NEBRASKA DEPARTMENT OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION

NEBRASKA
Good Life. Great Journey.
DEPARTMENT OF TRANSPORTATION

Nebraska List of Modified Test Standards

July 1, 2024

Nebraska List of Modified Test Standards

The Nebraska Department of Transportation utilizes testing standards from various entities such as AASHTO, ASTM, ISO Compliance, and others. This document details the NDOT modifications to such standards.

Safety Statement

These standards may involve hazardous materials, operations, and equipment. They do not purport to address all safety problems associated with use. It is the responsibility of whomever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Index of Applicable Test Methods

1. Aggregate Test Methods

1.1 NDT T 2 Sampling Aggregates

NDT T 2 is identical to **AASHTO T 2-91(2000)** except for the following provisions: Replace Section 4.4 of AASHTO T 2-91(2000) with the following:

4.4 Number and Masses of Field Samples:

4.4.1 The number of field samples (*obtained by one of the methods described in Section 4.3*) required depends on the criticality of, and variation in, the properties to be measured. The number of samples to be tested at the source, project or Branch Laboratory, and the number to be submitted to the Lincoln Laboratory for quality and correlation tests shall be as shown in the "Materials Sampling Guide."

4.4.2 The size of the sample shall be in accordance with the following Size of Samples chart. Test portions from the field sample shall be obtained by methods stated in AASHTO T 248-02.

SIZE OF SAMPLE

Nominal Maximum Size of Particles Passing Sieve		Minimum Weight of Field Samples(*1*)	
Standard	**Alternate *(mm)***	**lb.**	**kg.**
No. 10	2.00	10	5
No. 4	4.75	10	5
3/8 in.	9.50	10	5
1/2 in.	12.5	20	10
3/4 in.	19.0	30	15
1 in.	25.0	50	25
1 1/2 in.	37.5	70	30
2 in.	50.0	90	40
2 1/2 in.	63.0	100	45
3 in.	75.0	125	60
3 1/2 in.	90.0	150	65

ROUTINE FIELD CONTROL AND CORRELATION *(1)*

Type of Material	Gradation Only	Gradation & Quality	Progress Record	EBCM & EBM
Fine Aggregate *(2)*	12 lb.	60 lb.	12 lb.	60 lb.
Coarse Aggregate *(3)*	40 lb.	60 lb.	60 lb.	60 lb.
Soil Binder	8 lb.	--	8 lb.	30 lb.
Mineral Filler	8 lb.	--	8 lb.	30 lb.

(1) -- Samples prepared for tests shall be obtained from the field sample by quartering or splitting to ensure a representative portion (see AASHTO T 248-02).

(2) -- Fine aggregates are those shown in Table III of NDT T 27.

(3) -- Coarse aggregates are those shown in Table IV and Table V of NDT T 27.

1.2 NDT T 27 Sieve Analysis of Fine and Coarse Aggregates – Lab / Field

NDT T 27 is identical to **AASHTO T 27-99** except for the following provisions: Replace Sections 7.3, 7.4, and 7.5 of AASHTO T 27-99 with the following:

7.3 **Fine Aggregate** - See Table II and Table III for detailed test sample size for various types of fine aggregate and soil.

7.4 **Coarse Aggregate** - See Table IV for detailed test sample sizes for various types of coarse aggregates.

7.5 **Coarse and Fine Aggregate Mixtures** - See Table VI for detailed test sample sizes for various types of mixtures of fine and coarse aggregate materials.

TABLE II

SAMPLE SIZE AND SIEVE REQUIREMENTS

Material	Approx. Minimum Sample Size, g *	**Required Sieves Based on 8-inch Diameter Sieves												
		1	3/4	3/8	4	6	8	10	16	20	40	50	100	200
Gravel	1000	X	X	X	X	X	X	X	X	X	X	X		X
Sand Gravel Before Crushing (1)	1000	X	X	X	X	X	X	X				X		X
Before Crushing (2)	5000	X	X	X	X	X	X	X				X		X
Sand Gravel After Crushing	500			X	X	X	X	X	X	X		X		X
Fine Sand with less than 5% on the No. 10 Sieve	200		X		X			X			X	X	X	X
Sand with 5% or more retained on the No. 10 sieve	200/500		X	X	X	X	X	X	X	X	X	X		X
Mineral Aggregate for Armor Coat	500/600		X	X	X	X	X	X	X	X	X	X		X
Gravel for Surfacing	1000	X	X	X	X	X	X	X	X					
Crushed Rock Screening for Base Coarse	1000		X	X	X	X	X	X		X		X		X
Soil-Aggregate Base Course Mixture	1000	X	X	X	X	X	X	X	X	X	X	X		X
Foundation Course Aggregate	500/1000	X	X	X	X	X	X	X	X	X	X	X		X
Soil Binder	100				X			X			X		X	X
Mineral Filler	100				X			X				X	X	X
Soil	100				X			X			X		X	X

* If the materials being tested are in the coarser range, sample sizes should be adjusted upward accordingly.

** Required sieves indicated include sieves to prevent overloading. If more than 200 g, based on 8-inch sieves, is retained on any sieve after sieving, additional spacer sieves should be used, or the sample sieved through the nest of sieves in smaller increments.

1) Material before crushing with less than 5 percent retained on the 3/4-inch sieve.

2) Material before crushing with 5 percent or more retained on the 3/4-inch sieve.

