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DETERMINING MOISTURE CONTENT & DENSITY OF SOILS, BASES, & SUBBASES WITH A NUCLEAR GAUGE

SCOPE

This test method describes the procedure used in determining the in-place density and moisture content of soils, cold-in-place recycled asphalt pavement, soil aggregate sub-base, soil lime sub-base, and cement treated granular base or sub-base by the use of nuclear method.

OPERATOR QUALIFICATION

In addition to complying with IM 206, an operator, to determine the moisture content and density of soils, bases, and sub-bases with a nuclear gauge, must first demonstrate knowledge and proficiency in various related areas that may affect the test result. The specific areas will be determined by and demonstrated to the satisfaction of the District Materials Engineer or an authorized representative.

PROCEDURE

A. Apparatus

1. A recognized nuclear moisture-density gauge containing a radioisotope, detectors and related circuitry. The gauge shall be capable of determining densities by either the backscatter or direct transmission methods.

2. A reference standard for the purpose of taking standard counts, and for checking equipment operation

3. Calibration curves or tables for the gauge

4. A drill rod and combination guide-scraper plate for preparing the testing site

5. Manufacturer Instructional Manual

B. Standard Counts

1. Place the reference standard in a position recommended by the manufacturer to obtain standard counts.

2. Allow the gauge to warm up as suggested by the manufacturer.

3. Take one automatic four-minute standard count per manufacturer instructions. This count should be within 1% of the latest standard count established for the gauge. In the event the standard count varies by more than 1%, take four additional automatic four-minute standard counts. Use the average of the five four-minute counts to establish a new standard count for the gauge.

4. If the day-to-day shift in the standard count varies more than 2% for moisture or 1% for density, reset the gauge on the standard and repeat the procedure in B3.

5. Keep a log of the gauge standard counts.

6. Standard counts should be taken twice a day to detect any shift during daily use.

C. Site Preparation

1. Select a location for test where the gauge will be a least 6 in. (150 mm) away from any vertical projection. Be sure the vehicle is at least 10 ft. (3 m) away from the test site.

2. Remove all loose and disturbed material, and remove additional material as necessary to reach the top of the compacted lift to be tested.

3. Prepare a horizontal area, sufficient in size to accommodate the gauge, using the scraper plate supplied with the gauge; by planing to a smooth condition so as to obtain maximum contact between the gauge and material being tested. Make sure the gauge sits solidly on the site without rocking.

4. The maximum depressions beneath the gauge shall not exceed 1/8 in. (3 mm). Use native fines or fine sand to fill voids and level the excess with the scraper plate. The total area thus filled with native fines or sand should not exceed ten percent of the bottom area of the gauge.

D. Moisture Determination

1. Prepare test site as described in C.

2. Obtain a one-minute moisture count.

3. Determine the moisture content form the calibration data supplied with the gauge.

4. The moisture measurement is based upon the thermalization of fast neutrons by hydrogen atoms. Because some materials may contain hydrogen other than free water or may contain thermalizing elements other than hydrogen, not less than ten moisture samples should be oven dried to correct the calibration data. If the gauge reading is higher than the values obtained by oven dry samples, the error is due to hydrogen containing materials, and the correction may be made by subtracting a constant value from the gauge reading. If the gauge reading is lower than that obtained by oven drying, the error is likely due to materials which absorb thermalized neutrons. In this case, the error is not a constant offset, but varies directly with the moisture content. The compensation is made by adding the full error at moisture contents used to obtain the error data and reducing the added value at lower moisture contents. At zero moisture, the error would be zero.

E. Density Determination - Direct Transmission

1. Place the guide plate on the site for the moisture determination and drive the drive pin through the guide to a depth at least 2 in. (50 mm) below the depth of material to be measured. Remove the drive pin by pulling straight up in order to avoid disturbing the access hole.

2. Place the gauge over the access hole and push the index handle down until the source has reached the desired depth.

3. With the source at the desired depth, pull the gauge so that the probe is in contact with the near side of the hole, take and record a one-minute density count.

4. Determine the wet density from the calibration data supplied with the gauge.

5. Generally no corrections for density need be made due to soil compositional error, however, if a soil has a mean atomic weight higher than limestone, the gauge may indicate a high density. If it is felt that the gauge is indicating an unrealistic high density, two undisturbed soil cores shall be obtained. These two cores should be sent to the Central Materials Laboratory and be tested for density using Iowa Test Method 102. A correction factor should be obtained based on the density measured by the Central Materials Laboratory. This factor should be applied to the field nuclear densities.

F. Calculations

1. When determining the moisture correction described in D4, use the oven dry percent of moisture and the gauge wet density to calculate the moisture content in kilograms per cubic meter (pounds per cubic foot) as follows:

$$\text{Moisture Content } [\text{kg/m}^3 \text{ (lbs./cu. ft.)}] = \frac{\%\,\text{Moisture x Wet Density}}{\%\,\text{Moisture} + 100}$$

2. Calculate the dry density as follows:

$$\text{Dry Density} = \text{Wet Density} - \text{Moist. Content } [\text{kg/m}^3 \text{ (lbs./cu. ft.)}]$$

3. Calculate the percent moisture as follows:

$$\%\ \text{Moisture} = (\text{Moisture Content} \times 100)/(\text{Dry Density})$$

G. General Notes

1. Do not attempt to operate a nuclear gauge before thoroughly reading the Instruction Manual.

2. Do not attempt to operate a nuclear gauge before thoroughly reviewing the radiological safety precautions described in Office of Materials IM 206, "Nuclear Test Equipment."