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

This standard is issued under the fixed designation C 1170; 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—Section reference in paragraph 9.2.9 was editorially updated in December 1998.

1. Scope

1.1 These test methods are used to determine the consistency of concrete by the Vebe[2] consistometer apparatus and the density of the consolidated concrete specimen. These test methods are 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 methods are applicable only when performed on the fraction passing the 50-mm (2-in.) sieve with the larger aggregate being removed in accordance with Practice C 172.

1.2 These test methods, 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 inch-pound units are to be regarded as the standard. The values given in parentheses are for information purposes only.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 29/C 29M Test Method for Unit Weight and Voids in Aggregate[3]

C 172 Practice for Sampling Freshly Mixed Concrete[3]

E 1 Specification for ASTM Thermometers[4]

E 11 Specification for Wire Cloth and Sieves for Testing Purposes[5]

2.2 *ACI Reports and Standards:*

207.5R-88 Report on Roller-Compacted Concrete[6]

211.3-75 (R 1988) Standard Practice for Selecting Proportions for No-Slump Concrete[6]

2.3 *Bureau of Reclamation Test Procedure:*

USBR 4905-86 Consistency and Density of No-Slump Concrete by Vibrating Table[7]

2.4 *British Standard:*

BS 1881: Part 104: 1983 Method for Determination of Vebe Time[8]

3. Summary of Test Method

3.1 The Vebe vibrating table is used to measure the consistency of stiff to extremely dry concrete mixtures (Note 1). Consistency is measured as the time required for a given mass of concrete to be consolidated by vibrating in a cylindrically shaped mold. Density of the compacted specimen is measured by determining the mass of the consolidated specimen and dividing by its volume, which is determined using water-displacement methods.

NOTE 1—Further description of concrete of this consistency is given in ACI 207.5R-88 and ACI 211.3-75 (R 1988).

3.2 Two procedures are provided:

3.2.1 *Test Method A* [using a 50-lb (22.7-kg) surcharge mass placed on top of the test specimen]—Test Method A shall be used for testing concrete of very stiff to extremely dry consistency in accordance with ACI 211.3-75 (R 1988).

3.2.2 *Test Method B* (no surcharge)—Test Method B shall be used for concrete of stiff to very stiff consistency or when the Vebe time by Test Method A is less than 5 s.

4. Significance and Use

4.1 These test methods are intended to be used for determining the consistency and density of stiff to extremely dry concrete mixtures common when using roller-compacted concrete construction.

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[1] These test methods are under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregatesand are the direct responsibility of Subcommittee C09.45on Roller-Compacted Concrete.

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[2] The Vebe vibrating table, including cylindrical mold and guide sleeves, is manufactured by SoilTest, 86 Albrecht Drive, P.O. Box 8004, Lake Bluff, IL 60044-9902.

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

[4] *Annual Book of ASTM Standards,* Vol 14.03.

[5] *Annual Book of ASTM Standards,* Vol 14.02.

[6] *ACI Manual of Concrete Practice, Part 1, Materials and General Properties of Concrete*, American Concrete Institute, P.O. Box 19150, Detroit, MI 48219, 1988.

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

[8] *Testing Concrete,* British Standards Institute, 2 Park Street, London, England W1A 2BS.

4.1.1 Because of the stiff to extremely dry consistency of some roller-compacted concrete mixtures, the standard Vebe test method[7] of rodding the specimen in a slump cone is substituted by Test Methods A and B. For Test Method A, the surcharge mass is increased from 6 lb (2.72 kg) to 50 lb (22.7 kg); and for Test Method B, the surcharge mass is eliminated.

4.2 Test Method A uses a 50-lb (22.7-kg) surcharge and is used for concrete consolidated by roller-compaction methods. The consistency and density of concrete suitable for consolidation by vibrating rollers can be determined using Test Method A.

4.3 Test Method B does not use a surcharge and can be used to determine the consistency and density of some concrete mixtures consolidated by conventional vibration techniques and some concrete mixtures consolidated by vibrating rollers.

5. Apparatus

5.1 *Vebe Vibrating Table*—A vibrating table with a ¾-in. (19-mm) thick steel deck with dimensions of approximately 15 in. (381 mm) in length, 10¼ in. (260 mm) in width, and 12 in. (305 mm) 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 total mass of the vibrator and table shall be approximately 210 lb (95 kg). The table shall be level and clamped to a concrete floor or base slab that has sufficient mass to prevent displacement of the apparatus during performance of the test (Note 2).

NOTE 2—The recommended vibrating table for these test methods is the Vebe vibrating table.[2] Testing to date has been performed using this apparatus. An alternative vibrating table may be substituted for the Vebe apparatus (Fig. 1) provided it meets the specifications for the sinusoidal vibration given in 7.1 and is in accordance with the alternative testing requirements of Sections 9 and 11.

