Designation: C 1151 – 91

Standard Test Method for Evaluating the Effectiveness of Materials for Curing Concrete[1]

This standard is issued under the fixed designation C 1151; 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 laboratory determination of the efficiency of liquid membrane-forming compounds and sheet materials for curing concrete. This test method can also be useful in research work where the effect of different variables on the curing of concrete is studied.

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

1.3 *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 87 Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar[2]

C 150 Specification for Portland Cement[3]

C 511 Specification for Moist Cabinets, Moist Rooms and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[3]

C 670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials[2]

C 778 Specification for Standard Sand[3]

3. Summary of Test Method

3.1 Three slabs of a standard mortar are molded and after 4 h, one is covered with the curing material to be tested, the second is tightly sealed with an impermeable lid, and the third is left uncovered. All three molds are stored in a test environment for 3 days. The test environment may be any set of conditions selected by the tester, provided only that a minimum rate of evaporation from a free-water surface of 0.4 kg/m^2/h be maintained.

3.2 At the conclusion of the storage period, the slabs are demolded and three 25-mm (1-in.) diameter cores are cut at random from each of the slabs and stored under methanol for at least 24 h to stop the hydration of the cement and displace water. Using a diamond-blade saw and ethanol as coolant, the top surface of each core is then sliced off, and from the remaining core, 1-cm (0.39-in.) thick disks are cut from the top and the bottom, then placed in a vacuum desiccator for 24 h.

3.3 The absorptivity of each dried disk is determined by weighing it before and after a 60-s contact of its top surface with a water-saturated stack of filter paper. The difference in absorbtivity of the top and bottom disks is a measure of the effectiveness of the curing.

4. Significance and Use

4.1 This is an end result oriented test method. The effectiveness of a given curing material at a given environmental condition is determined by comparing the quality of the surface region of a 90.0-mm (3.5-in.) thick mortar specimen with the quality of the well-protected bottom region of the same specimen. The underlying assumption is that the bottom region of a 90.0-mm (3.5-in.) thick specimen is little affected by the environmental conditions at the surface that can cause rapid evaporation of water. The quality of the mortar is determined by the degree to which the pore structure of the cement paste has become less open due to proper hydration of the cement as indicated by the absorptivity of the mortar.

5. Apparatus

5.1 *Mortar Mixer*, power-driven, capable of thoroughly mixing batches of the prescribed size (approximately ½ ft^3 for 3 test slabs) at the prescribed consistency. A revolving drum tilting mixer, a revolving pan or a revolving paddle mixer may be satisfactory.

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[1] This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.22 on Curing Materials.

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

[3] *Annual Book of ASTM Standards*, Vol 04.01.

5.2 *Molds and Lid*, watertight, made of metal, glass, hard rubber, or plastic. The molds shall be approximately 310 by 165 mm (12¼ by 6½ in.) in horizontal cross-section and 90 ± 3 mm (3½ ± ⅛ in.) deep. For a set of three molds, one lid shall be available.

5.3 *Balances*:

5.3.1 The balance or scale for determining the mass of the test specimens shall have a capacity of 50 g or more, sensitive to 0.0001 g or less, and accurate within 0.01 % of the test mass at any point within the range of use for this test.

5.3.2 The balance or scale used for determining the mass of the curing compound, where curing compounds are involved, shall have a capacity of 1 kg or more, be sensitive to 0.1 g or less, and be accurate within 0.1 % of the test mass at any point within the range of use for this test.

5.4 *Tamper*, non-absorptive, smooth and rigid rod 120 to 150 mm (5 to 6 in.) long having a cross section of 13 by 25 mm (0.5 by 1 in.).

5.5 *Screed*, 25-mm (1-in.) diameter, rigid rod, 200 to 300 mm (8 to 12 in.) long.

5.6 *Moist Cabinet or Room*, as specified in Specification C 511.

5.7 *Brush*, with soft bristles of nylon or other suitable material for removing laitance from the test slabs.

5.8 *Drilling Machine*, with a 25-mm (1-in.) inside diameter water cooled diamond-core drill bit.

5.9 *Diamond Blade Saw*, low speed (300 rpm maximum) with 100-mm (4-in.) diameter blade.[4]

5.10 *Desiccator*, vacuum, large enough to accomodate the test specimens.

5.11 *Vacuum Pump*, of sufficient capacity to maintain an absolute pressure of approximately 2500 Pa or less (133 Pa = mm Hg). An aspirator may be sufficient.

6. Reagents and Materials

6.1 *Cement and Sand*—Portland cement meeting Type I of Specification C 150 and graded standard sand conforming to Specification C 778.

6.2 *Methanol and Ethanol*—The alcohols used for dehydrating the cores and cooling the saw blade shall initially contain <1 % water.

7. Test Environment

7.1 The environment in which the molds containing the test slabs are kept during the curing period shall be described by its temperature, relative humidity, and wind velocity, and the rate of evaporation from a free-water surface shall be given in terms of rate of evaporation of water per unit surface area. The minimum rate of evaporation shall be 0.4 kg/m^2/h.

