

IN-PLACE DENSITY TESTING OF FRESHLY PLACED ROLLER-COMPACTED CONCRETE BY NUCLEAR GAUGE TESTING—TECHNOTE

Keywords: acceptance testing; backscatter; concrete density; direct transmission; in-place density; nuclear gauge; roller-compacted concrete (RCC).

Question

What is the proper procedure for determining the in-place density of fresh roller-compacted concrete (RCC) according to **ASTM C1040/C1040M**, “Standard Test Methods for In-Place Density of Unhardened and Hardened Concrete, Including Roller Compacted Concrete, By Nuclear Methods?”

Answer

Two methods are discussed in ASTM C1040/C1040M for determining the in-place density of freshly placed RCC. Test Method A uses direct transmission and Test Method B uses backscatter. Improper use of these methods have led to inconsistencies in the in-place density results. For RCC, Test Method A should always be used.

Discussion

This TechNote discusses the inconsistencies in the use of the nuclear gauge as presented in ASTM C1040/1040M. When using a nuclear gauge under ASTM C1040/C1040M to determine the in-place density of fresh RCC, there are two methods for determining density: direct transmission and backscatter.

The density of roller-compacted concrete layers should be determined in accordance with ASTM C1040/C1040M using the direct transmission method and not the backscatter method. The backscatter method only measures the density to a depth of approximately 3 in. (75 mm) below the surface. The direct transmission method measures the density from the tip of the source probe to the surface of the RCC, as shown in Fig. 1 and 2.

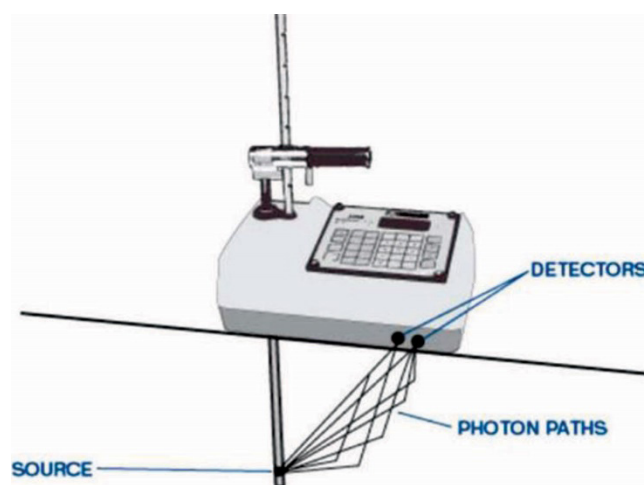


Fig. 1—Density is measured from the bottom of probe to the surface of the RCC. (Figure courtesy of Troxler Electronic Laboratories, Inc.)

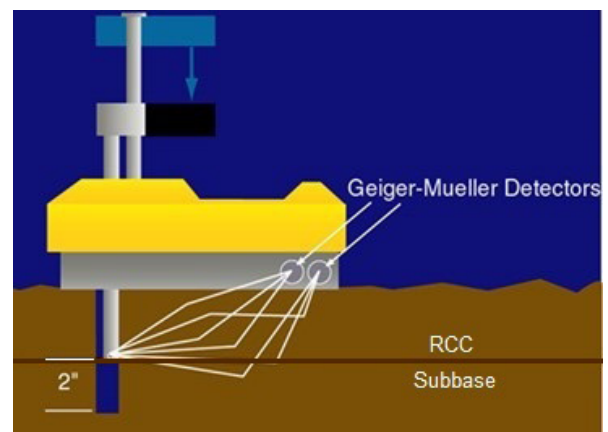


Fig. 2—Side view of proper guide hole and source rod positioning. (Figure courtesy of Troxler Electronic Laboratories.)
(Note: 1 in. = 25 mm.)

This TechNote does not replace **ASTM C1040/C1040M** but is more of a step-by-step guide for correctly determining the in-place density of RCC. The following provides the recommended steps for using ASTM C1040/1040M in the direct transmission mode.

Step 1: Determine the relationship between RCC moisture content and density per **ASTM D1557**. The results will likely be reported as a plot of dry density versus moisture content. Figure 3 shows an example of this type of report.

