Designation: C1170/C1170M – 14$^{\varepsilon 1}$

Standard Test Method for Determining Consistency and Density of Roller-Compacted Concrete Using a Vibrating Table[1]

This standard is issued under the fixed designation C1170/C1170M; 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.

ε^1 NOTE—Editorial corrections were made to 10.2.6 in June 2014.

1. Scope*

1.1 This test method is used to determine the consistency of concrete using a vibrating table and a surcharge and to determine the density of the consolidated concrete specimen. This test method is applicable to freshly mixed concrete, prepared in both the laboratory and the field, having a nominal maximum size aggregate of 50 mm [2 in.] or less. If the nominal maximum size of aggregate is larger than 50 mm [2 in.], the test method is applicable only when performed on the fraction passing the 50-mm [2-in.] sieve with the larger aggregate being removed in accordance with Practice C172.

1.2 This test method, intended for use in testing roller-compacted concrete, may be applicable to testing other types of concrete such as cement-treated aggregate and mixtures similar to soil-cement.

1.3 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.

1.4 *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]

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
C125 Terminology Relating to Concrete and Concrete Aggregates
C172 Practice for Sampling Freshly Mixed Concrete
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C1067 Practice for Conducting a Ruggedness Evaluation or Screening Program for Test Methods for Construction Materials
D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

3. Terminology

3.1 *Definitions:*

3.1.1 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 *extremely dry consistency, n*—for the purpose of this standard, the consistency of concrete having no slump and a Vebe consistency greater than 30 s when measured with Procedure A.

3.2.2 *stiff consistency, n*—for the purpose of this standard, the consistency of concrete having no slump and a Vebe consistency ranging from 5 to 20 s when measured with Procedure B.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.45 on Roller-Compacted 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**

3.2.3 *Vebe consistency, n*—the time required for a given mass of concrete to be consolidated by vibration in a cylindrically shaped mold under a surcharge mass.

3.2.4 *very stiff consistency, n*—for the purpose of this standard, the consistency of concrete having no slump and a Vebe consistency ranging from 20 to 30 s when measured with Procedure A or B.

4. Summary of Test Method

4.1 A vibrating table is used to measure the consistency of stiff to extremely dry concrete mixtures (see Note 1). Density of the compacted specimen is measured by determining the mass of the consolidated specimen and dividing by its volume.

NOTE 1—Further description of concrete of this consistency is given in ACI 207.5R[4] and ACI 211.3R.[5]

4.2 Two procedures are provided:

4.2.1 *Procedure A* uses a 22.7 kg [50 lb] surcharge mass placed on top of the test specimen. Procedure A shall be used for testing concrete of extremely dry consistency or when the Vebe consistency by Procedure B is 30 s or greater (see Note 2).

NOTE 2—Further description of the test procedure using a 22.7 kg [50 lb] surcharge can be found in the U.S. Bureau of Reclamation's Technical Memorandum No. 8.[6]

4.2.2 *Procedure B* uses a 12.5 kg [27.5 lb] surcharge mass placed on top of the test specimen. Procedure B shall be used for testing concrete of stiff consistency or when the Vebe consistency by Procedure B is less than 20 s (see Note 3).

NOTE 3—Further description of the test procedure using a 12.5 kg [27.5 lb] surcharge can be found in the U. S. Army Corps of Engineer's test procedure CRD-C-53-01.[7]

4.2.3 Either Procedure A or B can be used for testing concrete with a very stiff consistency or when the Vebe consistency by Procedure A or B ranges from 20 to 30 s.

5. Significance and Use

5.1 This test method is intended to be used for determining the consistency and density of stiff to extremely dry concrete mixtures common in roller-compacted concrete construction.

5.1.1 Because of the stiff to extremely dry consistency of some roller-compacted concrete mixtures, the standard Vebe test method of rodding the specimen in a slump cone is substituted by Procedures A and B.[8]

5.2 Procedure A uses a 22.7 kg [50 lb] surcharge and is used for concrete consolidated by roller-compaction methods when the consistency of the concrete is very stiff to extremely dry.

5.3 Procedure B uses a 12.5 kg [27.5 lb] surcharge and is used for concrete consolidated by roller-compaction methods when the consistency of the concrete is stiff to very stiff consistency, but not extremely dry.

