



Designation: C 1646/C 1646M – 07

Standard Practice for Making and Curing Test Specimens for Evaluating Frost Resistance of Coarse Aggregate in Air-Entrained Concrete by Rapid Freezing and Thawing¹

This standard is issued under the fixed designation C 1646/C 1646M; 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 practice covers procedures for making and curing test specimens for evaluating frost resistance of normal-weight coarse aggregates in air-entrained concrete in accordance with Test Method C 666/C 666M, Procedure A or B.

1.2 The values stated in either inch-pound or SI units shall be regarded separately as standard. The SI units are shown in brackets. 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 nonconformance with the standard.

1.3 *This practice does not purport to address all 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 skin and tissue upon prolonged use.²)*

2. Referenced Documents

2.1 *ASTM Standards:*³

C 33 Specification for Concrete Aggregates

C 39/C 39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C 143/C 143M Test Method for Slump of Hydraulic-Cement Concrete

C 150 Specification for Portland Cement

C 173/C 173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

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

C 231 Test Method for Air Content of Freshly Mixed

Concrete by the Pressure Method

C 490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete

C 494/C 494M Specification for Chemical Admixtures for Concrete

C 666/C 666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing

D 75 Practice for Sampling Aggregates

2.2 *ACI Standard:*⁴

211.1 Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete

3. Significance and Use

3.1 This practice provides standard requirements for evaluating frost-susceptible coarse aggregate in air-entrained concrete subjected to freezing and thawing in accordance with Test Method C 666/C 666M.

3.2 Concrete containing frost-resistant paste may not be resistant to freezing and thawing if it contains coarse aggregate that becomes critically saturated. An aggregate particle is considered to be critically saturated when there is insufficient unfilled pore space to accommodate the expansion of water that accompanies the freezing.

3.3 The potential of the coarse aggregate to cause damage due to cycles of freezing and thawing is evaluated by Test Method C 666/C 666M.

4. Apparatus

4.1 Equipment for mixing concrete and procedures for making and curing test specimens shall be in accordance with Practice C 192/C 192M.

5. Coarse Aggregate Preparation

5.1 *Sampling*—Sample in accordance with Practice D 75.

5.2 *Grading*—When coarse aggregates are to be compared using this practice, standardize the coarse aggregate gradings by recombining individual size fractions in accordance with

¹ This practice is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.67 on Resistance to the Environment.

Current edition approved Jan. 15, 2007. Published February 2007.

² Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Volume 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.



TABLE 1 Grading Requirements

Size No.	Nominal Max. Size	Amounts Finer Than Each Laboratory Sieve, Mass Percent									
		1 ½ in. [37.5 mm]	1 in. [25.0 mm]	¾ in. [19.0 mm]	½ in. [12.5 mm]	⅜ in. [9.5 mm]	No. 4 [4.75 mm]	No. 8 [2.36 mm]	No. 16 [1.18 mm]	No. 50 [300 µm]	No. 100 [150 µm]
467	1 ½ in. [37.5 mm]	100	70	50	30	20	0				
56	1 in. [25.0 mm]		100	60	25	0					
57	1 in. [25.0 mm]		100	75	40		0				
6	¾ in. [19.0 mm]			100	35	0					
67	¾ in. [19.0 mm]			100	60	35	0				
7	½ in. [12.5 mm]				100	55	0				
8	⅜ in. [9.5 mm]					100	20	0			
89	⅜ in. [9.5 mm]					100	35	15	0		
Fine Aggregate	No. 4 [4.75 mm]						100		65-75	12-20	2-5

Table 1 for the appropriate size aggregate being tested. Bring the as-received sample to a saturated-surface-dry (SSD) condition or drier prior to sieving. Do not oven-dry the coarse aggregate sample. If necessary, air drying of the sample to achieve this condition is permitted. The nominal-maximum-aggregate size shall not exceed one-third the least dimension of the test specimen to be used. Fine aggregate shall meet the requirements of Specification C 33 and the grading shall conform to Table 1.

5.3 *Conditioning*—Condition fine and coarse aggregates as follows:

5.3.1 *Fine Aggregate*—Uniformly wet the fine aggregate 24 h prior to mixing of concrete so that the moisture content exceeds the saturated-surface-dry condition but there is no tendency for loss of surface water by draining. Keep the fine aggregate covered to prevent evaporation prior to use.

5.3.2 *Coarse Aggregate*—Immerse the coarse aggregate in water 24 h prior to mixing of concrete. On the day of mixing, decant the water from the coarse aggregate.

6. Concrete Mixture

6.1 *Ingredients*—The portland cement shall meet the requirements of Specification C 150, Type I or Type II. Batches for a particular test series shall use cement, fine aggregate, and air-entraining admixture taken from the same lot.

6.2 *Air-entraining admixture*—As described in Specification C 494/C 494M, section on Air-Entraining Admixture.

6.3 *Proportions*—Except when tests are being made where mixture proportions are those proposed for the work, proportion all concrete using ACI 211.1 conforming to the following requirements:

6.3.1 The cement content shall be 517 ± 5 lb/yd³ [307 ± 3 kg/m³]

6.3.2 The air content used in the computation of mixture proportions shall be in accordance with Table 2. The amount of air-entraining admixture used shall be such as to give an air content as prescribed in Table 2, ± 1 %, when tested according to Test Method C 231 or Test Method C 173/C 173M.

6.3.3 The mixture shall contain the amount of coarse aggregate shown in the “Volume of Coarse Aggregate Per Unit of Volume of Concrete” table of ACI 211.1 for the nominal-

TABLE 2 Target Total Air Content

	Nominal Maximum Size of Aggregate, in. [mm]				
	¾ [9.5]	½ [12.5]	¾ [19.0]	1 [25.0]	1 ½ [37.5]
Total Air Content, %	7.5	7.0	6.0	6.0	5.5

maximum size of aggregate and for the fineness modulus of the fine aggregate being used.

6.3.4 Adjust the water content and fine aggregate content to obtain a slump of 3 ± 1 in. [75 ± 25 mm] when tested in accordance with Test Method C 143/C 143M.

6.4 *Mixing*—Machine mix the concrete as prescribed in Practice C 192/C 192M.

7. Specimen Preparation and Conditioning

7.1 *Specimen Preparation*—The type and size of the test specimen and the method for molding shall be in accordance with the Test Specimen section of Test Method C 666/C 666M, unless otherwise specified. If length change testing is to be performed as a permitted option in Test Method C 666/C 666M, fit the specimens with axially centered stainless steel gauge studs in accordance with Practice C 490.

7.2 *Number of Specimens*—Make at least three freezing-and-thawing test specimens from each batch. In addition, make at least three cylindrical specimens from each batch for strength verification. The cylindrical specimens shall be made in accordance with Practice C 192/C 192M and tested in accordance with Test Method C 39/C 39M.

7.3 *Curing*—Complete initial storage and remove from molds in accordance with Practice C 192/C 192M. After removal from the molds, inspect for defects and store in saturated limewater at 73.5 ± 3.5 °F [23.0 ± 2.0 °C] to an age of 14 days.

8. Method of Test

8.1 After the specimens have cured, test in accordance with Procedure A or Procedure B of Test Method C 666/C 666M.

9. Keywords

9.1 aggregate; coarse aggregate; freezing and thawing; frost resistance