WSDOT FOP for AASHTO T 310[1]

In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1. Scope

1.1 This test method describes the procedure for determining the in-place density and moisture of soil and soil-aggregate by use of nuclear equipment. The density of the material may be determined by direct transmission, backscatter, or backscatter/air-gap ratio method. The WSDOT standard method for determining density is by direct transmission.

1.2 Density – The total or wet density of soil and soil-rock mixtures is determined by the attenuation of gamma radiation where the source or detector is placed at a known depth up to 12 in (300 mm) while the detector(s) or source remains on the surface (Direct Transmission Method) or the source and detector(s) remain on the surface (Backscatter Method).

1.2.1 The density in mass per unit volume of the material under test is determined by comparing the detected rate of gamma radiation with previously established calibration data.

1.3 Moisture – The moisture content of the soil and soil-rock mixtures is determined by thermalization or slowing of fast neutrons where the neutron source and the thermal neutron detector both remain at the surface.

1.3.1 The water content in mass per unit volume of the material under test is determined by comparing the detection rate of thermalized or slow neutrons with previously established calibration data.

1.4 SI Units – The values stated in SI units are to be regarded as the standard.

1.5 This standard does not purport to address all of the safety problems, 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 (see Section 6).

2. Referenced Documents

2.1 AASHTO Standards

T 99 – Moisture-Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer and a 12 in (305 mm) Drop

T 180 – Moisture-Density Relations of Soils Using a 10 lb (4.54 kg) Rammer and an 18 in (457 mm) Drop

T 191 – Density of Soil In-Place by the Sand-Cone Method

[1]This FOP is based on AASHTO 310-11 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.

Documents
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T 217 – Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester

T 224 – Correction for Coarse Particles in the Soil Compaction Test

T 255 – Total Evaporable Moisture Content of Aggregate by Drying

T 265 – Laboratory Determination of Moisture Content of Soils

T 272 – Family of Curves – One-Point Method

2.2 ASTM Test Method

D 2216 – Laboratory Determination of Moisture Content of Soil

D 2487 – Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 – Description and Identification for Soils (Visual-Manual Procedure)

D 2937 – Density of Soil in Place by the Drive-Cylinder Method

D 4253 – Maximum Index Density and Unit Weight of Soils Using a Vibratory Table

D 4254 – Maximum Index Density and Unit Weight of Soils and Calculation of Relative Density

D 7013 – Standard Guide for Nuclear Surface Moisture and Density Gauge Calibration Facility Setup

2.3 WSDOT Standards

FOP for WAQTC TM 8 – In-Place Density of Bituminous Mixes Using the Nuclear-Density Gauge

T 606 – Method of Test for Compaction Control of Granular Materials

SOP 615 – Determination of the % Compaction for Embankment & Untreated Surfacing Materials using the Nuclear Moisture-Density Gauge

3. Significance

3.1 The test method described is useful as a rapid, nondestructive technique for the in-place determination of the wet density and water content of soil and soil-aggregate.

3.2 The test method is used for quality control and acceptance testing of compacted soil and rock for construction and for research and development. The non-destructive nature allows repetitive measurements at a single test location and statistical analysis of the results.

3.3 Density – The fundamental assumptions inherent in the methods are that Compton scattering is the dominant interaction and that the material under test is homogeneous.

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3.4 Moisture – The fundamental assumptions inherent in the test method are that the hydrogen present is in the form of water as defined by ASTM D 2216, and that the material under test is homogeneous.

3.5 Test results may be affected by chemical composition, sample heterogeneity, and, to a lesser degree, material density and the surface texture of the material being tested. The technique also exhibits spatial bias in that the gauge is more sensitive to water contained in the material in close proximity to the surface and less sensitive to water at deeper levels.

4. Interferences

4.1 In-Place Density Interferences

4.1.1 The chemical composition of the sample may affect the measurement, and adjustments may be necessary.

4.1.2 The gauge is more sensitive to the density of the material in close proximity to the surface in the Backscatter Method.

Note 1: The nuclear gauge density measurements are somewhat biased to the surface layers of the soil being tested. This bias has largely been corrected out of the Direct Transmission Method and any remaining bias is insignificant. The Backscatter Method is still more sensitive to the material within the first several inches from the surface. Density measurements with direct transmission is the WSDOT standard method for soil and soil aggregate.

4.1.3 Oversize rocks or large voids in the source-detector path may cause higher or lower density determination. Since there is lack of uniformity in the soil due to layering, rock, or voids the test site beneath the gauge will be excavated and a representative sample will be taken to determine the gradation per WSDOT SOP 615.

4.1.4 Keep all other radioactive sources at least the minimum distance recommended by the manufacture away from the gauge to avoid affecting the measurement.

4.2 In-Place Moisture Content Interferences

4.2.1 The chemical composition of the sample may dramatically affect the measurement and adjustments may be necessary. Hydrogen in forms other than water, as defined by ASTM D 2216, and carbon will cause measurements in excess of the true value. Some chemical elements such as boron, chlorine, and minute quantities of cadmium will cause measurements lower than the true value.

4.2.2 The water content determined by this test method is not necessarily the average water within the volume of the sample involved in the measurement. The measurement is heavily influenced by the water content of the material closest to the surface. The volume of soil and rock represented in the measurement is indeterminate and will vary with the water content of the material. In general, the greater the water content of the material, the smaller the volume involved in the measurement. At 10 lbs/ft^3 (160 kg/m^3), approximately 50 percent of the typical measurement results from the water content of the upper 2 to 3 in (50 to 75 mm).

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