TABLE III

SAMPLE SIZE AND SIEVE REQUIREMENTS FOR FINE AGGREGATE MATERIALS

Material Fine Concrete for Aggregate	Approx. Minimum Sample Size, g *	**Required Sieves Based on 8-inch Diameter Sieves													
		1	4	3/4	3/8	6	8	10	16	20	30	40	50	100	200
47B, 47BD, 47B-P, 47-PHE, 47B Special, PR, AX, ABX, BX, HE-A	1000	X	X	X	X	X	X	X	X	X	X	X	X		X
Silica Fume	500			X	X	X	X	X	X	X	X	X	X		X
Grout Sand	200				X	X	X	X	X	X	X	X	X		X

* If the materials being tested are in the coarser range, sample sizes should be adjusted upward accordingly.

** Required sieves indicated include spacer sieves to prevent overloading. If more than 200 g, based on 8-inch sieves, is retained on any sieve after sieving, additional spacer sieves should be used, or the sample sieved through the nest of sieves in smaller increments.

TABLE IV

SAMPLE SIZE AND SIEVE REQUIREMENTS FOR COARSE AGGREGATE MATERIALS

Material Coarse Aggregate	Approx. Minimum Sample Size, g*	**Required Sieves								
		1 1/2	1	3/4	1/2	3/8	4	10	20	200
47B, 47B-P, 47B-PHE, 47B Special, 47BD, PR	5000	X	X	X	X	X	X		X	X
Silica Fume	2500			X	X	X	X	X		X

* If the materials being tested are in the coarser range, sample sizes should be adjusted upward accordingly.

** Required sieves indicated include spacer sieves to prevent overloading when the sample is sieved through a nest of 12-inch diameter sieves. The size of sample to be sieved at one time and the length of sieving time will be regulated by the thoroughness of sieving when checked by the hand sieving method described in Paragraph 8.4.

TABLE V

SAMPLE SIZE AND SIEVE REQUIREMENTS FOR MIXTURES OF FINE AND COARSE GRAINED MATERIALS

Material to be separated into two sizes for testing.

Material	Approx. Minimum Size of Total Sample, g*	**Required Sieves Specifications												
		2	1 1/2	1	3/4	1/2	3/8	4	8	10	20	30	50	200
Crushed Rock for Asphaltic Concrete	5000			X	X	X	X	X	X	X	X	X	X	X
Crushed Rock for Surfacing	5000			X	X	X	X	X	X	X	X	X		X
Crushed Rock for Base Course	5000		X		X	X	X	X	X	X	X		X	X

TABLE VI

SAMPLE SIZE AND SIEVE REQUIREMENTS FOR CRUSHED CONCRETE FOUNDATION COARSE

Material	**Approx. Minimum Size of Total Sample, g***	****Required Sieves**							
		1 1/2	**1 1/4**	**1**	**3/4**	**4**	**10**	**40**	**200**
Crushed Concrete Foundation Coarse	4000/5000	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

*If the materials being tested are in the coarser range, sample sizes should be adjusted upward accordingly.

**Required sieves indicated include spacer sieves to prevent overloading when the sample is sieved through a nest of 12-inch diameter sieves. The size of sample to be sieved at one time and the length of sieving time will be regulated by the thoroughness of sieving when checked by the hand sieving method described in Paragraph 8.4.

If more than 200 g, based on 8-inch sieves, is retained on any sieve after sieving, additional spacer sieves should be used, or the sample sieved through the sieves is smaller increments.

1.3 NDT T 84 Specific Gravity and Absorption of Fine Aggregate

Modifications

AASHTO Designation: T 84-93 I

ASTM Designation: C 128-88

1. SCOPE

1.1. This method covers the determination of bulk and apparent specific gravity 23/23°C (73.4/73.4°F), and absorption of fine aggregate.

1.2. This method determines (after 15 h in water) the bulk specific gravity and the apparent specific gravity, the bulk specific gravity based on weight of saturated surface-dry aggregate, and the absorption as defined in AASHTO M 132.

1.3. The values stated in SI units are to be regarded as the standard.

1.4. This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPLICABLE DOCUMENTS

2.1. **AASHTO Standards:**

T 19 “Unit Weight and Voids in Aggregate”

T 85 "Specific Gravity and Absorption of Coarse Aggregate

T 133 “Density of Hydraulic Cement”

T 142 “Surface Moisture in Fine Aggregate”

M 231 “Weighing Devices Used in the Testing of Materials”

T 255 "Total Moisture Content of Aggregate by Drying"

2.2. **ASTM Standards**

C 125 “Terminology Relating to Concrete and Concrete Aggregates”

C 670 “Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials”

E 1 “Standard Specifications for ASTM Thermometers”

2.3. **NDT Standards:**

T 2 ”Sampling Aggregates”

T 248 ”Reducing Field Samples of Aggregate Testing Size”

T 506 ”Determination of the Free Moisture Content of Aggregate”

3. SIGNIFICANCE AND USE

3.1. Bulk specific gravity is the characteristics generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate including Portland cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Bulk specific gravity is also used in the computation of voids in aggregate in AASHTO T 19 and the determination of moisture in aggregate by displacement in water in AASHTO T 142. Bulk specific gravity determined on the saturated surface-dry basis is used if the aggregate is wet, that is, if its absorption has been satisfied. Conversely, the bulk specific gravity determined on the oven-dry basis is used for computations when the aggregate is dry or assumed to be dry.

3.2. Apparent specific gravity pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles that is accessible to water. This value is not widely used in construction aggregate technology.

3.3. Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregate for approximately 15 h in water . Aggregates mined from below the water table may have a higher absorption when used, if not allowed to dry. Conversely, some aggregates when used may contain an amount of absorbed moisture less than the 15 h soaked condition: For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture can be determined by deducting the absorption from the total moisture content determined by NDT T 255 by drying.

4. APPARATUS

4.1. **Balance** - conforming to the requirements of AASHTO M 231, Class G2.

