Method of Test for

DETERMINING IN-PLACE DENSITY AND CONSOLIDATION CONFORMANCE FOR HIGH DENSITY PORTLAND CEMENT CONCRETE OVERLAYS BY NUCLEAR METHOD

DOTD Designation: TR 232-84

Scope

1. This method of test covers the procedure for determining the in-place density of high density concrete. The procedure is to be used in conjunction with DOTD Designation: TR 201 Method B to determine the consolidation conformance of high density concrete.

Apparatus

2. (a) Troxler model 2401 or 3411 nuclear density-moisture gage, reference standard, calibration tables, and approved departmental operational manual.

(b) Suitable measuring device accurate to the nearest 0.25 inch.

(c) Dry fine sand.

(d) Density nomograph (See Figure 1).

(e) Fifty-foot tape measure.

(f) Suitable work bridge capable of spanning the width of paving.

Standardization

3. (a) Warm up the nuclear density gage in accordance with the manufacturer's recommendations.

(b) Take four one-minute counts for density with the gage on the reference standard and the probe in the standard count position. The gage should be located at least 5 feet (1.5 m) from any vertical structure and 30 feet (9.1 m) or more from any other nuclear gage.

(c) Record the four counts obtained in paragraph 3(b), calculate and record the average on the worksheet (See Figure 2).

(d) Take a standard four minute count for density.

(e) Record the four minute density standard count (R) obtained in 3(d) on the worksheet.

(f) If the average standard count recorded in paragraph 3(c) differs from R by more than 2%, refer to paragraphs 4(c) and (d). If the average standard count recorded in paragraph 3(c) differs from R by 2% or less, proceed to paragraph 4(a).

Frequency of Standardization

4. (a) Standardization of equipment by paragraph 3 using the reference standard is required at the beginning of each day's use, when the nuclear equipment has been idle for 4 hours or more, or when test measurements are suspect.

(b) In the event of repeatedly failing tests in the same location, single one minute standard counts shall be taken on the reference standard.

(c) If any one subsequent standard count run in the same day differs from the standard count R by more than 2%, or if the day to day shift in the standard count is greater than 2%, there is a possibility of gage malfunction or operator error in placing the gage on the reference standard. If such a malfunction occurs and is confirmed by the District Laboratory Engineer, the cause must be determined and corrected prior to continuing with the test procedure. A standby nuclear gage should be available due to the possibility of equipment malfunction. When the standby nuclear gage is used it shall be standardized in accordance with section 3 prior to use.

Procedure

5. Initial Readings

(a) Select a test location and record it.

(b) Prepare a smooth surface large enough to seat the nuclear gage with a minimum amount of dry fine sand at each test location.

(c) Warm up the equipment in accordance with the manufacturer's directions.

(d) At each test location, seat the gage on the prepared surface (with sand) and place the probe in the backscatter position.

(e) Obtain three one-minute test counts for density.

(f) Record the average test count on the worksheet as Initial Readings: Test Count, CI.

(g) Determine the initial density for each test location in accordance with paragraph 8(a) & (b) and record the results on the worksheet as Initial Readings: Density.

(h) Remove the fine sand from each location.

6. Final Readings

(a) After the concrete has been consolidated and prior to texturing operations, center the nuclear gage on the plastic concrete surface over the same test location at which the initial reading was taken.

(b) Place the probe in the backscatter position.

(c) Obtain a one-minute test count for density.

(d) Record the test count on the worksheet as Final Readings: Test Count, CF.

(e) Determine the thickness of the overlay at the test location to the nearest 0.25 inches and record on the worksheet.

(f) Calculate the final density in accordance with paragraph 8(a) & (b) and record as Final Readings: Density.

In-Place Density

7. (a) Using the nomograph (Figure 1), determine the in-place density of the concrete overlay as follows:

1. Extend a horizontal line from the final density on the right hand density scale to the vertical line corresponding to the thickness of the overlay.
2. Extend a line through this point to the initial density on the left hand scale.
3. Project this line to the right hand scale and read the in-place density.

(b) Record the in-place density on the worksheet.

Calculations

8. (a) Calculate the count ratio for each test by dividing the density test count (CI or CF) by the density standard count (R).

(b) Using the count ratio, refer to the backscatter density calibration chart (provided with each individual nuclear gage) to determine the density in lbs/ft^3.

