Standard Test Method for Slump Flow of Self-Consolidating Concrete[1]

This standard is issued under the fixed designation C1611/C1611M; 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 slump flow of self-consolidating concrete (SCC).

1.2 The values stated in either 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 non-conformance with the standard.

1.3 The text of this standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 *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 skin and tissue upon prolonged exposure.[2])

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C125 Terminology Relating to Concrete and Concrete Aggregates

C143/C143M Test Method for Slump of Hydraulic-Cement Concrete

C172 Practice for Sampling Freshly Mixed Concrete

C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

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

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *halo, n*—an observed cement paste or mortar ring that has clearly separated from the coarse aggregate, around the outside circumference of concrete after flowing from the mold.

3.2.2 *spread, n*—the distance of lateral flow of concrete during the slump-flow test.

3.2.3 *stability, n*—the ability of a concrete mixture to resist segregation of the paste from the aggregates.

3.2.4 *viscosity, n*—resistance of a material to flow under an applied shearing stress.

4. Summary of Test Method

4.1 A sample of freshly mixed concrete is placed in a mold either in the upright or inverted position. The concrete is placed in one lift without tamping or vibration. The mold is raised, and the concrete is allowed to spread. After spreading ceases, two diameters of the concrete mass are measured in approximately orthogonal directions. Slump flow is the average of the two diameters.

5. Significance and Use

5.1 This test method provides a procedure to determine the slump flow of self-consolidating concrete in the laboratory or the field.

5.2 This test method is used to monitor the consistency of fresh, unhardened self-consolidating concrete and its unconfined flow potential.

5.3 It is difficult to produce self-consolidating concrete that is both flowable and nonsegregating using coarse aggregates larger than 25 mm [1 in.]. Therefore, this test method is considered applicable to self-consolidating concrete having coarse aggregate up to 25 mm [1 in.] in size. Appendix X1 provides non-mandatory visual rating criteria that may be used to classify the ability of a self-consolidating concrete mixture to resist segregation (stability).

5.4 The rate at which the concrete spreads is related to its viscosity. Appendix X1 provides a non-mandatory procedure that may be used to provide an indication of relative viscosity of self-consolidating concrete mixtures.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.47 on Self-Consolidating Concrete.

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[2] 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.

***A Summary of Changes section appears at the end of this standard**

6. Apparatus

6.1 *Mold*—The mold used in this test method shall conform to that described in Test Method C143/C143M.

6.2 *Base Plate*—A nonabsorbent, smooth, rigid plate having a minimum diameter of 915 mm [36 in.] (See Note 1).

NOTE 1—*Field experience and results from the round robin test program have shown that base plates made from sealed/laminated plywood, acrylic plastic, or steel are suitable for performing this test.*

6.3 *Strike-off Bar*—As described in Test Method C173/C173M.

6.4 *Measuring Device*—A ruler, metal roll-up measuring tape, or similar rigid or semi-rigid measuring instrument marked in increments of 5 mm [¼ in.] or less.

6.5 *Sample Receptacle*—A pan or wheelbarrow that is water-tight, has a nonabsorbent surface, and is large enough to allow both remixing of the entire sample and retain a volume of concrete sufficient to fill the mold.

6.6 *Pouring Vessel for SCC*—A water-tight container having a volume such that concrete is not spilled during placement in the mold.

NOTE 2—A pouring vessel with a pouring lip is useful in reducing the probability of concrete spilling while filling the mold.

6.7 *Other Tools*—Items such as shovels and scoops capable of remixing the concrete in the sample receptacle, filling the pouring vessel, or both.

7. Sample

7.1 Obtain a sample of freshly-mixed self-consolidating concrete in accordance with Practice C172 and place it in the 34 sample receptacle.

8. Procedure

8.1 Perform this test on a flat, level, nonabsorbent work surface such as a concrete floor or base plate. Use a base plate in conditions where a flat, level surface is not available, such as on a construction site. When the base plate is used, position and shim the base plate so that it is fully supported. Dampen the work surface, removing any standing water. Do not subject the work surface or mold to vibration or disturbance.

8.1.1 When performing the slump flow test for a given study or project, do not change the base plate surface type for the duration of the study or project.

