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Standard Test Methods for In-Place Density of Unhardened and Hardened Concrete, Including Roller Compacted Concrete, By Nuclear Methods[1]

This standard is issued under the fixed designation C 1040/C 1040M; 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 These test methods cover the determination of the in-place density of unhardened and hardened concrete, including roller compacted concrete, by gamma radiation. For notes on the nuclear test see Appendix X1.

1.2 Two test methods are described, as follows:

~~1.3The values stated in inch-pound units are to be regarded as the standard. The SI equivalents of inch-pound units may be approximate.~~

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.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 29/C 29M ~~Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate~~ Test Method for Bulk Density (Unit Weight) and Voids in Aggregate

C 138/C 138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

3. Significance and Use

3.1 These test methods are useful as rapid, nondestructive techniques for the in-place determination of the density of unhardened concrete. The backscatter test method is also useful for the same purpose on hardened concrete. The fundamental assumptions inherent in the test methods are that Compton scattering is the dominant interaction and that the material under test is homogeneous.

3.2 These test methods are suitable for control and for assisting in acceptance testing during construction, for evaluation of concrete quality subsequent to construction, and for research and development.

NOTE 1—Care must be taken when using these test methods in monitoring the degree of consolidation, which is the ratio of the actual density achieved to the maximum density attainable with a particular concrete. The test methods presented here are used to determine the actual density. A density measurement, by any test method, is a function of the components of the concrete and may vary, to some extent, in response to the normal, acceptable variability of those components.

3.3 Test results may be affected by reinforcing steel, by the chemical composition of concrete constituents, and by sample heterogeneity. The variations resulting from these influences are minimized by instrument design and by the user's compliance with appropriate sections of the test procedure. Results of tests by the backscatter test method may also be affected by the density

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[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.

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

of underlying material. The backscatter test method exhibits spatial bias in that the apparatus's sensitivity to the material under it decreases with distance from the surface of the concrete.

NOTE 2—Typically, backscatter gauge readings represent the density in the top 75 to 100 mm [3 to 4 in.] of material.

4. Apparatus

4.1 The exact details of construction of the apparatus may vary, but the apparatus as a whole shall satisfy the requirements for system precision stated in Annex A1. The system shall consist of the following:

4.1.1 *Gamma Source*—An encapsulated and sealed radioisotopic source, such as cesium-137 (see X1.2).

4.1.2 *Detector*—Any type of gamma detector, such as a Geiger-Müller tube, scintillation crystal, or proportional counter.

4.1.3 *Probe*—For direct transmission measurements, either the gamma source or the detector shall be housed in a probe for inserting in a preformed hole in the material to be tested. The probe shall be marked in increments of ~~2 in. (50 mm)~~50 mm [2 in.] for tests with probe depths from ~~2~~50 to ~~12 in. (50~~300 mm [2 to ~~300 mm).~~12 in.]. The probe shall be so made mechanically, that when moved manually to the marked depth desired, it will be held securely in position at that depth.

4.1.4 *Readout Instrument*—A suitable scaler or direct readout meter.

4.1.5 ~~*Gage Housing*~~Gauge Housing—The source, detector, readout instrument and appropriate power supplies shall be in housings of rugged construction that are moisture and dust proof.

4.1.6 *Reference Standard*—A block of uniform, unchanging density provided for checking equipment operation, background count, and count-rate reproducibility.

4.1.7 *Guide Plate and Hole-Forming-Device*—For direct transmission measurements, a guide plate and a device, such as a pin or drill rod, having a nominal diameter slightly larger than the probe, for forming a hole normal to the concrete surface are required.

4.1.8 *Calibration Adjustment Container*— The container shall be rigid and watertight, with minimum inside dimensions large enough to allow the calibration curve adjustment procedure (5.2) to be followed with no effect of the finite size of the container on the instrument's responses. The volume of the container shall be established following the procedure outlined in Test Method C 29/C 29M.

NOTE ~~2—For backscatter measurements, a container 18 by 18 by 6 in. (450 by 450 by 150 mm) will meet this requirement for most equipment currently available commercially. For 2-in. (50-mm) depth direct transmission measurements, a container 24 by 24 by 4 in. (600 by 600 by 100 mm) will meet this requirement.~~ 3—For backscatter measurements, a container 450 by 450 by 150 mm [18 by 18 by 6 in.] will meet this requirement for most equipment currently available commercially. For 50-mm [2-in.] depth direct transmission measurements, a container 600 by 600 by 100 mm [24 by 24 by 4 in.] will meet this requirement.

4.1.9 *Scale*—The scale shall be accurate to within ~~0.5 lb (0.2 kg)~~0.2 kg [0.5 lb] of the test load at any point within the range of use. The range of use shall be considered to extend from the weight of the calibration adjustment container empty, to the weight of the measure plus the contents at ~~160 lb/ft~~2600 kg/m^3 ~~(2600 kg/m$^{[160\ lb/ft^3}$).~~].

4.1.10 *Strike-Off Plate or Bar*—This shall be a flat metal or glass plate or metal bar with a length at least ~~2 in. (50 mm)~~50 mm [2 in.] greater than the length, width, or diameter of the calibration adjustment container. The strike-off must be rigid, straight, and smooth enough to finish the concrete surface flat and flush with the edges of the calibration adjustment container.

5. Calibration

5.1 Calibration curves are established by determining the nuclear count rate of each of several materials at different and known densities, plotting the count rate (or count ratio) versus each known density, and placing a curve through the resulting points. The method used to establish the curve must be the same as that used to determine the density. The materials used for calibration must be of uniform density.

NOTE ~~3~~4—Calibration curves are supplied by gauge manufacturers, or can be established using blocks of known density or prepared containers of uniform, unchanging material compacted to known densities. Materials considered satisfactory for use in blocks include granite, aluminum, chalk, limestone, and magnesium.

5.2 *Adjusting Calibration Curves*—Prior to use, adjust the instrument's calibration curve, if necessary, to compensate for chemical composition effects. Such an adjustment is necessary whenever the chemical composition of the concrete to be tested differs significantly from that for which the calibration curve was established. An adjustment is also necessary if the testing equipment has been changed. Adjustment is particularly important for backscatter test method measurements. Determine the necessary adjustments using the same mode of operation and at the same depth (if using direct transmission) as that intended for testing. A recommended procedure for making this adjustment is as follows:

5.2.1 Prepare a concrete mix similar in composition to the material to be tested subsequently.

5.2.2 Fill the calibration adjustment container with concrete and consolidate to produce a uniform, homogeneous material with approximately the density that will be achieved in the construction.

NOTE ~~4~~5—Consolidation may be achieved by the procedure used for unit weight testing (Test Method C 138/C 138M) or by other methods, such as spading the concrete and then dropping the ends of the container alternately on a rigid surface.

5.2.3 Strike off the container with strike-off plate or bar. Take care to make the concrete surface flat and flush with the container edges.