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

This standard is issued under the fixed designation C 1611/C 1611M; 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.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. 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]

C 125 Terminology Relating to Concrete and Concrete Aggregates
C 143/C 143M Test Method for Slump of Hydraulic-Cement Concrete
C 172 Practice for Sampling Freshly Mixed Concrete
C 173/C 173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C 670 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 C 125.

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 slump cone.

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 shaped as the frustum of a cone. The concrete is placed in one lift without tamping or vibration. The mold is raised, and the concrete allowed to spread. After spreading ceases, two diameters of the concrete mass are measured in approximately orthogonal directions, and 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 1 in. [25 mm]. Therefore, this test method is considered applicable to self-consolidating concrete having coarse aggregate up to 1 in. [25 mm] in size. Appendix X1

[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.**

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.

6. Apparatus

6.1 *Mold*—The mold used in this test method shall conform to that described in Test Method C 143/C 143M.

6.2 *Base Plate*—The base plate on which the mold rests shall be nonabsorbent, smooth, rigid, and have a minimum diameter of 36 in. [915 mm].

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 C 173/C 173M.

7. Sample

7.1 The sample of concrete from which test specimens are made shall be representative of the entire batch. It shall be obtained in accordance with Practice C 172.

8. Procedure

8.1 The slump-flow test shall be performed on a flat, level, nonabsorbent surface such as a pre-moistened concrete floor or a base plate. The base plate shall be used in conditions where a flat, level surface is not available, such as on a construction job site. When the base plate is used, position and shim the base plate so that it is fully supported, flat, and level. 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 *Filling the Mold:* The user has the option of filling the mold by following either Procedure A or Procedure B.

8.2.1 *Filling Procedure A (Upright Mold):* Dampen and place the mold, with the larger opening of the mold facing down, in the center of a flat, moistened base plate or concrete surface. Firmly hold the mold in place during filling by the operator standing on the two foot pieces. From the sample of concrete obtained in accordance with Section 7, immediately fill the mold in one lift. Slightly overfill the concrete above the top of the mold.

8.2.2 *Filling Procedure B (Inverted Mold):* Dampen and place the mold, with the smaller opening of the mold facing down, in the center of a flat, moistened base plate or concrete surface. From the sample of concrete obtained in accordance with Section 7, immediately fill the mold in one lift. Slightly overfill the concrete above the top of the mold.

NOTE 2—*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 C 143/C 143M. 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.*

8.3 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 9 ± 3 in. [225 ± 75 mm] in 3 ± 1 seconds by a steady upward lift with no lateral or torsional motion. Complete the entire test from start of the filling through removal of the mold without interruption within an elapsed time of 2 ½ minutes.

8.4 Wait for the concrete to stop flowing and then measure the largest diameter of the resulting circular spread of concrete to the nearest ¼ in. [5 mm]. 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 of the circular spread at an angle approximately perpendicular to the original measured diameter.

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

9. Calculation

9.1 Calculate the slump flow using Eq 1:

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

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 ½ in. (10 mm).

10. Report

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

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

11. Precision and Bias

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 1.1 in. [27 mm] (See Note 3) for mixtures having slump flow values between approximately 19 and 27 in. [480 and 680 mm]. Therefore, results of two properly conducted tests by the same operator on the same batch of concrete should not differ by more than 3.0 in. [75 mm] (See Note 3).

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 1.1 in. [27 mm] (See Note 3) for mixtures with slump flow values between approximately 21 and 29 in. [530 and 740 mm]. Therefore, the results of properly conducted tests by two operators on the same batch of concrete should not differ by more than 3.0 in. [75 mm] (See Note 3).

NOTE 3—*These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C 670.*

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

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 20 in. [500 mm] 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.

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 slump cone, and a further concentric circle at 20 in [500 mm].

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 ≤ 0.5 in.(≤ 10 mm) and/or aggregate pile in the of the concrete mass.
3 = Highly Unstable	Clearly segregating by evidence of a large mortar halo > 0.5 in. (> 10 mm) and/or a large aggregate pile in the center of the concrete mass.

NOTE X1.2—The centrally located circular mark made at the 20 in. [500 mm] 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.