Designation: C1760 – 12

Standard Test Method for Bulk Electrical Conductivity of Hardened Concrete[1]

This standard is issued under the fixed designation C1760; 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 the determination of the bulk electrical conductivity of saturated specimens of hardened concrete to provide a rapid indication of the concrete's resistance to the penetration of chloride ions by diffusion (See Note 1). The results of this test method can be related to the apparent chloride diffusion coefficient that is determined using Test Method C1556.

NOTE 1—The term "bulk" is used because the electrical conductivity is determined by measuring the current passing through all the phases of a test specimen (e.g., cement paste, sand, aggregate). This is accomplished using electrodes that cover the ends of the specimen. Other test methods that measure conductivity may use probes placed on the side surface of the specimen.

1.2 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C125 Terminology Relating to Concrete and Concrete Aggregates

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

C1202 Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

C1543 Test Method for Determining the Penetration of Chloride Ion into Concrete by Ponding

C1556 Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

3. Terminology

3.1 *Definitions:*

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

4. Summary of Test Method

4.1 This test method measures the electrical current through a saturated concrete specimen with a potential difference of 60 V dc maintained across the ends of the specimen. Test specimens can be 100 mm diameter by 200 mm long molded cylinders or nominal 100 diameter cores with length ranging from 100 to 200 mm. The apparatus and specimen conditioning procedures are the same as described in Test Method C1202, except that the side of the specimen does not have to be sealed. The current is measured 1 min after the voltage is first applied. The measured current, the applied voltage, and the specimen dimensions are used to calculate the bulk electrical conductivity of the concrete.

5. Significance and Use

5.1 This test method measures the bulk electrical conductivity of concrete, which has a theoretical relationship to the diffusion coefficient of chloride ion, or other ions, in the concrete (**1, 2**).[4] Experimental data confirm that there is a correlation between the apparent chloride diffusion coefficient measured by Test Method C1556, or similar method, and the bulk electrical conductivity (**3, 4**).

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.66 on Concrete's Resistance to Fluid Penetration.

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[2] See section on Safety Precautions, *Manual of Aggregate and Concrete Testing*, *Annual Book of ASTM Standards*, Vol. 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] The boldface numbers in parentheses refer to a list of references at the end of this standard.

5.2 A number of factors are known to affect electrical conductivity of concrete: water cementitious materials ratio, the type and amount of supplementary cementitious materials, presence of polymeric admixtures, admixtures that contain soluble salts, specimen age, air-void system, aggregate type, degree of consolidation, degree of saturation, and type of curing. Different curing methods are used in this test method depending on whether the concrete contains supplementary cementitious materials. Use the same method and duration of curing when comparing mixtures.

5.3 This test method is suitable for evaluation of concrete mixtures for proportioning purposes and for research and development. Specimens must be sufficiently saturated for measured electrical conductivity to provide an indication of the resistance of the concrete to chloride ion penetration. Because the electrical conductivity depends upon the degree of saturation, specimens are vacuum saturated before testing to ensure a common reference state for comparison purposes. If the specimen is tested in a partially saturated, or "as delivered" state, it shall be noted in the test report.

5.4 This test can be used to evaluate the electrical conductivity of concretes in structures for applications that may require such information, such as the design of cathodic protection systems.

5.5 The type of specimen and conditioning procedure depends on the purpose of the test. For evaluation of concrete mixtures, specimens are 100 mm diameter molded cylinders that are moist cured up to the time of testing. For evaluation of concrete samples taken from structures, specimens are 100 mm diameter cores that are vacuum saturated before performing the test.

5.6 Age of the test specimen may have significant effects on the test results, depending on the type of concrete and the curing procedure. Most concretes, if properly cured, become progressively and significantly less conductive with time.

5.7 Measured electrical conductivity can be used as a basis for determining the acceptability of a concrete mixture.

NOTE 2—Because the method and duration of curing of test specimens affect the test results, the acceptance criteria will need to specify the curing procedure and test age.

6. Interferences

6.1 This test method can produce misleading results if one is comparing concrete mixtures with and without soluble chemical admixtures such calcium nitrite (See Note 3). Calcium nitrite increases greatly the conductivity of the pore solution. For two concrete samples with the same microstructure, the electrical conductivity of concrete made with a calcium nitrite admixture will be greater than that of the same concrete without calcium nitrite. This could be interpreted falsely as a lower resistance to chloride ion penetration. Long-term chloride ponding tests indicated that concretes with calcium nitrite were at least as resistant to chloride ion penetration as the control mixtures (See Note 4).

NOTE 3—Procedures are available for estimating the pore solution conductivity from the concentration of ionic species present in the solution (**5**).

NOTE 4—Other admixtures that provide large quantities of ions might affect results of this test similarly. Long term ponding tests using Test Method C1543 or diffusion testing using Test Method C1556 are recommended if an admixture effect is suspected.

6.2 Because the test results are a function of the electrical resistance of the specimen, the presence of reinforcing steel or other embedded electrically conductive materials, including some types of aggregates, may yield unrepresentative results, as these will result in higher conductivity than a concrete of similar quality but with no embedded conductive material. Therefore, the test is not valid for specimens containing reinforcing steel.

7. Apparatus

7.1 *Vacuum Saturation Apparatus*—As described in Test Method C1202.

7.2 *Movable Bed, Water-Cooled Diamond Saw or Silicon Carbide Saw*—For trimming test specimen to test length, if required.

7.3 *Applied Voltage Cells*—As described in Test Method C1202.

7.4 *Voltage Application and Data Readout Apparatus*—As described in Test Method C1202.

7.5 *Jaw Caliper, Micrometer or Diameter Tape*—For measuring specimen diameter, readable to at least the nearest 0.1 mm. Depth of jaw for a jaw caliper shall be at least 70 mm.

7.6 *Jaw Caliper*—For measuring specimen length, with a measuring range up to at least 250 mm and readable to at least the nearest 0.1 mm.

8. Reagents and Materials

8.1 *Sodium Chloride Solution*—3.0 % by mass (reagent grade) in distilled water.

8.2 *Specimen-Cell Sealant*—As described in Test Method C1202. Needed if rubber gaskets are not used to seal test specimen in voltage cells.

8.3 *Filter Paper*—No. 2, 90-mm diameter. This is not required if rubber gaskets are used to seal test specimen in voltage cells.

9. Test Specimens

9.1 *Molded Cylinders*

9.1.1 Prepare 100 mm by 200 mm cylindrical specimens in accordance with Practice C192/C192M or Practice C31/C31M, whichever is applicable. The method of final curing depends on whether the concrete contains supplementary cementitious materials. Unless otherwise directed by the specifier of tests, moist cure specimens in accordance with 9.1.2 for concrete mixtures containing only portland cement. For concrete mixtures containing supplementary cementitious materials, moist cure in accordance with 9.1.3 or 9.1.4 as directed by the specifier of tests. If no specific instructions are provided, cure mixtures containing supplementary cementitious materials in accordance with 9.1.3.

9.1.2 *Basic Moist Curing*—Cure test specimens for 28 days in accordance with Practice C192/C192M for specimens prepared in the laboratory or in accordance with the standard