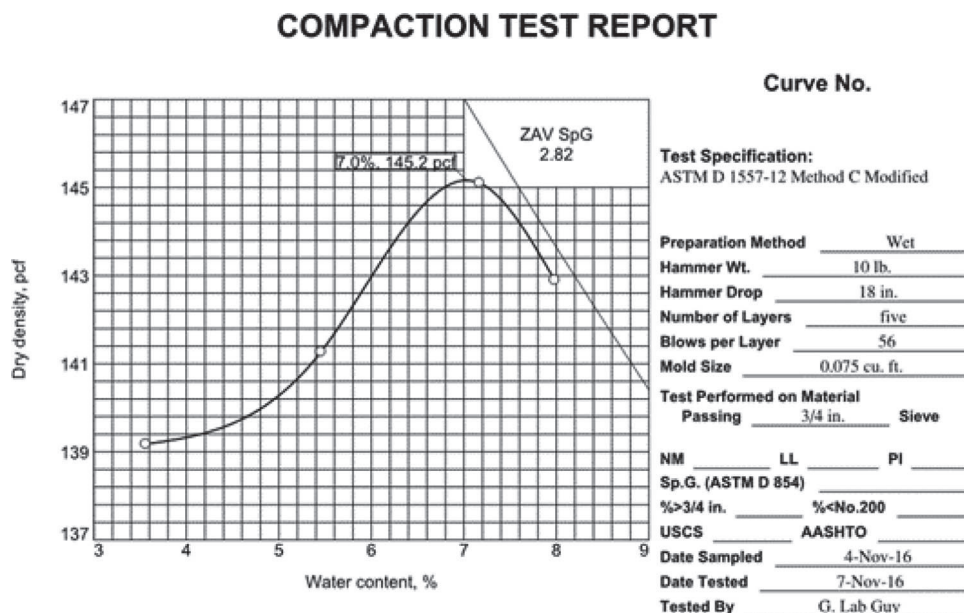


Fig. 3—Example of laboratory report. (Figure courtesy of Flood Testing Laboratories, Inc.) (Note: 1 in. = 25 mm; 1 lb = 0.45 kg; 1 ft³ = 0.03 m³.)

Step 2: Convert the maximum dry density to a reference wet density in accordance with Eq. (1).

$$\text{Wet Density (lb/ft}^3\text{) (kg/m}^3\text{)} = \text{Dry Density (lb/ft}^3\text{) (kg/m}^3\text{)} \times (1 + \% \text{ Optimum Moisture Content}) \quad (1)$$

Step 3: Place the nuclear gauge in asphalt mode (total density). Enter the reference wet density (not dry density) through the device's appropriate target menu option.

Step 4: Use the guide plate to drive the pin, creating a pilot hole that terminates 2 in. (50 mm) below the bottom of the layer being tested, as shown in Fig. 2 and 4. As an example, for an 8 in. (200 mm) RCC lift, the pilot hole should be driven 10 in. (250 mm) deep. Remove the pin without damaging the hole by slightly twisting the pin. Do not hit the side of the pin with a hammer when removing the pin. Mark the corners of the plate to determine the footprint for placement of the nuclear gauge.



Fig. 4—Driving the pilot hole pin. (Figure courtesy of Portland Cement Association.)

Step 5: Align the gauge inside the footprint of the plate. Insert the source probe to a depth equal to the thickness of the RCC layer being tested. For an 8 in. (200 mm) RCC layer, the probe should extend the full 8 in. (200 mm). Slide the gauge so that the side of the probe facing the center of the gauge is in intimate contact with the side of the hole, as shown in Fig. 2.

Step 6: Making sure the gauge is in asphalt mode (total density), press Start to take a reading. Wait a minimum of 1 minute and record the in-place density and corresponding percentage of total wet density (stated on most gauges as % of Marshall or % of Gmb).

Unless the gauge has been calibrated for the material being tested, do not use the gauge result to record moisture content. Materials such as cement, gypsum, coal, mica, and lime all contain chemically bound hydrogen that will cause the gauge to display a moisture content that is higher than the actual amount. Moisture contents can be determined in accordance with **ASTM D2216** (oven dry), **ASTM D4959** (direct heating), or **ASTM D4043** (microwave).