6. Apparatus

6.1 *Vibrating Table*—A vibrating table with a steel deck approximately 20-mm [¾-in.] thick with dimensions of approximately 380 mm [15 in.] in length, 250 mm [10 in.] in width, and 300 mm [12 in.] in height. The vibrating table shall be constructed in such a manner as to prevent flexing of the table during operation. The table deck shall be activated by an electromechanical vibrator. The table shall produce a sinusoidal vibratory motion with a frequency of at least 60 ± 2 Hz [3600 ± 100 vibrations per min] and a double amplitude of vibration of 0.43 ± 0.08 mm [0.0170 ± 0.0030 in.] when a 27 ± 2-kg [60.0 ± 2.5-lb] surcharge is bolted to the center of the table. The vibrator and table shall have a total mass of at least 90 kg [200 lb]. The table shall be level and have sufficient mass or be secured to prevent displacement of the apparatus during performance of the test.

6.2 *Cylindrical Mold*—The cylindrical mold shall be made of steel or other hard metal resistant to corrosion by cement paste and shall have an inside diameter of 240 ± 2 mm [9 ½ ± 1⁄16 in.], a depth of 200 ± 2 mm [7 ¾ ± 1⁄16 in.], and a wall thickness of 6 ± 2 mm [¼ ± 1⁄16 in.]. The mold shall be equipped with permanently affixed slotted metal brackets so it can be rigidly clamped to the vibrating table. The top rim of the mold shall be smooth, plane, and parallel to the bottom of the mold and shall be capable of providing an air and watertight seal when a glass or plastic plate is placed on the top rim.

6.3 *Swivel Arm and Guide Sleeve*—A metal guide sleeve with a clamp assembly or other suitable holding device mounted on a swivel arm (see Fig. 1). The swivel arm and guide sleeve must be capable of holding the metal shaft with the attached 22.7 kg [50 lb] or 12.5 kg [27.5 lb] cylindrical mass in a position perpendicular to the vibrating surface and allowing the shaft to slide freely when the clamp is released. The inside diameter of the guide sleeve shall be 3 ± 2 mm [1⁄8 ± 1⁄16 in.] larger than the diameter of the metal shaft of the surcharge. The swivel arm must be capable of maintaining the guide sleeve in a locked position directly over the center of the vibrating surface. The swivel arm shall be capable of being rotated away from the center of the table.

6.4 *Surcharge Assembly*—A cylindrical steel mass with a circular plastic plate attached to its base and a metal shaft at least 450 mm [18 in.] in length and 16 ± 2 mm [5⁄8 ± 1⁄16 in.] in diameter attached perpendicularly to the plate and embedded in the center of the mass. The shaft shall slide through the guide sleeve without binding. The plastic plate shall be approximately 13 mm [½ in.] in thickness and shall have a diameter of 230 ± 3 mm [9 ± 1⁄8 in.]. The edge of the plastic plate shall not be chipped or rounded. The surcharge assembly including the plastic plate and the metal shaft shall have a mass of either of

[4] ACI 207.5R, *Report on Roller-Compacted Concrete*, 1999. Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333, http://www.concrete.org.

[5] ACI 211.3R, *Guide for Selecting Proportions for No-Slump Concrete*, 2002. Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333, http://www.concrete.org.

[6] *Guidelines for Designing and Constructing Roller-Compacted Concrete Dams*, ACER Technical Memorandum No. 8, Bureau of Reclamation, Denver, CO, Appendix A, 1987.

[7] *Test Method for Consistency of No-Slump Concrete Using the Modified Vebe Apparatus*, CRD-C-53-01, U. S. Army Corps of Engineers, Vicksburg, MS, 2001.

[8] *ACI Manual of Concrete Practice*, Part 1, 2005. Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333, http://www.concrete.org.