8.2 *Remixing of Sample*—Remix the sample, obtained in accordance with 7.1, in the sample receptacle using a shovel or scoop so that the concrete is homogeneous.

8.3 *Filling the Mold*—Fill the mold by following either Procedure A or Procedure B (See Note 3).

8.3.1 *Filling Procedure A (Upright Mold)*—Dampen the interior of the mold and place it on the work surface, or centered on the base plate, with the larger opening facing down. Hold the mold firmly in place during filling by standing on the two foot pieces.

8.3.2 *Filling Procedure B (Inverted Mold)*—Dampen the interior of the mold and place it on the work surface, or centered on the base plate, with the smaller opening facing down (See Note 4).

NOTE 3—*During the development of this test method, it was found that some of the users preferred to perform the test with the large opening of the mold facing down as is performed in Test Method C143/C143M. The provision of a collar to the top of the mold is useful to reduce the probability of concrete spilling over the mold and on to the base plate. Other users preferred to place the mold with the smaller opening face down, which facilitates the ease of filling. Both filling procedures have been found to be suitable when performing this test. The precision statement in Section 10 reflects the use of both procedures. Test data using the two filling procedures can be obtained in the round robin test report available from ASTM headquarters.*

NOTE 4—*As a precaution, when filling the mold in the inverted position, the mold may be supported to prevent accidental movement or tipping. Experienced users of this test method have found that it is not necessary to support the mold.*

8.3.3 *Fill Pouring Vessel*—Immediately fill the pouring vessel with a portion of SCC from the sample receptacle, either by passing the pouring vessel through the concrete or by scooping concrete into the vessel.

8.3.4 *Filling Procedure*—Immediately fill the mold with SCC by tilting the pouring vessel. Position the lowest point on the rim of the pouring vessel no more than 125 mm [5 in.] above the top of the mold. Ensure an even distribution of concrete, without rodding the concrete or tapping the sides of the mold, while filling the mold.

8.3.5 If necessary, repeat the procedures in 8.3.3 and 8.3.4 until the mold is filled slightly above its rim.

8.4 Strike off the surface of the concrete level with the top of the mold by a sawing motion of the strike-off bar. Remove concrete from the area surrounding the base of the mold to preclude interference with the movement of the flowing concrete. Remove the mold from the concrete by raising it vertically. Raise the mold a distance of 225 ± 75 mm [9 ± 3 in.] in 3 ± 1 s by a steady upward lift with no lateral or torsional motion. Complete the entire test from the start of filling through removal of the mold without interruption within an elapsed time of 2 ½ min.

8.5 Wait for the concrete to stop flowing and then measure the largest diameter (d_1) of the resulting circular spread of concrete. When a halo is observed in the resulting circular spread of concrete, it shall be included as part of the diameter of the concrete. Measure a second diameter (d_2) of the circular spread at an angle approximately perpendicular to the first measured diameter (d_1). Measure the diameters to the nearest 5 mm [¼ in.]. Determine the Slump flow in accordance with Section 9.

8.6 If the measurement of the two diameters differs by more than 50 mm [2 in.], the test is invalid and shall be repeated.

9. Calculation

9.1 Calculate the slump flow using Eq 1:

$$\text{Slump flow} = (d_1 + d_2)/2 \quad (1)$$

where:

d_1 = the largest diameter of the circular spread of the concrete, and

d_2 = the circular spread of the concrete at an angle approximately perpendicular to d_1.

9.2 Record the average of the two diameters to the nearest 10 mm [½ in.].

10. Report

10.1 Report the filling procedure (A or B) used.

10.2 Report the slump flow to the nearest 10 mm [½ in.].

11. Precision and Bias[4]

11.1 The precision of this test method was determined based on the results obtained from a round robin test program conducted by members of the ASTM C09.47 subcommittee on January 9, 2003. The round robin test program consisted of using single and multiple operators performing 3 replicas of the test using the mold in both the upright and inverted positions. The tests were performed using self-consolidating concrete with high and low levels of slump flow and on stable and unstable mixes. Complete details of the round robin test program are available from ASTM headquarters in a report entitled "Report on Development of a Precision Statement for the Slump Flow Test Method for Self-Consolidating Concrete."