4.2. **Pycnometer** - a flask or other suitable container into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced with ±0.1 cm^3. The volume of the container filled to mark shall be at least 50 percent greater than the space required to accommodate the test sample. A volumetric flask of 500 capacity or a fruit jar fitted with a pycnometer top is satisfactory for a 500-g test sample of most fine aggregates. A Le Chatelier flask as described in AASHTO T 133 is satisfactory for an approximately 55-g test sample.

4.3. **Mold** - A metal mold is in the form of a frustum of a cone with dimensions as follows: 40 ± 3 mm inside diameter at the top, 90 ± 3 mm inside diameter at the bottom, and 75 ± 3 mm in height, with the metal having a minimum thickness of 0.8 mm.

4.4. **Tamper** - A metal tamper weighing 340 ± 15 g and have a flat circular tamping face 25 ± 3 mm in diameter.

4.5. **Thermometers -** Calibrated liquid-in-glass, partial immersion of suitable range with gradations to determine a temperature of 23 C ± 1°C and one to determine a temperature of 110° C ± 5°C.

5. SAMPLING

5.1. Sampling shall be accomplished in general accordance with NDT T 2.

6. PREPARATION OF TEST SPECIMEN

6.4. Obtain approximately 1.3 kg of minus 3/8-inch sieve fine aggregate from the sample using the applicable procedures described in AASHTO T 248. Discard the aggregate retained on the 3/8-inch sieve.

6.4.1 Dry the sample in a suitable pan or vessel to constant weight at a temperature of 110 ± 5° C (230 ± 9° F). Allow it to cool to comfortable handling temperature, cover with water and permit to stand for a minimum of 15 hours.

6.4.2 As an alternative to Section 6.1.1, where the absorption and specific gravity values are to be used in proportioning concrete mixtures with aggregates used in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated and, if the surfaced of the particles have been kept wet, the 15-hour soaking may also be eliminated.

Note 1: Values for absorption and for specific gravity in the saturated surface-dry condition may be significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in accordance with Section 6.1.1.

6.5. Decant excess water with care to avoid loss of fines, spread the sample on a flat nonabsorbent surface exposed to a gently moving current of warm air, and stir frequently to secure homogeneous drying. If desired, mechanical aids such as tumbling or stirring may be employed to assist in achieving the saturated surface-dry condition. A hot plate may be used to initially dry the sample, care being taken not to dry any of the particles below the saturated surface dry condition.

Continue this operation until the test specimen approaches a free-flowing condition. Follow the procedure in Section 6.2.1 to determine whether surface moisture is present on the constituent fine aggregate particles. It is intended that the first trial of the cone test will be made with some surface water in the specimen. Continue drying with constant stirring and test at frequent intervals until the test indicates that the specimen has reached a surface-dry condition. If the first trial of the surface moisture test indicates that moisture is not present on the surface, it has been dried past the saturated surface-dry condition. In this case, thoroughly mix a few milliliters of water with the fine aggregate and permit the specimen to stand in a covered container for 30 min. Then, resume the process of drying and testing at frequent intervals for the onset of the surface-dry condition.

6.5.1 **Cone Test for Surface Moisture**- Hold the mold firmly on a smooth nonabsorbent surface with the large diameter down. Place a portion of the partially dried fine aggregate loosely in the mold by filling it to overflowing and heaping additional material above the top of the mold by holding it with the cupped fingers of the hand holding the mold. Tamp the fine aggregate into the mold with 25 light drops of the tamper. Each drop should start about 5mm (0.2 in.) above the top surface of the fine aggregate. Permit the tamper to fall freely under gravitational attraction on each drop. Adjust the starting height to the new surface elevation after each drop and distribute the drops over the surface.

Remove loose sand from the base and lift the mold vertically. If surface moisture is still present, the fine aggregate will retain the molded shape. When the fine aggregate slumps slightly, it indicates that it has reached a surface-dry condition. Some angular fine aggregate or material with a high proportion of fines may not slump in the cone test upon reaching a surface-dry condition. This may be the case if fines become airborne upon dropping a handful of the sand from the cone test 100 to 150 mm onto a surface.

For these materials, the saturated surface-dry condition should be considered as the point that one side of the fine aggregate slumps slightly upon removing the mold.

Note 2: The following criteria have also been used on materials that do not readily slump:

1. **Provisional Cone Test** - Fill the cone mold as described in Section 6.2.1 except only use 10 drops of the tamper. Add more fine aggregate and use 10 drops of the tamper again. Then, add material two more times using 3 and 2 drops of the tamper, respectively. Level off the material even with the top of the mold, remove loose material from the base; and lift the mold vertically.
2. **Provisional Surface Test** - If airborne fines are noted when the fine aggregate is such that it will not slump when it is at a moisture condition, add more moisture to the sand, and at the onset of the surface-dry condition, with the hand, lightly pat approximately 100 g of the material on a flat, dry, clean, dark or dull nonabsorbent surface such as a sheet of rubber, a worn oxidized, galvanized, or steel surface, or a black-painted metal surface. After 1 to 3 seconds, remove the fine aggregate. If noticeable moisture shows on the test surface for more than 1 to 2 seconds, then surface moisture is considered to be present on the fine aggregate.
3. Colorimetric procedures described by Kandhal and Lee, Highway Research Record No. 307, p. 44.
4. For reaching the saturated surface-dry condition on a single-size material that slumps when wet, hard-finish paper towels can be used to surface dry the material until the point is just reached where the paper towel does not appear to be picking up moisture from the surfaces of the fine aggregate particles.