5.2 *Cylindrical Mold*—The cylindrical mold shall be made of steel or other hard metal resistant to cement paste corrosion and shall have an inside diameter of 9 ½ ± 1⁄16 in. (241 ± 2 mm), a height of 7¾ ± 1⁄16 in. (197 ± 2 mm), and a wall thickness of ¼ ± 1⁄16 in. (6 ± 2 mm). The volume of the mold shall be determined to the nearest 0.001 ft^3 (0.028 L) in accordance with Test Method C 29/C 29M. 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 the glass or plastic plate is placed on the top rim.

5.3 *Swivel Arm and Guide Sleeve*—A metal guide sleeve with a clamp assembly or other suitable holding device mounted on a swivel arm. The swivel arm and guide sleeve must be capable of holding the metal shaft with the attached 50-lb (22.7-kg) 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 ⅛ by 1⁄16 in. (3.2 ± 1.6 mm) 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 (Note 3).

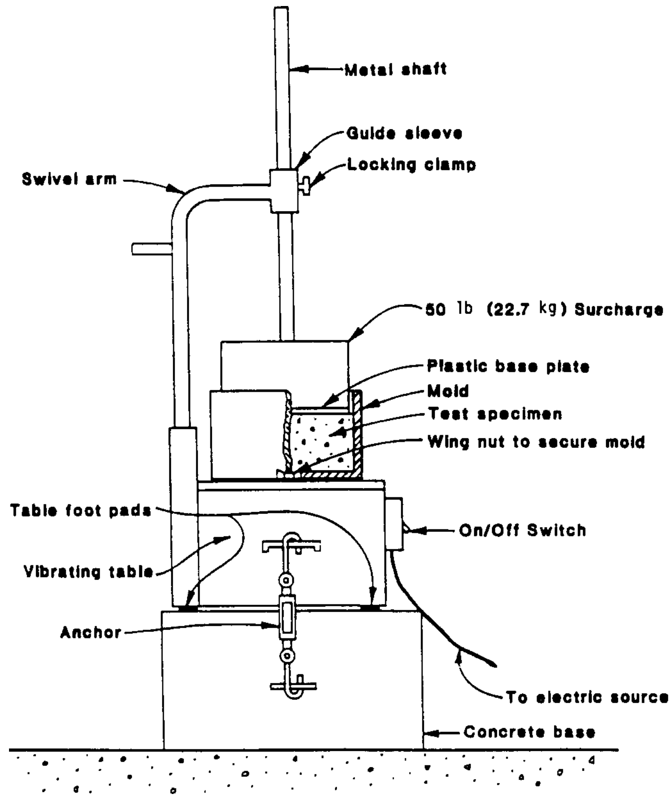

FIG. 1 Vibrating Table—Consistency Test (Test Method A)

NOTE 3—The Vebe vibrating table comes equipped with the swivel arm and guide sleeve.

5.4 *Surcharge*—A cylindrical steel mass with a circular plastic plate attached to its base and a metal shaft at least 18 in. (457 mm) in length and ⅝ ± 1⁄16 in. (16 ± 2 mm) 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 ½ in. (13 mm) in thickness and shall have a diameter of 9 ± ⅛ in. (229 ± 3 mm). The surcharge assembly shall have a mass of 50 ± 1 lb (22.7 ± 0.5 kg) including the mass of the plastic plate and the metal shaft.

5.5 *Balance or Scale*—Balance or scale of sufficient capacity to determine the total mass of the sample and the mold. The balance or scale shall be readable to the nearest 0.05 % of the concrete specimen mass.

5.6 *Flat Plate*—A plain, flat piece of plate glass or clear plastic, at least ½ in. (13 mm) thick and at least 1 in. (25 mm) larger than the diameter of the cylindrical mold.

5.7 *Sieve*—A 50-mm (2-in.) sieve conforming to Specification E 11.

5.8 *Timing Device*—A stopwatch, capable of recording time intervals of at least 2 min to the nearest 1 s.

5.9 *Thermometer*—ASTM No. 1F or 1C thermometer conforming to the requirements of Specification E 1.

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

6. Sampling

6.1 Specimens of fresh concrete shall be obtained in accordance with Practice C 172.

6.2 Concrete samples have a nominal maximum size of aggregate of 50 mm (2 in.) or less. If the concrete has aggregate larger than 2 in., samples shall be obtained by wet sieving over a 50-mm (2-in.) sieve in accordance with Practice C 172.

