October 17, 2006 Matls. IM 358
Supersedes October 19, 2004

DETERMINING PLASTIC DENSITY OF PORTLAND CEMENT CONCRETE WITH A NUCLEAR GAUGE

SCOPE

The plastic density of PC Concrete is dependent on the materials, proportions, air content and consolidation. For given materials and proportions, the consolidation of the concrete is an important factor in its durability.

The first part of the test is to determine the standard rodded density. Secondly, even though the nuclear gauge is very accurate and repeatable, sometimes a correction factor must be applied to the indicated value to yield the true density.

The last part of this test is to verify that the density requirement is met.

OPERATOR QUALIFICATION

In addition to complying with IM 206, an operator, to determine the plastic density of Portland Cement Concrete 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 his/her authorized representative.

PROCEDURE

I. Determination of the Standard Rodded Density

A. Apparatus

1. Scale [minimum capacity 100 lb. (45 kg) minimum accuracy ± .25 lb. (113 g) minimum sensitivity ± .25 lb. (113 g)]

2. Measure (Base of the Washington Pressure Meter)

3. Tamping rod – 5/8 in. (16 mm) diameter and approximately 14 in. (350 mm) long

4. Strike off - A flat straight bar of steel

5. Rubber mallet

B. Determination of the Calibrated Volume of the Measure Determined by the Central Laboratory

1. Fill the measure with water at room temperature and cover with a piece of plate glass in such a way as to eliminate bubbles and excess water.

2. Determine the net mass of water in the measure to an accuracy of ± 0.1 percent.

3. Measure the temperature of the water and determine its unit mass (weight), from the table below, interpolating if necessary.

4. Calculate to the nearest .001 $ft.^3$ (283 mm^3) the volume of the measure by dividing the mass (weight) required to fill the measure by the unit mass (weight) of the water.

UNIT MASS (WEIGHT) OF WATER

Temperature			
°F	°C	lb./$ft.^3$	kg/m^3
60	15.6	62.366	999.01
65	18.3	62.336	998.53
70	21.1	62.301	997.97
(73.4)	(23.0)	(62.274)	(997.53)
75	23.9	62.261	997.32
80	26.7	62.216	996.60

C. Test Procedure

1. Determine the weight of the dry measure.

2. Obtain a representative sample of PC Concrete that conforms to air content and slump required by the Specifications.

3. Fill the measure in three layers of approximately equal volume.

4. Consolidate each layer with 25 strokes of the tamping rod just through the layer being rodded.

5. After rodding each layer, close the rodding voids by striking the measure with the mallet.

6. After consolidation, finish the top surface with the strike off using a screening action leaving no excess or voids.

7. Balance the scale and weigh the measure filled with concrete to the nearest minimum accuracy of the scale.

8. Determine the air content of the concrete in accordance with step B2 of the Office of Materials Instructional Memorandum 318.

D. Calculations

$$\text{Rodded Density} = \frac{W - M}{V}$$

W = Mass (weight) of measure full of concrete
M = Mass (weight) of measure
V = Calibrated volume of the measure

Corrected Rodded Density (for 6.0% air content)

$$\text{Corrected Rodded Density} = \frac{\text{Rodded Density x } 94.0}{100 - \text{Determined Air Content}}$$

Example:

Determined Rodded Density = 2281 kg/m^3 (142.4 pcf)
Determined Air Content = 7.4%

$$\text{Corrected Rodded Density} = \frac{142.4 \text{ x } 94.0}{100 - 7.4}$$

$$= \frac{142.4 \text{ x } 94.0}{92.6}$$

= 2316 kg/m^3 (144.6 pcf)

E. Test Record Forms

1. Record the following data in a field book or worksheets:

   a. Date
   b. Calibrated volume of the measure (by Section B, above)
   c. Mass (weight) of measure
   d. Mass (weight) of measure full of concrete
   e. Location where concrete sample was obtained
   f. Corrected rodded density

II. Determination of the Correction Factor for the Nuclear Gauge (Determined by the Central Laboratory)

A. Apparatus

1. Standard blocks of granite, concrete, limestone, aluminum, aluminum/magnesium, and/or other materials of known density.

B. Test Procedures

1. Obtain 5 separate one-minute, 2 in., direct transmission density determinations on the designated area on each standard. The gauge should be completely removed from the standard between each reading. The average of the 5 readings should be considered the indicated nuclear density (N) of the block.

C. Calculations

Correction Factor = D-N

D = known density of the standard block
N = indicated nuclear average density from B, above

III. Determination of the "In-Place" Density of the Plastic PC Concrete

A. Apparatus

1. Nuclear gauge including:

a. Calibration Standard
b. Calibration Charts (not needed with Humboldt gauges)
c. Manufacturer Instruction 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 4-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 4-minute standard counts. Use the average of the five 4-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. Test Procedure

1. Use the correction factor furnished by the Central Laboratory as determined in Part II.

2. Determine the rodded density of the concrete at least twice during a normal day's placement.

3. Prior to concrete placement, determine locations to avoid being near steel and select areas where a total minimum depth of 3 in. (76 mm) is available. Mark reference points for locations where nuclear densities are to be obtained.

4. Immediately behind the finishing machine, but prior to texturing and curing operations, center the nuclear gauge on the plastic concrete surface over the test location center.

5. Lower the source rod to the 2 in. (50 mm) direct transmission indent, making sure the gauge is properly seated.

6. Pull the gauge slightly toward the scalar end.

7. Obtain a 1-minute density count.

8. Without retracting the source rod, pick the gauge up and clean the end of the source rod and the bottom of the gauge with a rag. Retract the source rod into the gauge.