7. PROCEDURES

7.1. Make and record all weight determinations to 0.1 g.

7.2. Partially fill the pycnometer with water. Immediately introduce into the pycnometer 500 ± 10 g of saturated surface-dry fine aggregate prepared as described in Section 6 and fill with additional water to approximately 90 percent of capacity. Roll, invert, and agitate the pycnometer to eliminate all air bubbles (Note 3). Adjust its temperature to 23 ± 1.7° C (73.4 ± 3°F), if necessary, by immersion in circulating water, and bring the water level in the pycnometer to its calibrated capacity. Determine total weight of the pycnometer, specimen, and water.

Note 3: It normally takes about 15 to 20 minutes to eliminate air bubbles. Adding a few drops of isopropyl alcohol, after removal of air bubbles and just prior to bringing the water level to its calibrated capacity, has been found useful in dispersing foam on the water surface. Do not use this procedure when using the alternative method described in Section 7.2.1.

7.2.1 **Alternative to Weighing in Section 7.2** - The quantity of added water necessary to fill the pycnometer at the required temperature may be determined volumetrically using a buret accurate to 0.15 mL. Compute the total weight of the **pycnometer**, specimen, and water as follows:

$$C = 0.9975\, V_a + S + W$$

where:

C = weight of pycnometer with specimen and water to calibration mark, g, V_a = volume of water added to pycnometer, mL

S = weight of saturated surface-dry specimen, g, and

W = weight of the pycnometer empty, g.

7.2.2 **Alternative to the Procedure in Section 7.2** - Use a Le Chatelier flask initially filled with water to a point on the stem between the 0 and the 1-mL mark. Record this initial reading with the flask and contents within the temperature range of 23 ± 1.7°C (73.4 ± 3F). Add 55 ± 5 g of fine aggregate in the saturated surface- dry condition (or other weight as necessary to result in raising the water level to some point on the upper series of graduation). After all fine aggregate has been introduced, place the stopper in the flask and roll the flask in an inclined position, or gently whirl it in a horizontal circle to dislodge all entrapped air; continuing until no further bubbles rise to the surface (Note 4). Take a final reading with the flask and contents within 1°C (1.8°F) of the original temperature.

Note 4: When using the Le Chatelier flask method, slowly adding a small, measured amount (not to exceed 1 mL.) of isopropyl alcohol, after removal of air bubbles, has been found useful in dispersing foam appearing on the water surface. The volume of alcohol used must be subtracted from the final reading (R2).

7.3. Remove the fine aggregate from the pycnometer, dry to constant weight at a temperature of 110 ± 5°C (230 ± 9F), cook in air at room temperature and weigh.

7.3.1 If the Le Chatelier flask method is used, a separate sample portion is needed for the determination of absorption. Weigh a separate 500 ± 10 g portion of the saturated surface-dry fine aggregate, dry to constant weight, and reweigh.

7.4. Determine the weight of the pycnometer filled to its calibration capacity with water at 23 ± 1.7°C (73.4 ± 3°F).

7.4.1 **Alternative to Weighing in Section 7.4** - The quantity of water necessary to fill the empty pycnometer at the required temperature may be determined volumetrically using a buret accurate to 0.15 mL. Calculate the weight of the pycnometer filled with water as follows:

$$B = 0.9975\,V + W$$

where:

B = weight of flask filled with water g,

V = volume of flask, mL, and

W = weight of the flask empty, g.

8. BULK SPECIFIC GRAVITY

8.1. Calculate the bulk specific gravity, 23/23C (73.4/73.4F), as defined in AASHTO M 132 as follows:

$$\text{Bulk sp gr} = A\,/\,(B + S - C)$$

where:

A = weight of oven-dry specimen in air , g,

B = weight of pycnometer filled with water , g,

C = weight of pycnometer with specimen and water to calibration mark, g, and S = weight of saturated surface-dry specimen, g.

8.1.1 If the Le Chatelier flask method was used, calculate the bulk specific gravity , 23/23°, as follows:

$$\text{Bulk Sp. Gr.} = \frac{S_1(A/S)}{09975\,(R_2 - R_1)}$$

where:

R_1 = initial reading of water level in Le Chatelier flask,

R_2 = final reading of water level in Le Chatelier flask, and

S_1 = weight of saturated surface-dry specimen used in Le Chatelier flask, g.

9. BULK SPECIFIC GRAVITY (SATURATED SURFACE-DRY BASIS)

9.1. Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), on the basis of weight of saturated surface-dry aggregate as follows:

9.1.1 If the Le Chatelier flask method was used, calculate the bulk specific gravity 23/23°C, based on saturated surface-dry aggregate as follows:

Bulk sp gr (saturated surface-dry basis)

$$= \frac{S1}{9975 \qquad (R_2 - R_1)}$$

10. APPARENT SPECIFIC GRAVITY

10.1. Calculate the apparent specific gravity, 23/23C (73.4/73.4F), as defined in AASHTO M 132 as follows:

$$\text{Apparent sp gr} = A / (B + A - C)$$

11. ABSORPTION

11.1. Calculate the percentage of absorption, as defined in ASTM C 125, as follows:

$$\text{Absorption, \%} = [\, (S - A) / A \,] \times 100$$

12. REPORT

12.1. Report specific gravity results to the nearest 0.01 and absorption to the nearest 0.1 percent. The appendix gives mathematical interrelationships among the three types of specific gravities and absorption. These may be useful in checking the consistency of reported data or calculating a value that was not reported by using other reported data.

11.2. If the fine aggregate was tested in a naturally moist condition other than the oven dried and 15-hour-soaked condition, report the source of the sample and the procedures used to prevent drying prior to testing.

13. PRECISON AND BIAS

13.1. The estimates of precision of this test method (listed in Table 1) are based on results from the AASHTO Materials Reference Laboratory Reference Sample Program, with testing conducted by this test method and ASTM C 128. The significant difference between the methods is that ASTM C 128 requires a saturation period of 24 ±4 hours, and T 84 requires a saturation period of 15 to 19 hours. This difference has been found to have an insignificant effect on the precision indices. The data are based on the analyses of more than 100 paired test results from 40 to 100 laboratories.