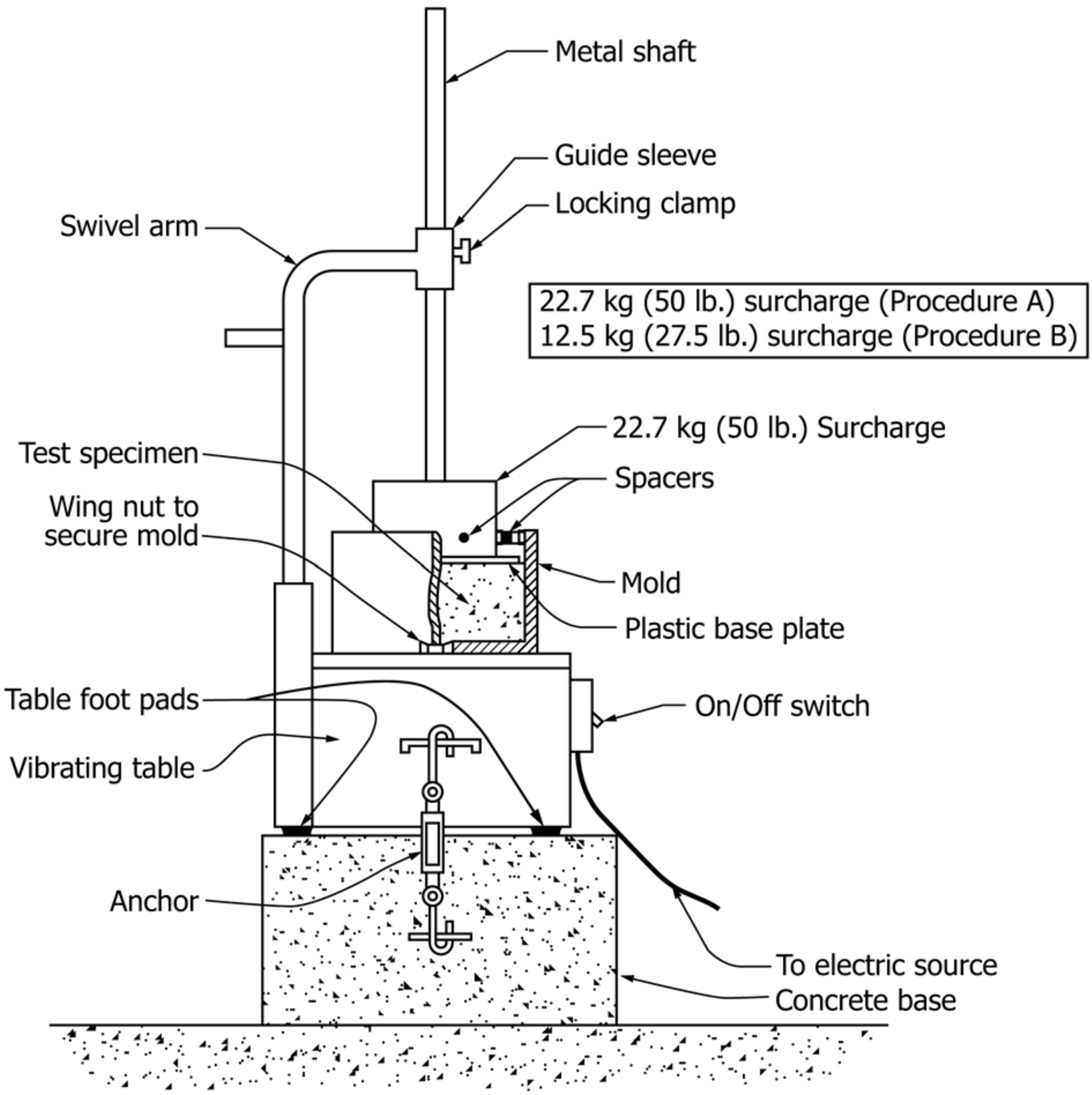

FIG. 1 Vibrating Table—Consistency Test

the following:

Procedure A—22.7 ± 0.5 kg [50 ± 1 lb], or

Procedure B—12.5 ± 0.5 kg [27.5 lb ± 1 lb].