(c) After determining the vibrated unit weight in lbs/ft^3 in accordance with TR 201, Method B (See Figure 3), calculate the air content of the vibrated unit weight specimen as follows:

$$A = \frac{T-(VUW)}{T} \times 100$$

where:

A = Calculated air content of the concrete inside the unit weight measure after vibration, %.

T = Theoretical weight per cubic foot of the concrete computed on an air free basis, lbs/ft^3. The theoretical weight per cubic foot is calculated by dividing the sum of the component weights (batch weights of cement, fine aggregate, coarse aggregate, and water) by the sum of the absolute volumes of the components, excluding the design air content.

VUW = Weight per cubic foot, determined after external vibration.

(d) Calculate the standard unit weight (unit weight corrected for intended air content) as follows:

$$SUW = \frac{VUW \times (100-SA)}{(100-A)}$$

where:

SUW = Standard Unit Weight, lbs/ft^3.

SA = Specified air content, %.

(e) Calculate the percent consolidation by dividing the in-place density by the standard unit weight and multiplying by 100.

Normal testing time is 10 minutes per reading.

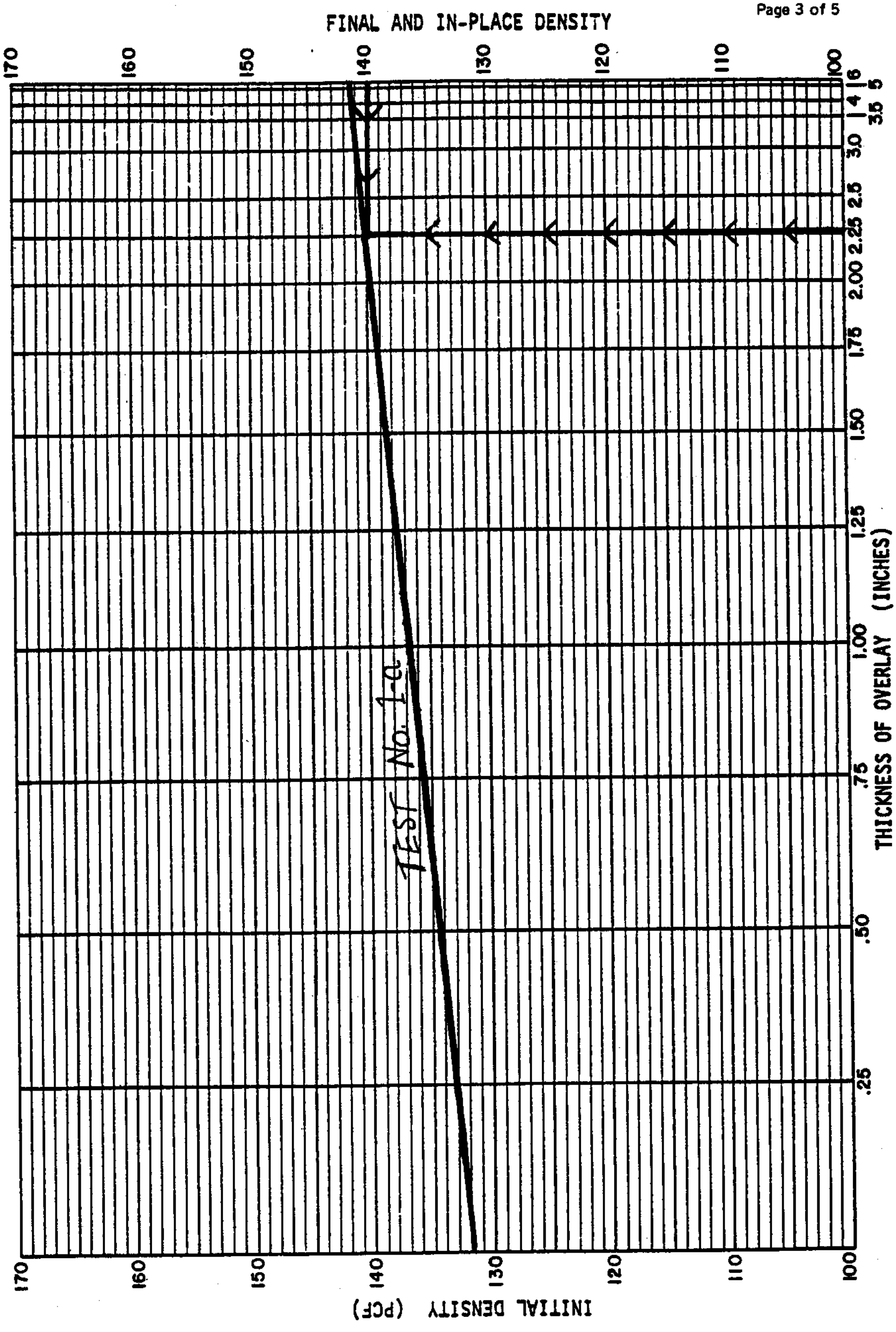
FINAL AND IN-PLACE DENSITY
170
160
150
140
130
120
110
100
THICKNESS OF OVERLAY (INCHES)
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.5
3.0
3.5
4
5
6
INITIAL DENSITY (PCF)
TEST No. 1a