11.2 *Single-Operator Precision*—The single-operator precision statement reflects the use of both procedures A and B. The single-operator standard deviation for slump flow has been found to be 27 mm [1.1 in.] (See Note 5) for mixtures having slump flow values between approximately 480 and 680 mm [19 and 27 in.]. Therefore, results of two properly conducted tests by the same operator on the same batch of concrete should not differ by more than 75 mm [3.0 in.] (See Note 5).

11.3 *Multi-Operator Precision*—The multi-operator precision statement reflects the use of both procedures A and B. The multi-operator standard deviation for slump flow has been found to be 27 mm [1.1 in.] (See Note 5) for mixtures with slump flow values between approximately 530 and 740 mm [21 and 29 in.]. Therefore, the results of properly conducted tests by two operators on the same batch of concrete should not differ by more than 75 mm [3.0 in.] (See Note 5).

NOTE 5—*These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C670.*

11.4 *Bias*—The procedure used in this test method has no bias since slump flow is defined only in terms of this test method.

12. Keywords

12.1 halo; self-consolidating concrete; slump flow; spread; stability; viscosity; visual stability index

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1033. Contact ASTM Customer Service at service@astm.org.

APPENDIX

(Nonmandatory Information)

X1. RELATIVE MEASURE OF FLOW RATE, VISCOSITY, AND STABILITY

X1.1 The flow rate of a self-consolidating concrete mixture is influenced by its viscosity. Hence, for the purpose of developing a self-consolidating concrete mixture in the laboratory, a relative measure of viscosity is useful. When performing the slump flow test, the time it takes for the outer edge of the concrete mass, to reach a diameter of 500 mm [20 in.] from the time the mold is first raised, provides a relative measure of the unconfined flow rate of the concrete mixture. For similar materials, this time period, termed T_{50}, gives an indication of the relative viscosity of the self-consolidating concrete mixture.

NOTE X1.1—The T_{50} value can provide information on the flow properties of the self-consolidating concrete mixture, whereby longer values normally correspond to increased viscosity. Special high-range water-reducing admixtures are typically used to modify the flow properties of the self-consolidating concrete mixture. In addition, viscosity-modifying admixtures and other changes in mixture proportions and materials can also influence flow properties and resistance to segregation.

X1.2 The stability of self-consolidating concrete can be observed visually by examining the concrete mass and therefore can be used for quality control of self-consolidating concrete mixtures. Table X1.1 contains Visual Stability Index (VSI) values with corresponding criteria to qualitatively assess the stability of self-consolidating concrete. However, these values do not quantify a concrete property.

TABLE X1.1 Visual Stability Index Values

VSI Value	Criteria
0 = Highly Stable	No evidence of segregation or bleeding.
1 = Stable	No evidence of segregation and slight bleeding observed as a sheen on the concrete mass.
2 = Unstable	A slight mortar halo ≤ 10 mm [≤ 0.5 in.] and/or aggregate pile in the of the concrete mass.
3 = Highly Unstable	Clearly segregating by evidence of a large mortar halo > 10 mm [> 0.5 in.] and/or a large aggregate pile in the center of the concrete mass.

X1.3 *Apparatus:*

X1.3.1 *Inscribed Base Plate*—a base plate as described in 6.2, with a circular mark centrally located for the placement of mold, and a further concentric circle at 500 mm [20 in.].

NOTE X1.2—The centrally located circular mark made at the 500 mm [20 in.] location on the base plate will assist the user in determining the T_{50} value.

X1.3.2 *Stop Watch*—least reading of not more than 0.01 s.

X1.4 *Procedure:*

X1.4.1 To determine T_{50}, use a stopwatch to measure the time in seconds it takes any part of the outer edge of the spreading concrete to reach the inscribed mark on the base plate from the time the mold is first lifted.

X1.4.2 After spreading of the concrete has stopped, visually inspect the concrete mixture by observing the distribution of the coarse aggregate within the concrete mass the distribution of the mortar fraction particularly along the perimeter, and the bleeding characteristics. Assign a Visual Stability Index (VSI) value to the concrete spread using the criteria shown in Table X1.1 and illustrated in Figs. X1.1-X1.4.

X1.5 *Recording:*

X1.5.1 Record T_{50} to the nearest 0. 2 second.