6.4.1 The cylindrical steel mass shall include a minimum of six spacers affixed to the side of the mass. The spacers shall be located at equal distances around the circumference of the mass (see Fig. 2). The center of each spacer shall be located a maximum distance of 40 mm [1 ⅝ in.] from the bottom of the plastic plate. Each spacer shall project from the side of the mass so that, when centered in the cylindrical mold, each spacer almost touches the inside of the mold. The distance between each spacer and the inside of the mold shall not exceed 0.5 mm [0.02 in.] when the mass is centered in the mold. The spacers shall not bind so that the centered mass with spacers is allowed to freely move up and down throughout the upper half of the mold (see Note 4). The surcharge assembly including the steel mass with spacers, plastic plate, and the metal shaft shall have a mass of 22.7 ± 0.5 kg [50 ± 1 lb] or 12.5 ± 0.5 kg [27.5 lb ± 1 lb].

NOTE 4—It is advisable that the spacers be made of material that is softer than the steel used to make the cylindrical mold to avoid damage to the mold. Bolts made of nylon or brass may be used for spacers. The cylindrical steel mass can be drilled and tapped at each spacer location to receive the bolt. Washers or nuts may be added or the bolt heads milled to adjust the distance between each spacer and the inside of the mold.

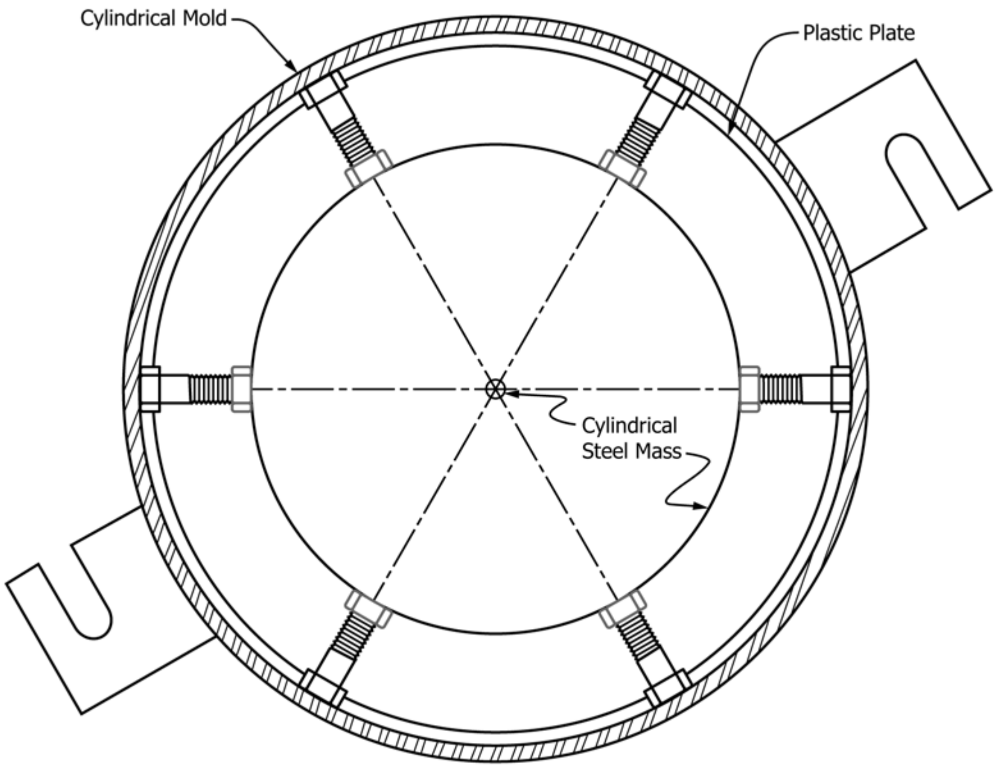

FIG. 2 Surcharge With Spacers and Plastic Plate Centered in Steel Mold

6.5 *Balance or Scale*—Balance or scale of sufficient capacity to determine the total mass of the concrete specimen and the mold. The balance or scale shall be readable to the nearest 5 g [0.01 lb].

6.6 *Strike-Off Plate*—A flat square metal plate at least 6 mm [¼ in.] thick, or a glass or clear plastic plate at least 13 mm [½ in.] thick, and at least 50 mm [2 in.] larger than the diameter of the cylindrical mold.

6.7 *Sieve*—A 50-mm [2-in.] sieve conforming to Specification E11.

6.8 *Timing Device*—A stopwatch, capable of recording time intervals of at least 60 s to the nearest 1 s.

