

4.2 Important characteristics of these procedures are shown in Table 1.

5. Significance and Use

5.1 The accelerated curing procedures provide, at the earliest practical time, an indication of the potential strength of a specific concrete mixture. These procedures also provide information on the variability of the production process for use in quality control.

5.2 The accelerated early strength obtained from any of the procedures in this test method can be used to evaluate concrete strengths in the same way conventional 28-day strengths have been used in the past, with suitable changes in the expected strength values. Since the practice of using strength values obtained from standard-cured cylinders at 28 days is long established and widespread, the results of accelerated strength tests are often used to estimate the later-age strength under standard curing. Such estimates should be limited to concretes using the same materials and mixture proportions as those used for establishing the correlation. Appendix X2 provides a procedure to estimate the 90 % confidence interval of the average later-age strength based on accelerated strength test results.

5.3 Correlation between accelerated strength and strength achieved at some later age by using conventional curing methods depends upon the materials comprising the concrete, the mixture proportions, and the specific accelerated test procedure.

5.4 The user shall choose which procedure to use on the basis of experience and local conditions. These procedures, in general, will be practical when a field laboratory is available to house the curing containers and the testing equipment to measure compressive strength within the specified time limits.

6. Interferences

6.1 When wet sieving of the concrete sample is required prior to molding the test specimens due to maximum aggregate size limitations (such as Procedure D, which is limited to 25 mm maximum), consider the effect of wet sieving on the air content and strength of the test specimens.

7. Apparatus

7.1 Equipment and small tools for fabricating specimens, measuring slump, and determining air content shall conform to Practice C 31/C 31M.

7.2 *Molds*:

7.2.1 Cylinder molds for test specimens used in Procedures A, B, and C shall conform to Specification C 470. Paper molds are excluded. When specimens are to be tested without capping, use only reusable molds with machined end plates that can be securely connected to both top and bottom of the mold. The end plates shall produce specimens with bearing surfaces that are plane within 0.05 mm (0.002 in.) and whose ends do not depart from perpendicularity to the axis of the cylinder by more than 0.5° (approximately equivalent to 10 mm/m (⅛ in. in 12 in.). When assembled, the mold assembly is sufficiently tight to permit the filled mold to be turned from the vertical filling position to a horizontal curing position without loss of mortar or damage to the test specimen.

7.2.2 Cylinder molds for Procedure D shall conform to the following:

7.2.2.1 Made of stainless steel,

7.2.2.2 Equipped with removable top and bottom metal plugs and O-ring seals,

7.2.2.3 Equipped with a heating element capable of raising the concrete temperature within the mold to 150 ± 3°C (300 ± 5°F) within 30 ± 5 min, and are capable of maintaining this temperature throughout the time required by the test procedure,

7.2.2.4 Equipped with devices to measure the temperature within each mold to ascertain that the temperature of the concrete satisfies the temperature requirements stated herein, and

7.2.2.5 Equipped with a companion loading component capable of maintaining a pressure of 10.3 MPa ± 0.2 MPa (1500 ± 25 psi) on the concrete during the curing period.

7.3 *Curing Apparatus*:

7.3.1 *Accelerated Curing Tank for Procedures A and B*:

7.3.1.1 The tank is of any configuration suitable for the number of cylinders to be tested. Arrange the cylinders in any configuration that provides a clearance of at least 50 mm (2 in.) between the side of each cylinder and the side of the tank, and at least 100 mm (4 in.) between adjacent cylinders. Maintain the water level at least 100 mm (4 in.) above the tops of the cylinders.

NOTE 1—Provision for an overflow pipe is a convenience in controlling the maximum depth of water. A number of different tanks have been used successfully. Guidelines are given in Appendix X1.

TABLE 1 Characteristics of Accelerated Curing Procedures

Procedure	Molds	Source of Strength Acceleration	Accelerated Curing Temperature °C (°F)	Age Accelerated Curing Begins	Duration of Accelerated Curing	Age at Testing
A. Warm Water	reusable or single-use	heat of hydration	35 (95)	immediately after casting	23.5 h ± 30 min	24 h ± 15 min
B. Boiling Water	reusable or single-use	boiling water	boiling	23 h ± 30 min after casting	3.5 h ± 5 min	28.5 h ± 15 min
C. Autogenous	single-use	heat of hydration	initial concrete temperature augmented by heat of hydration	immediately after casting	48 h ± 15 min	49 h ± 15 min
D. High-Temperature and Pressure	reusable	external heat and pressure	150 (300)	immediately after casting	5 h ± 5 min	5.25 h ± 5 min[A]

[A] Add 30 min if capping with sulfur compound is used.