X1.5.2 Record the VSI value.

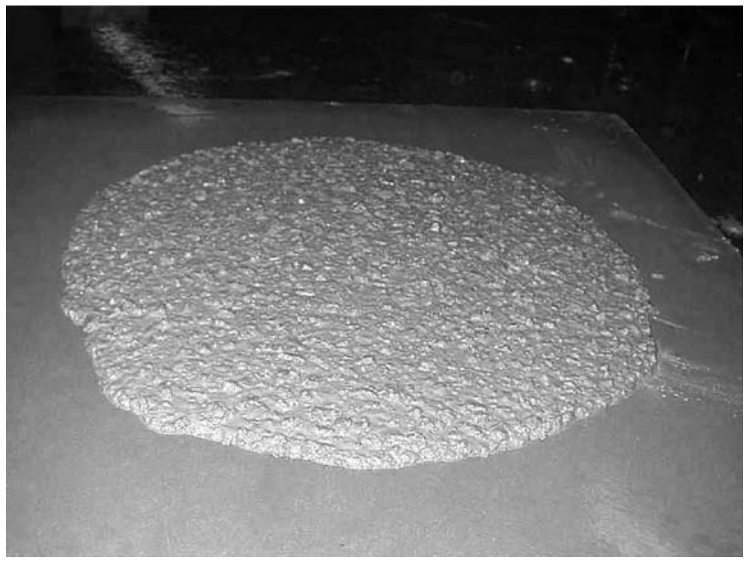

FIG. X1.1 VSI = 0 – Concrete Mass is Homogeneous and No Evidence of Bleeding.

FIG. X1.2 VSI = 1 – Concrete Shows Slight Bleeding Observed as a Sheen on the Surface.

FIG. X1.3 VSI = 2 – Evidence of a Mortar Halo and Water Sheen.

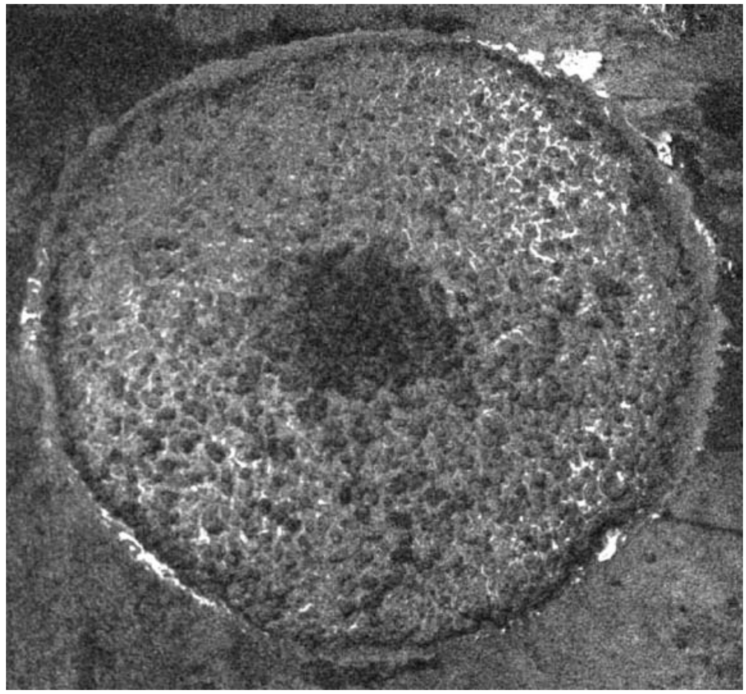

FIG. X1.4 VSI = 3 – Concentration of Coarse Aggregate at Center of Concrete Mass and Presence of a Mortar Halo.

SUMMARY OF CHANGES

Committee D09 has identified the location of selected changes to this standard since the last issue (C1611/C1611M – 09b$^{\varepsilon 1}$) that may impact the use of this standard. (Approved April 1, 2014.)

(1) Added new 6.5, 6.6 with Note, and 6.7.
(2) Revised 7.1.
(3) Revised 8.1 .
(4) Added new 8.2.
(5) Revised 8.3, including the addition of 8.3.3–8.3.5.
(6) Removed old Note 3.