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

7. Calibration and Standardization

7.1 *The Vibrating Table*, shall produce a sinusoidal vibratory motion with a frequency of at least 3600 ± 100 vibrations per min (60 ± 1.67 Hz) and a double amplitude of vibration of 0.0170 ± 0.0030 in. (0.43 ± 0.08 mm) when a 60.0 ± 2.5-lb (27.2 ± 1.1-kg) surcharge is bolted to the center of the table.

7.1.1 Determine the frequency and double amplitude[9] of the vibrating table under simulated test conditions prior to initial use and annually thereafter. A vibrating reed tachometer should be used to check the frequency of vibration.

7.2 *Cylindrical Mold*—Determine the volume of the cylindrical mold to the nearest 0.001 ft^3(0.028 L) in accordance with Test Method C 29/C 29M. Verify the volume of the mold monthly during times of regular use and annually when used infrequently. If used in density computations (that is, when a balance with tare is unavailable), determine the mass of the cylindrical mold to the nearest 0.01 lb (5 g). For balances with tare capability, tare the balance with the mold and flat plate.

7.3 Determine the mass of the flat plate to the nearest 0.01 lb (5 g).

7.4 In addition to the calibration frequency given in 7.1.1, calibrate the vibrating table after any event (including repairs) that might affect its operation, or whenever test results are questionable.

8. Technical Precautions

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

8.2 Concrete with stiff to very 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.

TEST METHOD A—VEBE TIME

9. Procedure

9.1 *Vebe Consistency Time (With a Surcharge)*:

9.1.1 Using square-ended shovels and scoops, obtain a representative sample with a minimum mass of 50 lb (22.7 kg) in accordance with Practice C 172. Handle concrete in such a manner that coarse aggregate does not separate from the mortar.

9.1.2 Dampen the interior of the mold and fill with 29.5 ± 1.5 lb (13.4 ± 0.7 kg) 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.

9.1.3 Secure the mold on the Vebe table by hand tightening the wing nuts. Slide the shaft of the surcharge mass through the guide sleeve, and rotate the surcharge to its locked position centered over the mold, ensuring that it will fit inside the mold when released. The surcharge 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. Secure the wing nuts of the Vebe table with a wrench to prevent loosening during the test. Gently lower the surcharge onto the surface of the specimen.

9.1.4 If the surcharge cannot be centered in the mold without binding on the inside wall of the mold, place the surcharge directly onto the specimen in the mold without the use of the guide sleeve, and manually hold the surcharge shaft perpendicular to the top of the table. The surcharge shaft must be held manually throughout the remainder of the Vebe test. Do not apply additional hand pressure to the surcharge when manually holding the surcharge.

9.1.5 Start the vibrator and timer. Using the flashlight, observe the concrete in the annular space between the edge of the surcharge and the inside wall of the mold. As the test progresses, mortar will fill in the annular space between the outer edge of the surcharge and the inside mold wall. Observe the mortar until it forms a ring around the total perimeter of the surcharge. When the mortar ring forms completely around the surcharge, stop the vibrator and timer; determine the elapsed time to the nearest minute and second. Record this time as the Vebe consistency time, Test Method A. If the wing nuts loosen during the test, repeat the test with a fresh sample of concrete. If the ring of mortar does not form after 2 min of vibration, stop the vibrator and timer; record this condition on the report.

9.1.6 If the following conditions exist after two min have elapsed, document them in the report, record the elapsed time, and retest if necessary:

9.1.6.1 A rock pocket in the loose specimen prevents the mortar ring from forming at one small location even though the mortar ring forms in all other locations, or

9.1.6.2 The elapsed time in which the majority of the mortar ring formed is similar to previous readings with the same mixture proportions.

9.1.7 Determine the density of the specimen in accordance with Section 9.2.

9.2 *Vebe Density of Freshly Consolidated Concrete*:

9.2.1 Following determination of the Vebe time, remove the surcharge. Vibrate the specimen without the surcharge for a total cumulative time (including the initial consistency time) of 2 min.

9.2.2 Remove the mold with the consolidated specimen from the Vebe table, and wipe any mortar from the inside wall of the cylinder mold above the level of the consolidated concrete. Place the flat plate on the cylinder mold and determine to the nearest 0.01 lb (4.5 g) the mass of the cylindrical mold, consolidated concrete specimen, and flat plate. Determine the mass of the specimen by subtracting the mass of the cylindrical mold and flat plate from the mass of the cylindrical mold, consolidated specimen, and flat plate. Remove the flat plate.

9.2.3 Place the mold on a level surface and carefully fill the

[9] "Suggested Method for the Calibration of Vibrating Tables for Maximum Index Density Testing," *ASTM Geotechnical Journal*, Vol 2, No. 3, p. 152, September 1979.

mold with water at room temperature to a meniscus level just above the top rim while minimizing washout of paste from the specimen surface.