6.9 *Small Tools*—Square-ended shovel and hand scoops, wrench, tamping rod, flashlight, and feeler gauges as required.

7. Sampling

7.1 Specimens of fresh concrete shall be obtained in accordance with Practice C172.

7.2 Concrete samples shall have a nominal maximum size of aggregate of 50 mm [2 in.] or less. If the concrete contains aggregate larger than 50 mm [2 in.], samples shall be obtained by wet sieving over a 50 mm [2 in.] sieve in accordance with Practice C172.

7.3 Testing of concrete samples shall be completed within 45 min after the completion of mixing unless otherwise stipulated.

8. Preparation of Apparatus

8.1 *Vibrating Table*—Verify that the vibrating table meets the requirements of 6.1. Make adjustments if necessary.

8.1.1 Determine the frequency and double amplitude of the vibrating table under simulated test conditions prior to initial use and annually thereafter (see Note 5).

NOTE 5—A vibrating reed tachometer may be used to check the vibration frequency.

8.1.2 In addition to the calibration schedule given in 8.1.1, calibrate the vibrating table after any event (including repairs) that might affect its operation, or whenever test results are questionable causing vibrating table operation to be suspect.

8.2 *Surcharge Assembly*—Adjust the surcharge assembly spacers, as necessary, to ensure the spacers do not bind and the maximum allowable distance between the spacers and the inside of the mold is not exceeded when the surcharge assembly is centered in the cylindrical mold. (See Note 6.)

NOTE 6—Feeler gauges can be used to measure the distance between the spacers and the inside of the mold. One feeler gauge per spacer is needed. Bond paper may be used in lieu of feeler gauges. The bond number is directly proportional to the paper thickness. Number 10 bond paper has a thickness of approximately 0.05 mm [0.002 in.], number 20 bond paper has a thickness of approximately 0.1 mm [0.004 in.], etc.

8.2.1 Check the edge of the surcharge assembly plastic plate and replace if it is chipped or rounded.

8.3 *Cylindrical Mold*—Determine the volume of the cylindrical mold to the nearest 0.03 L [0.001 ft^3] in accordance with

Test Method C29/C29M. Verify the volume of the mold monthly during times of regular use and annually when used infrequently. Determine the mass of the cylindrical mold to the nearest 5 g [0.01 lb]. For balances with tare capability, tare the balance with the mold.

9. Technical Precautions

9.1 When obtaining samples, ensure that the samples are representative of the material being sampled.

9.2 Concrete with stiff to extremely dry consistency is highly susceptible to segregation during handling. To minimize segregation, use care in obtaining samples and during transporting, remixing, and testing of the concrete.

10. Procedure

10.1 *Vebe Consistency Time:*

10.1.1 Record the mass of the mold or tare the balance with the mold.

10.1.2 Using square-ended shovels and scoops, obtain a representative sample with a minimum mass of 25 kg [50 lb] in accordance with Practice C172. Handle concrete in such a manner that coarse aggregate does not separate from the mortar.

10.1.3 Dampen the interior of the mold and fill with 13.5 ± 1 kg [29.5 ± 1.5 lb] of concrete. Using a square-edged scoop and tamping rod, place and distribute the concrete evenly to minimize segregation and rock pockets. Level the surface of the loose concrete.

10.1.4 Select either the 22.7 kg [50 lb] surcharge (Procedure A) or the 12.5 kg [27.5 lb] surcharge (Procedure B) (see Note 7).

NOTE 7—The 12.5 kg [27.5 lb] surcharge is used for mixtures proportioned with a consistency of 20 s or less in accordance with Procedure B; or a paste volume in excess of the minimum volume of voids in the aggregate as determined using Test Method C29/C29M; or a total moisture content wet of the optimum, as determined using soil compaction test procedures in accordance with Test Methods D1557. The 22.7 kg [50 lb] surcharge is used for mixtures proportioned with a consistency of more than 30 s in accordance with Procedure A; or with a paste volume approaching the minimum aggregate voids volume as determined using Test Method C29/C29M; or total moisture approaching the optimum moisture content as determined using soil compaction test procedures in accordance with Test Methods D1557. Either procedure can be used if the consistency is between 20 and 30 s.