Figure 1

NUCLEAR DENSITY WORKSHEET FOR HIGH DENSITY CONCRETE
(Backscatter Method)

Bridge I.D. EXAMPLE

Project No. EXAMPLE
Date ______

Test Location	1-a	1-b	2-a	2-b	3-a	(PROCEDURE REFERENCE)
I. Initial Readings (Before Pour):						
Test Count, CI	275	274	270	271	268	5(e)
STD, R	267	267	267	267	267	3(a-f)
Count Ratio, (CI/R), CR	1.030	1.026	1.011	1.015	1.004	8(a)
Density, lbs/ft.^{3} (From Chart)	132.0	132.5	133.8	133.5	134.5	8(b)
II. Final Readings (After Pour):						
Test Count, CF	252	—	257	255	259	6(d)
STD, R	268	—	268	268	268	
Count Ratio, (CF/R), CR	0.940	—	0.959	0.951	0.966	
Density, lbs/ft.^{3} (From Chart)	141.0	—	139.0	139.8	138.5	
Thickness, in.	2¼	—	2	2¼	3	6(e)
III. In-Place Density, (lbs/ft.^{3}) (From Nomograph)	141.5	—	140	140.5	138.5	7
IV. SUW	142.0	—	142.0	142.0	142.0	8(d) and TR 201, Method B
V. % Consolidation ((In-Place Density / SUW) x 100)	99.6	—	98.6	98.9	97.5*	8(e)

*Failure at test location 3-a; therefore, final density readings were obtained at test location 2-b and found to be in conformance with specifications. In this example, the concrete would then be reconsolidated, beginning at 2-b, and a retest performed at 3-a.

STANDARDIZATION

Nuclear Density-Moisture Gage No. 34

Standard Count (STD)
Initial Readings, STD
1 min. counts 269 270 270 269
Avg. = 270

4 min. (R) = 267

Final Readings, STD
1 min. counts 268 270 270 272
Avg. = 270
4 min. (R) = 268

RETESTS (Final Readings)

Test Location	3-a
Test Count, CF	253
Count Ratio (CF/R), CR	0.944
Density, lbs/ft^3 (From Chart)	140.5
In-Place Dens., (lbs/ft^3) (From Nomograph)	141.8
% Consolidation	99.9

Tested by: NDH

STANDARD UNIT WEIGHT (SUW) OF HIGH DENSITY CONCRETE (by Vibration)

Project No. EXAMPLE Date Poured 2/13/84

Bridge I.D. EXAMPLE Specified Air (In-Place), SA: 6.5 %

MIX DESIGN:

	Batch Weights (lbs.)	Spec. Gravity	Absolute Volume (cu. ft.)
Cement	826	3.15	4.202
Fine Agg.	1366	2.62	8.355
Coarse Agg.	1350	2.59	8.353
Water (gals. x 8.34)	257	1.00	4.119
Total	TW= 3799		TV= 25.029

Theor. Unit Weight (Excl. Air): T = TW/TV = 151.8 lbs./cu. ft.

VIBRATED UNIT WEIGHT (VUW):

Weight of measure + concrete, W = 93.56 Lbs.

Weight of measure, M = 22.70 Lbs.

Calibrated Volume, K = .4997

$$VUW = \frac{(W-M)}{K} = 141.8 \text{ Lbs./cu. ft.}$$

Vibration Time = 15 sec./Layer

AIR CONTENT OF VIBRATED CONCRETE (A):

$$A = \frac{T - (VUW)}{T} \times 100 = 6.6\ \%$$

STANDARD UNIT WEIGHT (SUW):

$$SUW = \frac{VUW \times (100 - SA)}{100 - A} = 142.0 \text{ Lbs./cu. ft.}$$

Inspector CDA

Figure 3