
Standard Method of Test for Resistance of Concrete to Rapid Freezing and Thawing

AASHTO Designation: T 161-22

Technically Revised: 2022

Technical Subcommittee: 3c, Hardened Concrete

ASTM Designation: C666/C666M-15



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1. SCOPE

- 1.1. This method covers the determination of the resistance of concrete specimens to rapidly repeated cycles of freezing and thawing in the laboratory by two different procedures: Procedure A, Rapid Freezing and Thawing in Water, and Procedure B, Rapid Freezing in Air and Thawing in Water. Both procedures are intended for use in determining the effects of variations in the properties of concrete on the resistance of the concrete to the freezing and thawing cycles specified in the particular procedure. Neither procedure is intended to provide a quantitative measure of the length of service that may be expected from a specific type of concrete.
- 1.2. The values stated in 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 nonconformance with the standard.
- 1.3. All material in this test method not specifically designated as belonging to Procedure A or Procedure B applies to either procedure.
- 1.4. *This standard does not purport to address all of the safety concerns 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.*
- 1.5. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- M 194M/M 194, Chemical Admixtures for Concrete
 - M 339M/M 339, Thermometers Used in the Testing of Construction Materials

- < R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- < R 39, Making and Curing Concrete Test Specimens in the Laboratory
- < R 70M/R 70, Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
- < T 157, Air-Entraining Admixtures for Concrete

2.2. *ASTM Standards:*

- < C215, Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens
- < C295/C295M, Standard Guide for Petrographic Examination of Aggregates for Concrete
- < C341/C341M, Standard Practice for Preparation and Conditioning of Cast, Drilled, or Sawed Specimens of Hydraulic-Cement Mortar and Concrete Used for Length Change Measurements
- < C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- < C823/C823M, Standard Practice for Examination and Sampling of Hardened Concrete in Constructions
- < E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- < E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- < E2877, Standard Guide for Digital Contact Thermometers
- < Klieger, P., and J. Lamond, eds. *Significance of Tests and Properties of Concrete and Concrete-Making Materials*. STP169C and STP169D. ASTM International, West Conshohocken, PA, 1994. Available from <https://doi.org/10.1520/STP169C-EB> and <https://doi.org/10.1520/STP169D-EB>

2.3. *International Electrotechnical Commission Standard:*

- < IEC 60584-1:2013 Thermocouples - Part 1: EMF Specifications and Tolerances

3. SIGNIFICANCE AND USE

- 3.1. As noted in the scope, the two procedures described in this method are intended to determine the effects of variations in both properties and conditioning of concrete in the resistance to freezing and thawing cycles specified in the particular procedure. Specific applications include specified use in M 194M/M 194, T 157, and ranking of coarse aggregates as to their effect on concrete freeze-thaw durability, especially where soundness of the aggregate is questionable.
- 3.2. It is assumed that the procedures will have no significantly damaging effects on frost-resistant concrete that may be defined as (1) any concrete not critically saturated with water (that is, not sufficiently saturated to be damaged by freezing) and (2) concrete made with frost-resistant aggregates and having an adequate air-void system that has achieved appropriate maturity and thus will prevent critical saturation by water under common conditions.
- 3.3. If, as a result of performance tests as described in this method, concrete is found to be relatively unaffected, it can be assumed that it was either not critically saturated or was made with “sound” aggregates, a proper air-void system, and allowed to mature properly.
- 3.4. No relationship has been established between the resistance to cycles of freezing and thawing of specimens cut from hardened concrete and specimens prepared in the laboratory.

Note 1—There is no apparent reason to expect a difference in performance in these two procedures if the concrete properties are fundamentally the same. However, the fact that these two conditions may have been executed with different consolidation procedures or other procedures could affect the number and size of empty, and possibly water-filled voids, which could affect test results.

- 3.5. There is no specific guidance in this standard on choosing between Procedure A and Procedure B for a given application, except when contained in another standard. Standards T 157 and M 194M/M 194 both stipulate Procedure A.
- 3.5.1. In many instances, the choice is based on the user's determination of suitability to a specific application.
 - 3.5.1.1. Procedure A is generally considered to be more aggressive of the two and to better reveal defective materials, although some consider the constant saturation of the test specimens to be unrealistic.
 - 3.5.1.2. Some users prefer Procedure B as being more representative of the saturation patterns in some field applications.
- 3.5.2. A more complete discussion of the significance and use can be found in ASTM STP169C and STP169D.
- 3.6. The accuracy of testing for the purpose of verifying compliance with a quantitative specification limit, such as durability factor, can be impacted if the multi-laboratory precision of the method has not been determined or indicates poor reproducibility (Note 2).

Note 2—Multi-laboratory variation is considered to be the best estimator of the actual precision of a test method for determining specification compliance. Single-laboratory variation is a more useful indicator of precision for cases in which the user is only interested in ranking material, or in detecting changes in concrete, properties that result from variations in materials and/or mixture design.
- 3.7. There is no specific guidance on choosing between fundamental transverse frequency or length change, or the combination thereof, for the method of measurement.
 - 3.7.1. Durability factor (DF) evaluates the integrity of the hardened concrete system, including the aggregates, cement, air void system, and strength.
 - 3.7.2. Length change is usually used as an indicator of aggregate D-cracking potential.
 - 3.7.3. Length change in percent and durability factor are inversely related. As the beam expands during freezing, the durability factor usually decreases.
 - 3.7.4. It is recommended that the user determine the method(s) of measurement best suited for their application prior to proceeding with laboratory evaluation.

4. APPARATUS

- 4.1. *Freezing and Thawing Apparatus:*
 - 4.1.1. The freezing and thawing apparatus shall consist of a suitable chamber or chambers in which the specimens may be subjected to the specified freezing and thawing cycle, together with the necessary refrigerating and heating equipment and controls to produce, continuously and automatically, reproducible cycles within the specified temperature requirements. In the event that