13.2. Since there is no accepted reference material suitable for determining the bias for the procedure in T 84 for measuring specific gravity and absorption of fine aggregate, no statement on bias is being made.

Table 1 Precision

	Standard Deviation (1S)[A]	Acceptable Range of Two Results (D2S)[A]
Single Operator Precision:		
Bulk specific gravity (dry)	*0.011*	*0.032*
Bulk specific gravity (SSD)	*0.0095*	*0.027*
Apparent specific gravity	*0.0095*	*0.027*
Absorption[B], percent	*0.11*	*0.31*
Multi laboratory Precision:		
Bulk specific gravity (dry)	*0.023*	*0.066*
Bulk specific gravity (SSD)	*0.020*	*0.056*
Apparent specific gravity	*0.020*	*0.056*
Absorption[B], percent	*0.23*	*0.660*

[A] These numbers represent, respectively, the (1S) and D2S) limits as described in ASTM C 670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory reference sample data from laboratories using 15- to 19-hour saturation times and other laboratories using 24 ± 4 hours saturation time. Testing was performed on normal weight aggregates and started with aggregates in the oven-dry condition.

[B] Precision estimates are based on aggregates with absorptions of less than 1 percent and may differ for manufactured fine aggregates and fine aggregates having absorption values greater than 1 percent.

14. APPENDIX (Non-mandatory Information)

14.1. Interrelationships between specific gravities and absorption as defined in Methods T 84 and T 85

14.1.1 Let:

S_d = bulk specific gravity (dry-basis),

S_s = bulk specific gravity (SSD-basis),

S_a = apparent specific gravity, and

A = absorption in percent

Then:

(1) $$S_d = (1 + A / 100) S_d$$

(2) $$S_a = \frac{1}{\frac{1}{S_d} - \frac{A}{100}} = \frac{S_d}{1 - \frac{AS_d}{100}}$$

or

(2a) $$S_a = \frac{1}{\frac{1 + A/100}{S_s} \qquad \frac{A}{100}}$$

$$= \frac{Ss}{1 - \frac{A}{100} (S_s - 1)}$$

(3) $$A = \left(\frac{S_s}{S_d} - 1 \right) 100$$

(4) $$A = \left(\frac{S_s - S_s}{S_d (S_s - 1)} \right) 100$$

1.4 NDT T 103 Soundness of Aggregates by Freezing and Thawing

Modifies - AASHTO Designation: T 103-91 I

1. SCOPE

1.1. This method describes procedures to be followed in testing aggregates to determine their resistance to disintegration by freezing and thawing. It furnishes information helpful in judging the soundness of aggregates subjected to weathering, particularly when adequate information is not available from service records of the behavior of the aggregate.

1.2. It provides for a numerical measure of the disintegration caused by this method of freezing and thawing called the “Percent Loss,” and is used as a basis for acceptance or rejection of the material, when requirements are in the Specifications or Special Provisions.

2. APPLICABLE DOCUMENTS

2.1. **AASHTO Standards:**

M 92	“Wire-Cloth Sieves for Testing Purposes”
M 231	“Weighing Devices Used in the Testing of Materials”
R 16	"Regulatory Information for Chemicals used in AASHTO Tests"

3. APPARATUS

3.1. The apparatus shall consist of the following:

3.1.1 **Freezing Equipment** - No specific requirements for the type or size of the freezing equipment are given as many laboratories have adequate equipment but variable in type and size. All equipment shall be capable of being operated at a temperature not higher than -26 C *(-15F)* at any point in the freezing chamber.

3.1.2 **Sample Containers** - Shall be of metal, preferably non-corroding, or of plastic, rubber, or other materials suitable for the procedure to be followed.

3.1.3 **Sieves** - Shall meet the requirements of AASHTO M 92.

3.1.4 **Balances** - Shall conform to the requirements of AASHTO M 231 for the class of general purpose balance required for the principal sample weight of the sample being tested, G5.

3.1.5 **Drying Oven** - Shall provide a free circulation of air through the oven and shall be capable of maintaining a temperature of 110 + 5 C (230± 9 F).

3.1.6 **Thawing Tank** - A tank of a size suitable for the samples and sample containers used, permitting complete or partial submergence of the samples as required by the procedure used. Unless otherwise desired, the water or solution in the thawing tank shall be maintained at 21 to 27 C *(70 to 81 F)* during the thawing period. The thawing tank shall be filled with a 0.5 percent of methyl alcohol-water solution.

4. SAMPLES

4.1. **Fine Aggregate** - Is determined by AASHTO T 104.

4.2. **Coarse Aggregate** - Test shall consist of representative material coarser than the No. 4 sieve.

5. PREPARATION OF TEST SAMPLE

5.1. A test portion for the freezing and thawing test of sufficient size to yield approximately 5,000 grams of material retained on the No. 4 sieve shall be separated from the original air-dried sample by means of a sample splitter . Make a rough separation of the sample on the No. 4 sieve. Discard the passing No. 4 material.

5.1.1 The sample for testing shall be thoroughly washed and dried to substantially constant weight at 1 10 ± 5 C *(230 ± 9 F).* The test sample shall then be sieved over a No. 4 sieve, rejecting all material passing the No. 4 sieve, and weighed to the nearest gram.

