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Designation: D 5195 – 02

Standard Test Method for Density of Soil and Rock In-Place at Depths Below the Surface by Nuclear Methods[1]

This standard is issued under the fixed designation D 5195; 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 calculation of the density of soil and rock by the attenuation of gamma radiation, where the gamma source and the gamma detector are placed at the desired depth in a bored hole lined by an access tube.

1.2 The density, in mass per unit volume of the material under test, is calculated by comparing the detected rate of gamma radiation with previously established calibration data (see Annex A1).

1.3 A precision statement has not been developed for this standard at this time. Therefore, this standard should not be used for acceptance or rejection of a material for purchasign purposes unless correlated to other accepted ASTM standards.

1.4 The values stated in SI units are regarded as the standard. The inch-pound units given in parentheses are for information only and may be approximate.

1.5 *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.* Specific precautionary statements are given in Section 6, "Hazards."

2. Referenced Documents

2.1 *ASTM Standards:*

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2,3]

D 1587 Practice for Thin Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 2922 Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth)[2]

D 2937 Test Method for Density of Soil In-Place by the Drive-Cylinder Method[2]

D 4428/D4428M Test Method for Crosshole Seismic Testing[2]

D 5220 Test Method for Water Content of Soil and Rock In-Place by Downhole Neutron Probe Method[4]

3. Significance and Use

3.1 This test method is useful as a rapid, nondestructive technique for the calculation of the in-place density of soil and rock at desired depths below the surface as opposed to surface measurements in accordance with Test Method D 2922.

3.2 This test method is useful for informational and research purposes. It should only be used for quality control and acceptance testing when correlated to other accepted methods such as Test Method D 2937.

3.3 The non-destructive nature of the test method allows repetitive measurements to be made at a single test location for statistical analysis and to monitor changes over time.

3.4 The fundamental assumptions inherent in this test method are that Compton scattering and photoelectric absorption are the dominant interactions of the gammas and the material under test.

4. Interferences

4.1 The chemical composition of the sample may effect the measurement and adjustments may be necessary. Some elements with atomic numbers greater than 20 such as iron (Fe) or other heavy metals may cause measurements higher than the true value.

4.2 The sample heterogeneity affects the measurements. This test method also exhibits spatial bias in that it is more sensitive to material closest to the access tube.

4.2.1 Voids around the access tube can affect the measurement (see 8.1.2.1).

4.3 The sample volume is approximately 0.028 m^3 (0.8 ft^3). The actual sample volume is indeterminate and varies with the

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] Replace with continuous flight and hollowstream methods when available.

[4] *Annual Book of ASTM Standards*, Vol 04.09.

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apparatus and the density of the material. In general, the greater the density the smaller the volume.

5. Apparatus (See Fig. 1)

5.1 The apparatus shall consist of a nuclear instrument capable of measuring density of materials at various depths below the surface and contain the following:

5.1.1 *Sealed Source of High Energy Gamma Radiation*, such as cesium-137, cobalt-60, or radium-226.

5.1.2 *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube.

5.1.3 *Suitable Timed Scaler and Power Source*.

5.2 *Cylindrical Probe*—The apparatus shall be equipped with a cylindrical probe, containing the gamma source and detector, connected by a cable of sufficient design and length, that is capable of being lowered down a cased hole to desired test depths.

5.3 *Reference Standard*—The apparatus shall be equipped with a reference standard, a fixed shape of dense material used for checking apparatus operation and to establish conditions for a reproducible reference count rate. It may also serve as a radiation shield.

5.4 *Apparatus Precision*—See Annex A3 for the precision of the apparatus.

5.5 *Accessories*:

5.5.1 *Access Tubing*—The access tubing (casing) is required for all access holes in nonlithified materials (soils and poorly consolidated rock) that cannot maintain constant borehole diameter with repeated measurements. If access tubing is required it must be of a material such as aluminum, steel, or polyvinyl chloride, having an interior diameter large enough to permit probe access without binding, and an exterior diameter as small as possible to provide close proximity of the material under test. The same type of tubing must be used in the field as is used in calibration.

5.5.2 *Hand Auger or Power Drilling Equipment*, that can be used to establish the access hole. Any drilling equipment that provides a suitable clean open hole for installation of access tubing and insertion of the probe that ensures the measurements are performed on undisturbed soil and rock while maintaining constant borehole diameter shall be acceptable. The type of equipment and methods of advancing the access hole should be reported.

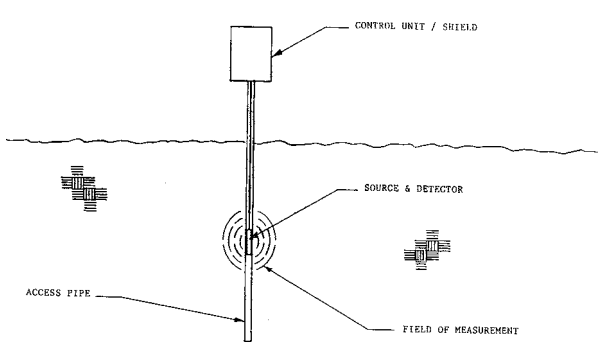

FIG. 1 Schematic Diagram: Depth Density by Nuclear Method

6. Hazards

6.1 This equipment utilizes radioactive materials that may be hazardous to the health of the users unless proper precautions are taken. Users of this equipment must become completely familiar with possible safety hazards and with all applicable regulations concerning the handling and use of radioactive materials. Effective user instructions together with routine safety procedures are a recommended part of the operation of this apparatus.

7. Calibration, Standardization, and Reference Check

7.1 Calibrate the instrument in accordance with Annex A1.

7.2 Adjust the calibration in accordance with Annex A2 if adjustments are necessary.

7.3 *Standardization and Reference Check*:

7.3.1 Nuclear apparatus are subject to the long-term decay of the radioactive source and aging of detectors and electronic systems that may change the relationship between count rate and material density. To offset these changes, the apparatus may be calibrated as the ratio of the measured count rate to a count rate made on a reference standard. The reference count rate should be in the same or a higher order of magnitude than the range of measurement count rates over the useful density range of the apparatus.

7.3.2 Standardization of equipment should be performed at the start of each day's work, and a permanent record of these data retained. Perform the standardization with the apparatus located at least 10 m (30 ft) away from other apparatus containing radioactive sources and clear of large masses or other items which may affect the reference count rate.

7.3.2.1 If recommended by the apparatus manufacturer to provide more stable and consistent results: turn on the apparatus prior to use to allow it to stabilize, and leave the power on during the day's testing.

7.3.2.2 Using the reference standard, take at least four repetitive readings at the normal measurement period and determine the mean. If available on the apparatus, one measurement at a period of four or more times the normal period is acceptable. These measurements constitute one standardization check.

7.3.2.3 If the value obtained above is within the limits stated below, the apparatus is considered to be in satisfactory condition and the value may be used to determine the count ratios for the day of use. If the value is outside these limits, allow additional time for the apparatus to stabilize, make sure the area is clear of sources of interference and then conduct another standardization check. If the second standardization check is within the limits, the apparatus may be used, but if it also fails the test, the apparatus shall be adjusted or repaired as recommended by the manufacturer. The limits are as follows:

$$Ns \leq No + \frac{2.0\sqrt{No}}{\sqrt{F}} \quad (1)$$

and:

$$Ns \geq No - \frac{2.0\sqrt{No}}{\sqrt{F}}$$

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