9. Obtain the "in-place" nuclear density value (N_2) from the calibration chart using the Reading/Standard Count ratio.

D. Calculations

Corrected Nuclear Density = N_2+ C

N_2 = "in-place" nuclear density

C = Correction Factor

$$\%\ \text{of Rodded Density} = \frac{\text{Corrected Nuclear Density x 100}}{\text{Corrected Rodded Density}}$$

E. Test Record Forms

1. The following additional data will be recorded in field book or worksheets of Part I.

   a. Location of "in-place" nuclear density
   b. “In-place" density count
   c. Count ratio
   d. "In-place" density
   e. Corrected nuclear density
   f. % of rodded density

2. Report this data on Form #1297.

F. Precautions

1. Before operating a nuclear gauge, you must have attended a course on operation and safety at the Central Laboratory and have a current Qualified Nuclear Gauge Operator Card.

2. Never touch the end of the source rod with your hand. A rag should be used when cleaning the rod and the rod should be pointed away from the body during this operation.

3. At the end of each day's operation remove the bottom cover plate from the nuclear gauge per manufacturer instruction to assure that no PC Concrete has been carried into the gauge.

4. Keep a light coat of oil and graphite on the probe, lead shield and gauge case to prevent PC Concrete from adhering.

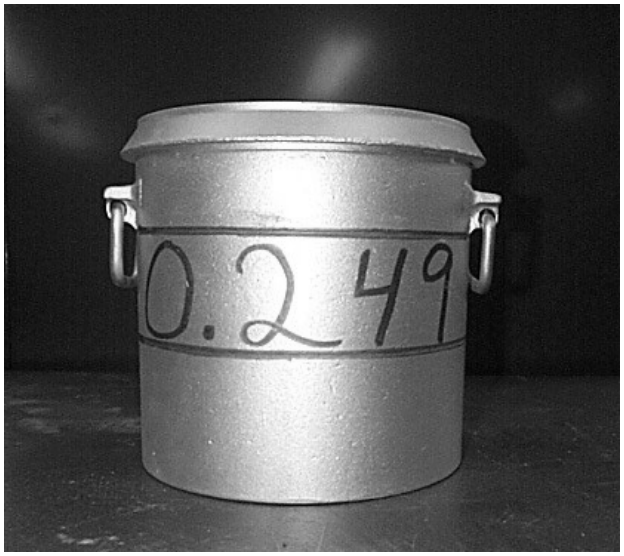

Figure 1. Calibrated Unit Weight Container Showing Volume of Container (in Cubic Feet)

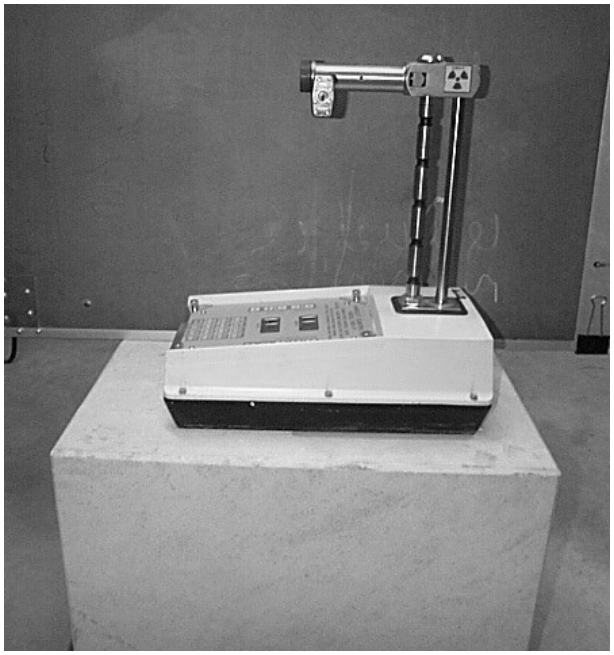

Figure 2. Nuclear Gauge in Place on Calibration Block

Form 821297
7-86

Iowa Department of Transportation
Highway Division
NUCLEAR TEST REPORT
DENSITY OF PLASTIC P.C. CONCRETE

County Chickasaw
Project No. FN-18-7(41)--21-19
Contractor Waterloo Construction
Design 289
Resident Engineer George Feazell
Contract No. 30887
Nuclear Gauge No. 1921
Date 8-8-90

RODDED DENSITY DETERMINATION

1. Sampling Location	Mixer						
2. Calibrated Volume of Measure (V)	0.248						
3. Weight of Measure (M)	8.5						
4. Weight of Measure + Concrete (W)	4.44						
5. Rodded Density (4 - 3) ÷ Line 2	144.8						
6. % Air Content	5.7						
7. Corrected Rodded Density	144.3						
8. Slump	3/8"						
9. Correction Factor	-0.5						
10. Density Standard Count	4599						

IN-PLACE DENSITY DETERMINATION

11. Test Location	9' Lt. 436+22	6' Lt. 436+14	3' Lt. 436+05				
12. Depth at Test Location	7	7	7				
13. In-Place Gauge Reading (Density)	4573	4915	4947				
14. Count Ratio (13 ÷ 10)	0.994	1.069	1.076				
15. In-Place Density (Table)	153.5	149.0	148.5				
16. Corr. In-Place Density (15 + 9)	153.0	148.5	148.0				
17. % Rodded Density (16 ÷ 7) X 100	106.0	102.9	102.6				

REMARKS:

(Calculations shown are for English units.)

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Signed _____
Inspector