5.2. **Ledge Rock** - Samples shall be prepared by crushing the material submitted for test in a jaw crusher, to meet the requirements of 47B gradation. The test sample shall consist of approximately 5,000 g of material retained on the No. 4 sieve. The sample for testing shall be thoroughly washed and dried to substantially constant weight at 110±5 C *(230 ± 9 F).*

6. PROCEDURES

6.1. **Procedure B - Partial Immersion**

6.1.1 In this procedure, the sample shall be saturated by subjecting it to an air pressure of not over 1 inch (*25.4 mm*) of mercury and breaking the vacuum with a sufficient amount of a 0.5 mass percent solution of methyl alcohol in water to completely cover the samples. The samples shall be left in the solution for 15 minutes.

6.1.2 The samples shall then be removed from the vacuum chamber. The entire test sample shall be placed in a container measuring 8 inches by 22 inches by 2 inches deep containing 1⁄4 inch of the methyl alcohol-water solution and frozen in this condition.

6.1.3 The time required to freeze the samples shall be determined. This will be dependent on the number of samples frozen and the effectiveness of the freezing equipment. In most instances, a freezing period of 90 minutes will be found suitable. Following completion of freezing, the samples shall be thawed for 30 minutes in the alcohol-water solution at a temperature of 21 to 27 C (70 to 81 F) to complete one cycle of the freezing and thawing treatment.

6.1.4 Care shall be taken to avoid loss of any of the samples during the testing procedure.

7. CYCLES

7.1. Alternate freezing and thawing shall be repeated until sixteen cycles have been completed.

8. PERCENT LOSS

8.1. After the sample has been subjected to the required number of cycles of freezing and thawing, the sample shall be dried to substantially constant weight at a temperature of 110 ± 5 C *(230 ± 9 F).* The sample shall then be sieved over a No. 8 sieve. The material passing the No. 8 sieve shall be calculated as the “Percent Loss” based on the original oven-dry weight of the sample before test.

9. REPORT

9.1. The result of the test shall be reported as the “Freeze and Thaw, Percent Loss” and shall be reported to one decimal place.

1.5 NDT T 113 Lightweight Pieces in Aggregate

NDT T 113 is identical to **AASHTO T 113** except for the following provisions:

Paragraphs 8.1, 8.2., and 9 are void and superseded by the following:

8.1. Fine Aggregate

8.1.1 The test specimen of fine aggregate shall cool to room temperature and sieved over a No. 50 (300-μm) sieve.

8.1.2 The fine aggregate will be in a dried condition; then introduce the fine aggregate into the heavy liquid in a suitable container (Figure 1). The volume of the heavy liquid shall be at least 2 times the absolute volume of the aggregate and have a specific gravity 0.20 less than that of the fine aggregate. Using the skimmer (Figure 2), remove the pieces that float to the surface, and save them. Repeatedly agitate a minimum of three times and remove the floating pieces until no additional pieces rise to the surface.

8.1.3 Wash the fine aggregate and lightweight pieces with water and then dry to saturated surface dry (SSD) condition by means of the procedure specified in T 84 (Section 7.1.1.). The lightweight pieces shall be dried to a SSD with care to avoid particle deterioration and loss.

- a. The water used for washing the coarse aggregate will be captured and disposed of appropriately according to state regulations.

8.1.4 Using the SSD fine aggregate, place the aggregate into a 500 ml flask (Figure 3), fill the flask with water at 23°C to the 500 ml mark and weigh (W_1).

8.1.5 Weigh the same 500 ml flask with 500 ml of water at 23°C and record as W_{FW}.

8.1.6 Repeat Paragraph 8.1.4 and 8.1.5 for the lightweight pieces. The mass of the lightweight pieces is recorded as (W_2).

Figure 1

Figure 2

Figure 3

8.2. Coarse Aggregate

8.2.2 The test specimen of coarse aggregate shall cool to room temperature and sieved over a No. 4 (4.75-mm) sieve.

8.2.3 The coarse aggregate shall be in a SSD condition (Note 2) by means of procedure specified in T 85.

8.2.4 In a container (Figure 4), drill a hole 1-inch down from the rim and insert a spout.

8.2.5 Place container below the spout to catch the overflow (Figure 5). Fill the container with water beyond the height of the hole. Allow the water level to reach equilibrium *(until there is no water coming out of the spout)*.

8.2.6 Place a 4-liter beaker under the spout. Carefully, place SSD aggregate into bucket without splashing water or overflowing above the rim of the container. Allow the water level to equilibrate and collect the water displaced into the beaker and determine the volume (V_1) by measuring the displaced collected water using a graduated cylinder no larger than 250 ml capacity and having maximum increments of 2 ml.

8.2.7 The coarse aggregate will be brought to an SSD condition; then introduce the coarse aggregate into the heavy liquid in a suitable container. The volume of the heavy liquid shall be at least 1.5 times the absolute volume of aggregate and have a specific gravity 0.20 less than that of the coarse aggregate. Using the skimmer (Figure 3), remove the pieces that float to the surface, and save them. Repeatedly agitate a minimum of three times and remove the floating pieces until no additional pieces rise to the surface.

8.2.8 Wash the coarse aggregate and lightweight pieces separately with water and then dry the lightweight pieces with a soft paper towel to SSD condition, avoiding degradation of the lightweight pieces.

   a. The water used for washing the coarse aggregate and lightweight pieces will be captured and disposed of appropriately according to State Regulations.

8.2.9 Using a 100 ml graduated cylinder with a maximum of 1 ml unit increments, fill the graduated cylinder with water to an initial known volume. Record the initial volume (V_i) and place the lightweight pieces in the graduated cylinder carefully. Record the final volume (V_f) after the lightweight pieces are added (Figure 6). The volume of the displaced water from the lightweight pieces is recorded as $(V_f - V_i) = V_2$.

Note 2 – If material undergoes degradation in water, the material does not behave to be brought to a SSD condition.