NOTE 1—The minimum required rate of evaporation can be obtained by using a variable speed fan in a room that is maintained at approximately 50 % relative humidity and 23°C (73°F).

7.2 The rate of evaporation in the test environment can be determined by placing two water containers with a known cross-sectional area next to the test specimens. Sufficient amount of water at room temperature to last through the duration of the curing period shall be put in the containers and weighed at regular intervals. The mass losses in terms of kilograms per square metre-per-hour from the two containers shall be averaged.

8. Number of Test Slabs

8.1 Make a set of three test slabs for a test of a given curing material. If either two or more curing materials, or the same material at different coverage rates are evaluated at the same time, it is necessary to make only one set of the control slabs, that is, one covered with a lid and the second left uncovered as described in 9.4.3 and 9.4.4.

NOTE 2—The data from the control slabs are to be used as references representing the best and worst conditions. If, for example, the test indicates a given curing material under evaluation is not effective but the test result is not significantly different from that of the sample covered with a lid, this would imply that something is wrong with the test. On the other hand, if a curing material is found to be effective but the test result is similar to that of the uncovered sample, this would indicate that the storage environment during curing did not cause sufficient drying.

9. Procedure

9.1 *Proportioning and Mixing Mortar*:

9.1.1 *Proportioning*—Determine the proportions of cement and sand by adding dry sand to a cement paste having a water-cement ratio of 0.44 so as to produce a flow of 65 ± 5. Perform the flow test in accordance with Test Method C 87 using 10 drops in 6 s.

NOTE 3—It is recommended that a trial batch be made to determine the mix proportions needed to achieve the required flow.

9.1.2 *Mixing*—Mix the mortar at room temperature, preferably 23 ± 1.7°C (73.4 ± 3°F) with a relative humidity of 40 to 60 %. Mix the mortar as follows: place the cement and water in the mixer and allow the cement to absorb water for 1 min and then mix for 1 min. Add the sand to the paste and mix for 2 min.

9.1.2.1 The mortar temperature, when determined immediately after mixing, shall be 23 ± 1.7°C (73.4 ± 3°F).

9.2 *Molding Test Slabs*—Place the mortar in a mold in three approximately equal layers and tamp each layer 75 times with the tamper. The third layer of mortar shall be of sufficient quantity to overfill the mold. After the third layer of mortar is tamped, fill the indentations made by the tamping by gently pressing down the mortar using the tamper turned on its side so that the 13 by 120 to 150-mm (0.5 by 5 to 6-in.) surface is in contact with the mortar. Press the entire surface down 18 times with the tamper, moving along the long dimension of the mold. Next, screed the slab off level with the top of the mold using the screed. Make only three passes in the direction of the long dimension of the test slab.

9.3 *Storage of Test Slabs*—Place the molds containing the test slabs in the moist cabinet or room immediately after casting is completed. Keep the molds there for 4 h protected from dripping water.

9.4 *Application of Curing Materials*:

[4] Model 11-1180, Isomet™ Low-Speed Saw with Model 11-4255 Diamond Wafering Blade by Buehler, Ltd., 41 Waukegan Rd., P.O. Box 1, Lake Bluff, IL 60044 has been found to be satisfactory.

9.4.1 Remove the test slabs in their molds from moist storage, 4 h ± 15 min after molding. Blot off any surface water and lightly brush the top surfaces with a soft-bristled brush to remove laitance.

9.4.2 Apply the curing material to the surface of one test slab in the manner specified for the material to be tested. If a liquid membrane-forming curing compound is being evaluated, and if the rate of application is not specified, apply the curing compound at a rate of 0.20 L/m^2 (1 gal/200 ft^2).

9.4.3 At the same time, place the lid on one of the two remaining slabs and tape it in such a way that no moisture loss occurs from the system.

9.4.4 Leave the third slab uncovered, exposed to the test environment.

9.5 *Duration of Exposure to Test Environment*—Keep all the test slabs in the test environment for a period of 3 days unless some other duration is specified for a specific application.

9.6 *Preparation of Test Specimens*

9.6.1 Demold the test slabs 3 days ± 2 h, or other specified time from the time of mixing.

9.6.2 From each test slab, under room temperature conditions, using water as coolant, drill three cores vertically through the slab as cast, approximately 25 mm (1 in.) in diameter, from random locations at least 38 mm (1.5 in.) from the edges of the slab. Blot the cores dry and submerge all three in a jar (approximately 1 qt or 1 L) containing 450 to 500 mL of methanol. Store the tightly closed jar and cores for at least 24 h to stop the hydration process and displace the water in the cores. Fresh methanol shall be used for each set of three cores to be evaluated.

