Designation: C1792 − 14

Standard Test Method for Measurement of Mass Loss versus Time for One-Dimensional Drying of Saturated Concretes[1]

This standard is issued under the fixed designation C1792; 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 determines the mass loss over time due to one-dimensional drying and moisture transport in an initially saturated cylindrical specimen with both ends exposed to constant temperature and relative humidity.

1.2 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

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

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

C1005 Specification for Reference Masses and Devices for Determining Mass and Volume for Use in the Physical Testing of Hydraulic Cements

E104 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions

3. Terminology

3.1 *Definitions:*

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

4. Summary of Test Method

4.1 Saturated cylindrical concrete specimens with sealed sides are prepared and the two ends are exposed to an environment at 23°C and 50 % relative humidity (RH), subjecting the specimen to one-dimensional drying. Their masses are measured periodically to establish a data set of average mass loss versus time.

5. Significance and Use

5.1 Drying behavior is related to the mass transport properties of concrete, such as liquid permeability and water diffusivity. It depends on a number of factors such as concrete mixture proportions, presence of admixtures and supplementary cementitious materials, composition and physical characteristics of the aggregates and cementitious materials, curing conditions, degree of hydration, and presence of microcracking. Drying behavior is also affected strongly by the degree of saturation and temperature of the concrete at the start of drying as well as the environmental conditions that exist during drying such as temperature, relative humidity, and air flow rate (wind speed).

5.2 This test method subjects initially saturated specimens of concrete to one-dimensional drying under controlled environmental conditions. The resulting mass loss versus time data can be used to estimate transport coefficients including liquid permeability[3] and water diffusivity.[4] These coefficients may be

[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.

Current edition approved July 1, 2014. Published July 2014. DOI: 10.1520/C1792-14.

[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.

[3] Baroghel-Bouny, V., Thiery, M., Barberon, F., Coussy, O., and Villain, G., "Assessment of Transport Properties of Cementitious Materials: A Major Challenge as Regards Durability?," *European Reviews in Civil Engineering*, Vol 11, No. 6, 2007, pp. 671–696.

[4] Samson, E., Maleki, K., Marchand, J., and Zhang, T., "Determination of the Water Diffusivity of Concrete Using Drying/Absorption Test Results," *Journal of ASTM International*, Vol 5, No. 7, 2008, pp. 1–12.

used in numerical models to estimate service life of concrete and reinforced concrete members exposed to different environmental conditions.[5,6]

5.3 The test method provides instruction and a sequence of steps for measuring mass loss versus time. The preferred rate of this mass loss will depend on the application. For example, for interior commercial flooring applications, a mass loss that occurs quickly may be preferable, while for outdoor exposures in an aggressive environment, slower mass loss may be beneficial.

6. Apparatus

6.1 *Drying Chamber,* a temperature- and humidity-controlled chamber or room with temperature maintained constant at 23°C ± 2°C and relative humidity at 50 % ± 4 %, such as the drying room specified in Test Method C157/C157M. The chamber shall have proper specimen supports to allow airflow around each concrete specimen (see Note 1). The chamber shall be of sufficient volume to hold at least three test specimens (see Note 2). The air movement around the specimens within the chamber shall result in an evaporation rate as required for the drying room described in Test Method C157/C157M.

NOTE 1—Rack shelving composed of metal, plastic, or composite materials will provide a convenient pathway for air circulation around each supported specimen.

NOTE 2—A walk-in chamber is preferable, so that the balance can be installed and maintained at constant conditions.

6.2 *Temperature and Relative Humidity Measuring Equipment,* of the digital type to be placed next to the specimens in the drying chamber and capable of measuring relative humidity with an accuracy of ±3 % at a relative humidity of 50 % and temperature with an accuracy of ±0.5 °C at a temperature of 23°C. At least two separate measurements of both temperature and relative humidity are required for each drying chamber. Measurements shall be obtained at intervals of 15 min or less.

NOTE 3—The accuracy of the relative humidity measured by the equipment can be verified by measurement of relative humidity over aqueous solutions of various salts, as outlined in Practice E104.

6.3 *Absorbent Towels,* wetted thoroughly and wrung out, for blotting free water from specimen surfaces.

6.4 *Balance,* complying with Specification C1005 with a capacity of at least 1500 g, but with an index scale readable to at least 0.01 g.

6.5 *Water-Cooled Saw,* with diamond impregnated blade of adequate dimensions to cut test specimens from larger samples.

6.6 *Caliper,* to measure the specimen dimensions to the nearest 0.1 mm.

6.7 *Compressed Air,* source of compressed air at sufficient pressure to dry surfaces of specimens.