Figure 4

Figure 5

Figure 6

9. CALCULATION

9.1 Calculate the percentage of lightweight pieces (pieces floating in the heavy liquid) as follows:

For Fine Aggregate:

$$V_1 = (W_1 - W_{FW})$$

$$V_2 = (W_2 - W_{FW})$$

$$V_t = V_1 + V_2$$

$$L = \frac{V_2}{V_t} \text{ x } 100$$

where:

W_{FW} = Weight of flask and water filled to 500 ml mark at 23°C
W_1 = Weight of flask, fine aggregate only and water filled to 500 ml mark at 23°C
W_2 = Weight of flask, lightweight pieces and water filled to 500 ml mark at 23°C
L = Percentage of lightweight pieces,
V_1 = SSD volume of fine aggregate,
V_2 = SSD volume of lightweight pieces,
V_t = Volume saturated surface fine aggregate.

For Coarse Aggregate:

$$L = \frac{V_2}{V_1} \text{ x } 100$$

where:

L = Percentage of lightweight pieces,
V_1 = Intial volume of SSD coarse aggregate with lightweight pieces,
V_2 = Final SSD volume of lightweight pieces.

Lightweight Pieces Testing Protocol – NDT T 113

Representative samples of the producer's fine and coarse aggregate shall be 60-lb samples. Samples and shall be taken by NDOT personnel.

- All plus #4 material will be classified as coarse aggregate.
- All minus #4 material will be classified as fine aggregate.

Sample Splitting

Since plus #4 material from both the fine and coarse aggregate samples is combined as one individual test sample and the minus #4 to plus #50 material is combined as one test sample it is important to split down to equal sample sizes of both materials based on the PCC Aggregate Mix Design**. Example:

PCC MIX DESIGN:	30% coarse aggregate with 93% retained on #4 & 0.3% retained on #50
	70% fine aggregate with 11% retained on #4 & 95% retained on #50

Split Sample Steps:

a. Split coarse aggregate sample down to 5,250 gm ± 50 gm.
b. Split fine aggregate sample down to 12,250 gm ± 50 gm.
c. Sieve coarse and fine samples over #4 sieve.
d. For coarse aggregate combine the plus #4 material from steps a. and b.

    +#4 from coarse = 4882.5 gm   +#4 from fine = 1347.5 gm

e. The remaining minus #4 material left over from step c. shall be sieved over the #50 sieve and then combined, as follows:

    -#4 to +#50 from coarse = 351.7 gm   -#4 to +#50 from fine = 10290 gm

f. Test samples for the coarse (plus #4) material shall be split one into two ~ 3,100 gm samples.
g. Test samples for the fine (minus #4 to plus #50) material shall be split into two ~ 300 gm samples.

** Split sample weights will vary based on the PCC Mix Design percentages and gradations.

Example of Splitting to Sample Test Sizes

PCC Mix Design 30% coarse aggregate and 70% fine aggregate

Total sample size = 17,500 gm

30% coarse = 5,250 gm

70% fine = 12,250 gm

Coarse aggregate has 93% retained on #4 and 0.3% retained on #50.

For +#4 sample: 93% x 5,250 = 4882.5 gm

For -#4 to +#50 sample: Remaining 7% passing #4 minus 0.3% retained on #50 = 6.7%

So: 6.7% x 5,250 = 351.7 gm

Fine aggregate has 11% retained on #4 and 5 % retained on #50.

For +#4 sample: 11% x 12,250 = 1,347.5 gm

For -#4 to +#50 sample: Remaining 89% passing #4 minus 5% retained on #50 = 84%

So: 84% x 12,250 = 10,290 gm

Combine +#4 from coarse and fine aggregate

4882.5 gm + 1,347.5 gm = 6,230 gm   Split into two ~ 3,100 gm samples

Combine -#4 to +#50 from coarse and fine aggregate

351.7 gm + 10,290 gm = 10,641.7 gm Split into two ~ 300 gm samples

NDT T 113 Test Procedure

Fine Aggregate (minus #4 to plus #50)

1. 300 gm (minimum) of dry aggregate sample added to dense liquid. Liquid specific gravity shall be 0.20 less than specific gravity of fine aggregate. Use skimmer to collect floating lightweight pieces and set aside. Continue to agitate sample until no floating pieces are observed. Agitate sample in liquid a minimum of 3 times to suspend additional lightweight pieces and collect.
2. Wash fine aggregate and lightweight pieces. Dry both to SSD.
3. Place SSD fine aggregate in 500 ml flax. Fill flax with 23°C water to 500 ml mark and weigh (W1).
4. Repeat step 3 for lightweight pieces. Weight of lightweight pieces is W2.

Calculation of Lightweight Pieces in Fine Aggregate

$$V_1 = (W_1 - W_{FW}) \qquad V_2 = (W_2 - W_{FW})$$

$$V_t = V_1 + V_2 \qquad L = \frac{V_2}{V_t}\ x\ 100$$

where:

W_{FW} = Weight of flask and water filled to 500 ml mark at 23°C
W_1 = Weight of flask, aggregate only and water filled to 500 ml mark at 23°C
W_2 = Weight of flask, lightweight pieces and water filled to 500 ml mark at 23°C
L = Percentage of lightweight pieces,
V_1 = SSD volume of fine aggregate,
V_2 = SSD volume of lightweight pieces,
V_t = Volume saturated surface fine aggregate.