10.1.5 Secure the mold on the vibrating table by hand tightening the wing nuts. Slide the shaft of the surcharge assembly through the guide sleeve, and rotate the surcharge assembly to its locked position centered over the mold, ensuring that it will fit inside the mold when released. The surcharge assembly may be lowered into the mold during this procedure to adjust the position of the mold but it shall not be placed on the specimen. Adjust the mold position so that the surcharge assembly is centered, ensuring it can move freely to prevent binding. After verifying the surcharge can move up and down without binding, secure the wing nuts of the mold with a wrench to prevent loosening during the test. Gently lower the surcharge assembly onto the surface of the specimen.

10.1.6 Start the vibrating table and timer. Using the flashlight, observe the concrete in the annular space between the edge of the plastic plate and the inside wall of the mold. As the test progresses, mortar will fill in the annular space between the outer edge of the plastic plate and the inside mold wall. Observe the mortar until it forms a complete ring around the total perimeter of the plastic plate. When the mortar ring forms completely around the plastic plate, stop the timer and vibrator; determine the elapsed time to the nearest second. Record this time as the Vebe consistency time, Procedure A or B, depending on which surcharge mass is used.

10.1.6.1 If a mortar ring forms around the total perimeter of the plastic plate except at an isolated location where a rock or rock pocket impedes the complete mortar formation, the timer and vibrator shall be stopped and the elapsed time to the nearest second shall be recorded as the Vebe consistency time, Procedure A or B. Note the presence of the rock obstruction.

10.1.6.2 If the ring of mortar does not form after 60 s of vibration, stop the vibrating table and timer and record "> 60 s" as the Vebe consistency time.

10.1.7 If the wing nuts loosen during the test, repeat the test with a fresh sample of concrete.

10.1.8 If the test result is out of the ranges specified in 4.2.1 or 4.2.2, change to the heavier or lighter surcharge mass, as applicable. Once chosen, however, the same surcharge mass shall be used for the mix for the duration of the project.

10.1.9 Determine the density of the specimen in accordance with 10.2.

10.2 *Vebe Density of Freshly Consolidated Concrete:*

10.2.1 Following determination of the Vebe time, remove the surcharge assembly. Add additional concrete on top of the previously compacted specimen. Overfill the mold by mounding the concrete above the top of the mold.

10.2.2 Place the surcharge assembly on top of the loose concrete and consolidate by vibrating. If the surcharge assembly consolidates concrete below the top level of the mold, turn off the vibrating table. Place additional concrete in the mold so that, when consolidated, the concrete will be less than 3 mm [⅛ in.] above the top of the mold.

10.2.2.1 Rotate the swivel arm away from the center of the table so that the surcharge assembly can be slid across the top of the cylindrical mold without interference from the swivel arm. Continue vibrating; and with a sawing, screeding action, slide. Continue vibrating; and with a sawing, screeding action, slide the surcharge assembly across the top of the mold until the compacted concrete is level with the top of the mold. Do not allow the surcharge assembly to remain in one position when the concrete is being finished because this can cause aggregates to be forced down and mortar to be forced out of the mold resulting in a non-representative test specimen.

10.2.3 After the surface has been screeded level with the top of the mold, stop the vibrating table. Remove the surcharge assembly and vibrate the specimen for 5 ± 1 s to fill in minor surface tears. If the top surface of the specimen is disturbed by large amplitude oscillations, stop the vibrating table immediately

10.2.4 *Surface Strike-Off and Finishing*—After screeding the top surface even with the top of the mold, finish the surface with the strike-off plate. The strike-off is best accomplished by pressing the strike-off plate on the top surface of the cylindrical mold to cover about two-thirds of the surface and, with continued downward force on the plate, withdrawing the plate with a sawing motion to finish only the area originally covered. Then place the plate on the top of the mold to cover the original two-thirds of the surface and advance it over the remaining third, with a vertical pressure and sawing motion to remove the concrete remaining above the top of the mold. Repeat 10.2.2 and 10.2.3, if necessary, until the concrete is even with the top rim of the mold. If the finishing procedure causes surface tears that cannot be corrected with additional finishing, discontinue the surface strike-off and finishing and use the screeded surface for the density determination.