9.6.3 Remove each core from the methanol and using ethanol as a coolant, cut a 4 to 5-mm (0.16 to 0.20-in.) layer of mortar off the top surface of the core with the low-speed diamond-blade saw. (Note 4). Discard the surface piece. Next, cut off the top 1 cm (0.39 in.) and the bottom 1 cm (0.39 in.) of the remaining core. As each disk is cut, mark it on its side to indicate its top cross-section, the section of the core from which it was taken (top or bottom), and the slab from which it was cut. Never allow the cores or disks to come in contact with water during this process.

NOTE 4—The use of such a saw produces surfaces of uniformly smooth texture and helps to minimize damage to mortar specimens with a wide range of strengths.

9.6.4 Place the disks in the vacuum desiccator, after slicing all the cores.

9.6.5 Evacuate the desiccator to approximately 2500 Pa and maintain this absolute pressure throughout the 24 ± 1 h drying period.

9.7 *Determination of Water Absorption*

9.7.1 Remove the disks from the desiccator and determine the dry mass of each disk to the nearest 0.0001 g after brushing off the disks with a dry, soft-bristle brush to remove all loose particles and dust from the surface. Dry compressed air may be used in this operation.

9.7.2 Place the top surface of each disk in contact with a free-water surface for 60 ± 3 s, blot off excess water and determine the wet mass of the disk.

9.7.2.1 Obtain the free-water surface by putting a stack of eight pieces of fast- or medium-fast-speed filter paper in an evaporating dish and wetting the filter paper using deionized water at room temperature. Provide enough deionized water to thoroughly wet the stack of filter paper with a few drops of water left in the evaporating dish around the stack of filter papers.

9.7.2.2 Keep the filter paper at approximately the same wetness by adding additional drops of water in the space around the filter paper.

NOTE 5—If the filter paper gets dirty or if sand and paste particles accumulate on it, or both, it is a sign that the test specimens were inadequately cleaned.

9.7.2.3 The time taken to pick up a disk from the free-water surface, to blot off excess water from the surface of the disk using damp tissue paper, and to determine the mass of the disk, shall not be more than 25 s.

10. Calculation

10.1 Determine the amount of water absorbed in 60 s by subtracting the dry mass from the wet mass. The mass of the absorbed water in grams can be assumed to be equal to the volume of the absorbed water in millilitres.

10.2 Measure the diameter of each disk to the nearest 0.1 cm and determine the cross-sectional area.

10.3 Calculate the absorptivity, K_a, of each disk as follows:

$$K_a = (V/A)^2/60 \quad (1)$$

where:

K_a = absorptivity, cm^2/s,
V = volume of water absorbed, mL, and
A = cross-sectional area of each disk, cm^2.

10.4 Determine the difference between K_a for the disk from the top of each core and K_a for the disk from the bottom of the same core.

NOTE 6—Studies[5] of results on which this test method is based, suggest that an average test result of $\leq 3.7 \times 10^{-6}$ cm^2/s for the difference between the top and bottom K_a's represents an acceptably cured sample; a difference of $\geq 5.5 \times 10^{-6}$ cm^2/s represents unacceptable performance. In the range of 3.7 to 5.5×10^{-6} cm^2/s, the performance of the curing material should be considered marginal and the test may be rerun with an increased amount of curing material.

11. Report

11.1 Report the following information regarding the material test:

11.1.1 Manufacturer's brand name for the curing material,

11.1.2 Manufacturer's name and address,

11.1.3 Manufacturer's batch number,

11.1.4 Type of curing material under evaluation,

11.1.5 Quantity of curing material represented by the sample,

11.1.6 Date sampled, and

11.1.7 Source of sample.

11.2 Report the following information regarding the testing:

[5] Senbetta, E., "Development of a Laboratory Technique to Quantify Concrete Curing Quality," Ph.D. Thesis Purdue University, 1981, pp. 133–138.

11.2.1 Laboratory sample identification,

11.2.2 Proportions of mortar by mass,

11.2.3 Brand of cement used,

11.2.4 Method of application of curing material,

11.2.5 Duration of test,

11.2.6 Temperature, relative humidity, and wind velocity in the test environment,

11.2.7 Rate of evaporation of water from the free water surface in the test environment, and

11.2.8 Rate of application where membrane-forming curing compounds are evaluated.

11.3 Report the following information regarding the test results:

11.3.1 Absorptivity, K_a, for each disk,

11.3.2 Average K_a difference between top and bottom disks for the cores from the test slab, and

11.3.3 Average K_a differences between top and bottom disks for the cores from the covered and the uncovered slabs.

12. Precision and Bias

12.1 *Precision*—The multilaboratory precision of this test method has not been determined.

12.1.1 The single-operator standard deviation for differences between the top and bottom K_a on this test as determined by the test's developer is 0.69×10^{-6} cm^2/s. Therefore, results of two tests by one operator using specimens made by the same operator should not differ from each other by more than 1.97×10^{-6} cm^2/s.

NOTE 7—The numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C 670 for preparing precision statements for test methods for construction materials.

12.2 *Bias*—Since no reference procedure exists for measuring effectiveness of curing, no statement on bias is being made.

13. Keywords

13.1 absorptivity of cured concrete; curing materials for concrete