7. Materials

7.1 *Sealing Material,* strips of low permeability adhesive sheets, epoxy coating, or (paraffin) wax for sealing the side surfaces of test specimens. The hardening time of the sealing material shall not exceed 30 minutes. The adequacy of the sealing material is to be verified with respect to both drying and limewater immersion. Adequacy with respect to drying is to be verified by sealing a saturated specimen on all sides and storing it in the drying chamber for 3 days. The sealing material is adequate if the measured mass loss is less than 0.1 % of the original mass of the sealed specimen. The sealing material also must not gain mass or deteriorate when placed in a limewater solution. Adequacy with respect to limewater immersion is to be verified by sealing a saturated specimen on all sides and immersing it in limewater for 7 days. Visually examine the sealing material after immersion to detect any reaction with the limewater. The sealing material is adequate if the measured mass gain is less than 0.1 % of the original mass of the sealed specimen.

8. Sampling, Test Specimens, and Test Units

8.1 Three cylindrical sawcut specimens are to be prepared for each concrete mixture to be evaluated. Unless required otherwise by the specifier of the tests, specimen dimensions after cutting shall be a diameter of 100 mm ± 5 mm and a length of 50 mm ± 2 mm. Specimens are cut to length, using a water-cooled saw (see 6.5), from either cylinders molded according to Practices C31/C31M or C192/C192M or cores drilled according to Test Method C42/C42M. The average diameters (see 9.3) of the end faces of a specimen shall not differ by more than 1 mm.

NOTE 4—While other specimen sizes may be employed, the minimum specimen dimension should exceed the nominal maximum aggregate size by a factor of two or more. Because the drying is one-dimensional through the exposed cylinder faces, a nominal diameter-length ratio of 2.0 does not have to be used if alternative specimen sizes are specified.

8.2 This test method may be applied to either specimens containing a cast or a finished wearing surface or those in which the cast or finished surface layer(s) of the concrete have been removed by sawing. In the latter case, the distances between the original exposed surface of the concrete and the end faces of replicate test specimens shall be within 5 mm of each other.

NOTE 5—An exterior surface of a concrete specimen seldom has the same porosity as the interior concrete. To reduce data scatter, measurements are made with the drying surfaces of replicate test specimens at the same distance from the original exposed surface of the concrete.

9. Sample Conditioning

9.1 Specimens are to be in a saturated condition at the start of the test. Cure molded concrete cylinders for at least 28 days in water storage tanks complying with the requirements of Specification C511. Condition cores in accordance with 9.7.

9.2 Seven days prior to the start of testing, cut test specimens to the necessary length and carry out steps 9.3 – 9.7.

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[5] Samson, E., and Marchand, J., "Modeling the Transport of Ions in Unsaturated Cement-Based Materials," *Computers and Structures*, Vol 85, No. 23–24, 2007, pp. 1740–1756.

[6] Henchi, K., Samson, E., Chapdelaine, F., and Marchand, J., "Advanced Finite-Element Predictive Model for the Service Life Prediction of Concrete Infrastructures in Support of Asset Management and Decision-Making," *Computing in Civil Engineering*, 2007, pp. 870–880.

9.3 Use the caliper to measure four diameters distributed uniformly around the circumference of each end face. Measure each diameter to the nearest 0.1 mm and calculate the average diameter for the eight readings to the nearest 0.1 mm.

9.4 Use the caliper to make four measurements of specimen length approximately 90° apart. Measure each length to the nearest 0.1 mm and calculate the average length to the nearest 0.1 mm.

9.5 Dry the specimen side surface along its length with compressed air until the surface is visibly dry. Seal the side surface of each specimen with an impermeable material, as described in 7.1, leaving the two end faces uncoated to act as drying surfaces (Note 6).

NOTE 6—It is best practice to minimize the drying of the end faces during the sealing operation. Moistened paper towels or sponges can be used to maintain the two end faces in a moistened condition during the sealing process.

9.6 After the sealing is completed and the coating has cured if applicable, measure and record the mass of each specimen to the nearest 0.1 g.

9.7 Immerse the sealed specimens for 7 days in water saturated with calcium hydroxide. After 7 days of immersion, determine each specimen mass after removing surface water by blotting with an absorbent towel that has first been wetted thoroughly and wrung out (see 6.3). If the mass has changed by more than 0.5 % from the mass determined in 9.6, repeat the immersion for another 7 days. Continue this cyclic procedure of immersion and weighing until the mass variation is less than 0.5 % between successive mass readings taken 7 days apart.