7.3.1.2 Equip the tank with environmental control element(s) capable of: (*1*) providing the specified water temperature, (*2*) maintaining the water temperature within ±3°C (±5°F) of the specified value at any point in the water, and (*3*) limiting the temperature drop, after immersion of specimens, to less than 3°C (5°F) and returning to the specified water temperature within 15 min. Thermometers or other temperature recording devices are required, independent of the thermostat, to check the temperature of the water.

NOTE 2—Depending upon the design features of the tank, insulation or mechanical agitation, or both, might be necessary to meet the specified temperature requirements. Electrical immersion heaters controlled by a thermostat are one suitable form of heating elements. For a particular procedure, the size of the heating element required will depend upon the size of the tank and the number of specimens to be cured at one time.

7.3.1.3 The plate supporting the specimens is perforated to permit circulation of the water.

7.3.1.4 A close fitting lid to reduce evaporation is required for Procedure B but is optional for Procedure A.

7.3.2 *Curing Container for Procedure C*:

7.3.2.1 The container consists of thermal insulation meeting heat retention requirements of 12.2.1 and closely surrounding the concrete specimen.

7.3.2.2 The container is capable of being opened to permit insertion and withdrawal of the specimen and has an outer casing and inner liner to protect the insulation from mechanical damage.

7.3.2.3 The container has a maximum-minimum recording thermometer which is not insulated from the concrete specimen (see Note 10).

7.3.2.4 The container has a lid or other means to provide secure closure during the specified curing period. The lid includes a heat seal that satisfies the requirements of 12.2.2.

7.3.2.5 The container is capable of holding either one or two specimens.

NOTE 3—Examples of suitable containers are included in Appendix X1. Any configuration is acceptable provided it meets the performance requirements of 12.2.

7.3.3 *Curing Apparatus for Procedure D*:

7.3.3.1 The curing apparatus consists of a loading system to apply the specified pressure to the concrete specimens and special molds to maintain the concrete specimens at the specified temperature during the curing period. The curing apparatus can be of any configuration suitable for the number of cylindrical specimens to be tested. Appendix X1 describes a successful apparatus designed for curing three specimens.

7.4 *Capping Apparatus*:

7.4.1 If capping of the test specimens is required, use the apparatus specified in Practice C 617 or Practice C 1231.

8. Materials

8.1 Capping compound or pad caps for use when the ends of the test specimens are unsuitable for testing without capping.

9. Hazards

9.1 Observe OSHA requirements and standard laboratory and field safety precautions when sampling, molding, curing, and testing concrete.

9.2 Observe the additional safety measures indicated when using Procedure B to prevent scalding or other burns resulting from the use of boiling water as a curing medium.

9.3 Observe the additional safety measures indicated when using Procedure D to prevent injury due to the high temperature and pressure used for curing.

10. Sampling

10.1 Determine the number of tests required from the concrete lot(s) or process. Use a random or systematic plan that provides the number of tests needed to characterize the strength of the concrete used in the construction.

10.2 If the lot(s) or process is stratified into sublots, locate the samples using a stratified random procedure. If circumstances dictate a non-stratified approach, use a random procedure.

NOTE 4—A stratified random sampling procedure can be implemented by dividing each lot of concrete into a number of equal-sized sublots, and randomly selecting a sample from each sublot. The number of sublots equals the number of samples that were scheduled to be taken from the lot. For example, if the job requirements called for each 500 m^3 of concrete to be treated as a lot and that five samples be obtained from each lot to determine compressive strength, divide the lot into five equal-sized sublots of 100 m^3 each. Randomly obtain one sample from each sublot. Test results from the five samples obtained in this manner provide unbiased estimates of the compressive strength of the 500 m^3 lot. This is the most practical approach to ensure that the samples obtained include the entire range of concrete in the production process. If unequal size sublots occur due to the construction process, weighting of the test results may be appropriate to maintain the fairness and defensibility of the sampling procedure.

NOTE 5—Practice D 3665 contains a table of random numbers, including instructions for use. Practices E 105, E 122, and E 141 contain additional information concerning sampling practices.

10.3 Sample the freshly mixed concrete in accordance with Practice C 172. Record in the job records the location at which the sampled batch is used in the structure.

11. Preparation of Apparatus

11.1 *Methods A and B*:

11.1.1 Activate the environmental control elements at least 1 h prior to the start of a scheduled test to allow the temperature of the water and equipment to stabilize.

11.2 *Method C*:

11.2.1 Conduct the proving tests specified in Section 12 prior to scheduling tests.

11.3 *Method D*:

11.3.1 Clean and check the molds and end plugs before starting a test. Standardize the loading system in accordance with Section 12 prior to scheduling tests.

12. Standardization

12.1 For all methods, verify the calibration of temperature measurement, control, and recording components on a frequent periodic basis. Calibrate such components in accordance with the manufacturer's recommendations or standard laboratory practice.

12.2 *Method C Requirements*:

12.2.1 *Heat Retention*—Place a watertight cylindrical container with internal dimensions of 300 mm (12 in.) in height by