9.2.4 Determine the temperature of the water to the nearest 1°F (1°C).

9.2.5 Carefully cover the mold with the flat plate in such a way as to eliminate air bubbles and excess water.

9.2.6 Wipe all excess water, and determine the total mass of the cylinder mold, consolidated specimen, water, and flat plate. Determine the mass of the water by subtracting the mass of the mold, specimen, and flat plate as determined in 9.2.2 from the total mass.

9.2.7 Determine the volume of water by dividing the mass of water by the density of water at the recorded temperature in accordance with the values given in Test Method C 29/C 29M, Table 3, interpolating if necessary. Determine the volume of water to the nearest 0.001 ft^3(0.028 L).

9.2.8 Determine the volume of the specimen by subtracting the volume of the water obtained in 9.2.7 from the volume of the water obtained in 9.2.7 from the volume of the cylinder mold obtained in 7.2.

9.2.9 Determine the density of the specimen in accordance with Section 11, Calculation. This is referred to as the Vebe density of the specimen, Test Method A.

9.3 *Vibrating Consistency Time and Density Using an Alternative Vibrating Table, Test Method A*:

9.3.1 Determine the consistency time of concrete in accordance with 9.1. Record the use of an alternative vibrating table, and record the time as vibrating consistency time, Test Method A.

9.3.2 Determine the density of the specimen in accordance with 9.2. Refer to this as the vibrating density of the specimen, Test Method A.

9.3.2.1 When determining the consistency and density of concrete using an alternative vibrating table, it may not be possible to vibrate the specimen without a surcharge. This is due to disturbance of the compacted specimen when large-amplitude, low-frequency vibration waves occur after the vibrator is turned off. If this occurs, leave the surcharge on the specimen after determining the vibrating time, and vibrate the specimen for a total cumulative time (including the initial vibrating consistency time) of 2 min. Record the use of the surcharge for the density determination.

9.3.2.2 Determine the density of the consolidated specimen in accordance with 9.2.2 through 9.2.9.

TEST METHOD B—VEBE TIME

10. Procedure

10.1 *Vebe Consistency Time (Without a Surcharge)*:

10.1.1 Obtain a representative sample of concrete in accordance with Section 6, and place the concrete in the cylindrical mold in accordance with 9.1.1 and 9.1.2.

10.1.2 Place the mold on the Vebe table, and tighten the wing nuts to prevent loosening during the test.

10.1.3 Start the vibrator and the timer. Observe the contact between the concrete and inside wall of the mold. As the specimen consolidates, a ring of mortar will form around the perimeter of the specimen against the inside wall of the mold and will fill in between coarse aggregates. Observe the formation of the mortar ring around the perimeter of the mold. When the mortar ring is completely formed, stop the vibrator and timer; determine the elapsed time to the nearest minute and second. Record this time as the Vebe consistency time, Test Method B. If the mortar ring does not form after 2 min, stop the vibrator. Record this condition on the report, and repeat the test with a fresh sample of concrete using Test Method A if necessary. If the wing nuts loosen during the test, repeat the test with a fresh sample of concrete.

10.1.4 Record the conditions of 9.1.6, if appropriate.

10.2 *Density of Fresh Concrete, Test Method B*:

10.2.1 Determine the density of the specimen in accordance with 9.2. Refer to the density as Vebe density of the specimen, Test Method B.

10.3 *Vibration Consistency Time and Density Using Alternate Vibrating Table, Test Method B*:

10.3.1 *Vibrating Consistency Time, Test Method B*:

10.3.1.1 Determine the vibrating consistency time, Test Method B, in accordance with 10.1.1 through 10.1.4. Record the use of an alternate vibrating table.

10.3.1.2 If the conditions of 9.3.2.1 are observed, discontinue the test and do not use Test Method B for vibrating consistency time or density.

10.3.2 *Density of Fresh Concrete, Test Method B*:

10.3.2.1 Determine the density of fresh concrete in accordance with 9.2. Refer to the density as vibrating density of the specimen, Test Method B.

11. Calculation

11.1 Determine the density of the specimen as follows:

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

where:

D = density, lb/ft^3[(kg/m^3) or k_g/dm^3(Note 4)],
M_s = mass of specimen, lb (kg)
V_s = volume of specimen, ft^3(dm^3 or m^3).

NOTE 4—To convert dm^3 to m^3, multiply by 1000.

12. Report

12.1 Report the Vebe consistency time in seconds and the density in lb/ft^3(kg/m^3), and state whether the data were determined by Test Method A or B and if a Vebe or an alternate vibrating table was used for the test.

13. Precision and Bias

13.1 The precision of these test methods has not yet been determined, but data are being collected and a precision statement will be included when it is developed.

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

14. Keywords

14.1 concrete; consistency; density; roller-compacted concrete