10. Procedure

10.1 Once the specimens have satisfied the immersion mass gain criteria in 9.7, remove the saturated specimens from the limewater one at a time and complete the initial mass measurements on the removed specimen before proceeding to the next one. For each removed specimen, to remove excess surface water, blot all surfaces with absorbent towels that have first been wetted thoroughly and wrung out (see 6.3). Record the date and time of the beginning of the drying exposure for each specimen.

10.2 Measure and record the initial mass (m_i) of each specimen to the nearest 0.1 g. After measuring its mass, place the specimen into its exposure location within the drying chamber. Maintain a minimum distance of 25 mm between the drying surfaces of neighboring specimens.

10.3 In the drying chamber, place each specimen on appropriate supports so that air can move freely across both exposed surfaces. Record temperature and relative humidity in at least two different locations within 150 mm of the specimens.

10.4 Record the mass change of the specimens by periodically determining their mass after drying (m_t) to the nearest 0.1 g, using the same balance as in 10.2. Unless required otherwise by the specifier of the tests, use the following measurement schedule:

10.4.1 *During Days 1 – 4:* One measurement per day at 24 ± 2 h intervals,

10.4.2 *During Days 5 – 13:* Two measurements, one taken after 7 d at 168 ± 2 h from the time of exposure to drying and the other taken after 10 d at 240 ± 2 h from the time of exposure to drying, and

10.4.3 *At Day 14 and Beyond:* One measurement per week (beginning on day 14) at 7 ± 1 d intervals.

10.5 Any time after four weeks of drying, terminate the monitoring of mass loss when three successive weekly mass measurements show less than 0.5 % variation from the immediately previous mass measurement.

11. Calculation

11.1 Calculate the cumulative mass loss in grams at any time using the equation:

$$\Delta M(t) = (m_i - m_t) \quad (1)$$

where:

$\Delta M(t)$ = the cumulative mass loss after drying at time t, g,
m_i = measured mass of the specimen prior to exposure to drying, g, and
m_t = measured mass of the specimen after drying at time t, g.

11.2 Calculate the cumulative mass loss per unit exposed surface area (two faces) at any time using the equation:

$$\Delta D(t) = \frac{(m_i - m_t)}{(\pi\ d^2/2)} = \frac{\Delta M(t)}{(\pi\ d^2/2)} \quad (2)$$

where:

$\Delta D(t)$ = the cumulative mass loss per unit exposed surface area after drying at time t, g/mm^2,
m_i = measured mass of the specimen prior to exposure to drying, g,
m_t = measured mass of the specimen after drying at time t, g, and
d = average of all measured diameters of cylindrical specimen tested (from 9.3), mm.

11.3 Calculate the average temperature and relative humidity recorded during the time of the drying exposure by averaging all of the readings acquired from the two locations during the actual time of drying exposure.

12. Report

12.1 Report the following:
12.1.1 Date when concrete was sampled or cast;
12.1.2 Source of sample;
12.1.3 Relevant background information on sample such as mixture proportions, curing history, type of finishing, and age at start of drying, if available;
12.1.4 Nature or description of the two exposed surfaces, whether cast, finished, or cut;
12.1.5 Average diameter and length of each specimen before sealing;
12.1.6 Mass of each specimen after sealing (from 9.6);
12.1.7 Initial mass of each specimen prior to exposure to drying (from 10.2);
12.1.8 Average temperature and relative humidity recorded during the drying exposure; and

12.1.9 A table of measured mass, calculated cumulative mass loss, and calculated cumulative mass loss per unit exposed surface area, based on Eq 1 and Eq 2, against drying time for each specimen, along with the average values for calculated cumulative mass loss per unit exposed surface area. Optionally, test results may also be presented in graphical form as a plot of cumulative mass loss (or cumulative mass loss per unit exposed surface area) versus drying time.

13. Precision and Bias

13.1 *Single-Operator Precision*—In accordance with Practice C670, a preliminary estimate of single-operator precision was obtained from tests on one concrete in one laboratory. The single operator coefficient of variation of a test result for cast cylinders, where a test result is the average of three individual determinations, using a concrete with average cumulative mass losses of 8.78×10^{-5} g/mm^2, 1.53×10^{-4} g/mm^2, and 2.45×10^{-4} g/mm^2 after 1 d, 7 d, and 28 d of drying, respectively, has been found to be 5.0 % or less. The single-operator coefficient of variation of individual determinations has been found to be 6.0 % or less.

NOTE 7—An interlaboratory program will be organized after approval of this test method to develop a complete precision statement.

13.2 *Bias*—The test method has no bias because the mass loss due to drying can only be defined in terms of the test method.

14. Keywords

14.1 concrete; drying; mass loss