10.2.5 *Cleaning and Weighing*—After strike-off and finishing, loosen the wing nuts from the vibrating table and remove the cylinder mold. Clean all excess concrete from the exterior of the mold and determine the mass of the filled mold to the nearest 5 g [0.01 lb]. Determine the net mass of concrete by subtracting the mass of the empty mold. Alternatively, the net mass is permitted to be determined by taring the balance or scale with the empty mold.

10.2.6 Calculate the density of the specimen in accordance with Section 11.

11. Calculation

11.1 Compute the density of the specimen as follows:

$$D = \frac{M_s}{V_s}$$

where:

D = density, kg/m^3 [lb/ft^3],
M_s = mass of specimen, kg [lb] = mass of specimen plus cylindrical mold – mass of cylindrical mold, and
V_s = volume of cylindrical mold, m^3 [ft^3].

12. Report

12.1 Report the:

12.1.1 Procedure used (Procedure A or B),

12.1.2 Vebe consistency time in seconds,

12.1.3 Density in kg/m^3 [lb/ft^3],

12.1.4 Make and model of the vibrating table, and

12.1.5 Occurrence of an incomplete ring due to a rock obstruction per 10.1.6.1, if applicable.

13. Precision and Bias

13.1 *Precision*—A ruggedness evaluation was executed per Practice C1067 to determine the sensitivity of the test method to changes in levels of pertinent operating factors. Forty-eight tests were conducted with replicate tests conducted on 24 different RCC mixtures. The seven factors evaluated were: (*1*) surcharge mass, (*2*) time elapsed from time mix was discharged, (*3*) proportioning lean or rich, (*4*) ratio of Portland cement to Class F fly ash, (*5*) aggregate angularity, (*6*) nominal maximum aggregate size, and (*7*) absence or presence of air entrainment. Some information on single-operator precision was obtained. A report of results and calculations is on file at ASTM [Research Report C09-1043[9]].

13.1.1 *SI [Inch-Pound]*—The data used to develop the precision statement was obtained using the inch-pound version of this test method. The precision indices shown in SI units are exact conversions of the values in brackets.

13.1.2 *Single-Operator Precision:*

13.1.2.1 *Consistency*—The single-operator standard deviation has been found to be 3.7s[10] for mixtures with Vebe consistencies below 20s and 8.7s[10] for mixtures with Vebe consistencies above 20s. Therefore, results of two properly conducted tests by the same operator on the same material are not expected to differ from each other by more than 10s for mixtures with Vebe consistencies below 20s and 24s for mixtures with Vebe consistencies of 20s or greater.

13.1.2.2 *Density*—The single-operator standard deviation has been found to be 8.0 kg/m^3 [0.5 lb/ft^3][10] for mixtures with Vebe consistencies below 20s, 11.2 kg/m^3 [0.7 lb/ft^3][10] for mixtures with Vebe consistencies over the range from 20s to 30s, and 14.4 kg/m^3 [0.9 lb/ft^3][10] for mixtures with Vebe consistencies above 30s. Therefore, results of two properly conducted tests by the same operator on the same material are not expected to differ from each other by more than 20.8 kg/m^3 [1.3 lb/ft^3] for mixtures with Vebe consistencies below 20s, 32.0 kg/m^3 [2.0 lb/ft^3] for mixtures with Vebe consistencies over the range from 20s to 30s, and 41.6 kg/m^3 [2.6 lb/ft^3] for mixtures with Vebe consistencies above 30s.

13.2 *Bias*—The procedure in this test method for determining consistency and density of roller-compacted concrete has no bias because consistency and density can only be defined in terms of this test method.

14. Keywords

14.1 concrete; consistency; density; fresh concrete properties; roller-compacted concrete; Vebe

[9] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1043. Contact ASTM Customer Service at service@astm.org.

[10] These numbers represent, respectively, the [1s] and [d2s] limits as described in Practice C670, Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials.

SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this test method since the last issue, C1170 – 08, that may impact the use of this test method. (Approved April 1, 2014)

(1) Revised three terms in the Terminology Section.
(2) Revised the Apparatus Section.
(3) Revised Figure 1 and added Figure 2.
(4) Added precision data.