Coarse Aggregate (plus #4)

1. Record dry weight of sample and soak sample overnight and bring to SSD (minimum sample size 3,000 gm).
2. Measure volume of total coarse aggregate sample and record using displacement method discussed in section 8.2.5.
3. After bringing total coarse aggregate sample to SSD, add sample to dense liquid.
4. Agitate sample in solution and collect lightweight pieces. Agitate repeatedly until no additional lightweight pieces are observed (minimum of 3 separate agitations).
5. Wash coarse aggregate and lightweight pieces separately.
6. Bring lightweight pieces to SSD, using soft paper towel.
7. Take a 100 ml graduated cylinder with an accuracy of 1 ml unit graduations and fill with water to approximately half full (enough to cover all lightweight pieces). Record initial volume (V_i)
8. Add lightweight pieces to graduated cylinder and record final volume (V_f).
9. Volume displaced from lightweight pieces is ($V_f - V_i$) = V_2.

Calculation of Lightweight Pieces in Coarse Aggregate

$$L = \frac{V_2}{V_1}\ \text{x}\ 100$$

where:

$L = Percentage\ of\ lightweight\ pieces,$
$V_1 = Intial\ volume\ of\ saturated\ surface\ dry\ coarse\ aggregate\ with\ lightweight\ pieces,$
$V_2 = Final\ saturated\ surface\ dry\ volume\ of\ lightweight\ pieces.$

*** The specific gravity of the dense liquid shall be checked between tests and filtered as necessary before re-use.

Test Results Reporting:

Coarse Aggregate (Plus #4 Test Sample):

For plus #4 material, there shall be no more than 3.5% lightweight pieces in accordance with NDT T 113 by volume. The cumulative percentage of clay, shale, soft particles in accordance with NDT T 504* and lightweight pieces shall not exceed 3.5%. Coarse aggregate test results shall be reported as shown below:

NDT T504			**NDT T113**	
% Clay Lumps (0.5% Max) A	% Shale (1.0% Max) B	% Soft Particles (3.5% Max) C	% Lightweight Pieces (3.5% Max) D	**% Cumulative Total** of A,B,C, & D **(3.5% Max)**

* In order to prevent double counting of light weight pieces, material collected from the NDT T504 test shall be placed in the high-density solution to check for possibility of lightweight pieces.

Fine Aggregate (Minus #4 Test Sample):

For minus #4 to plus #50 material, there shall be no more than 3.5% lightweight pieces in accordance with NDT T 113 by volume. Fine Aggregate test results shall be reported as shown below:

NDT T113
% Lightweight Pieces (3.5% Max) D

1.6 NDT T 504 Determination of Clay Lumps Shale & Soft Particles in Coarse Aggregate & Crushed Rock – Lab / Field

1. SCOPE

1.1. This method of test covers the procedure for determining the percent of clay lumps, shale and soft particles in coarse aggregate and crushed rock, and the percent of clay lumps in fine aggregate and sand gravel aggregate.

2. APPARATUS

2.1. **Balance** - The balance shall conform to the requirements of AASHTO M 231, "Weighing Devices Used in the Testing of Materials", for the class of general-purpose balance required for the principal sample mass of the sample being tested.

2.2. **Sample Container** - The sample containers shall be watertight metal pans, approximately 12 inches by 17 inches, and 2 ½ inches in depth.

2.3. **Drying Equipment** - An oven capable of maintaining a uniform temperature of 110□5 C. Other drying equipment capable of drying materials to substantially constant mass without injury to the material may be used if drying ovens are not available.

2.4. **Sieves** - The sieves shall conform to AASHTO M 92, "Wire-Cloth Sieves for Testing Purposes".

3. DEFINITIONS

3.1. **Clay** - Any material which can be broken with the fingers into finely divided particles when dry, or, after the initial rinsing of the material, is found to be soft, and can be extruded between the fingers when squeezed and feels greasy to the touch, or is found to be in this condition after the two hour soaking period as specified for coarse aggregate in Paragraph 5.1, shall be classified as clay.

3.2. **Shale** - Laminated material which can be broken with the fingers when dry, or after the initial rinsing of the material, is found to be separating or slacking off into layers or is found to be in this condition after the two-hour soaking period shall be called shale. This material generally is soft when wet and when squeezed may extrude between the fingers. Some pieces of shale, however, cannot be identified until completion of the 24 ± 2-hour soaking period. These cannot usually be squeezed or extruded between the fingers but can be broken easily. These are generally dark gray in color and have a slick or greasy surface.

3.3. **Soft Particles** - Soft particles shall be identified as such, if, after soaking for 24 ± 2 hours they can be broken with the fingers. This material can readily be identified as not being clay or shale due to its structure, which is generally sandy or chalk-like and loosely bonded.

4. COARSE AGGREGATE AND CRUSHED ROCK

4.1. **Sample** - A representative portion of air-dried material of sufficient size to yield approximately 2000 grams of material after sieving over a No. 4 sieve shall be selected from the sample submitted for test by quartering or by use of a sample splitter. The material retained on the No. 4 sieve shall be considered the test sample, and the material passing the No. 4 sieve shall be discarded.

5. PROCEDURE

5.1. The test sample shall first be rinsed free of surface dust and examined for soft lumps of clay or shale. At this time, any materials identified as clay or shale shall be removed from the test sample and retained in separate portions. After this preliminary examination, the sample shall be covered with water and allowed to soak for approximately 2 hours to soften the harder lumps of clay and softer lumps of shale. At the completion of the 2-hour soaking period, free water shall be poured off the sample and the sample handpicked for clay and shale, retaining them in their respective portions. After picking, the sample is again covered with water and allowed to soak for an additional 22□2 hours. At the completion of this soaking period, free water is poured off the sample and the sample is again handpicked for harder lumps of shale and soft particles of stone. When this last separation is complete, the test sample and separate portions of clay, shale and soft particles shall be dried to substantially constant mass using an oven or other suitable drying equipment.

NOTE: *When drying a sample using equipment other than a thermostatically- controlled drying oven, extreme care must be taken to not overheat the sample. Overheating may remove material other than moisture, causing erroneous results.*

6. CALCULATIONS

6.1. The percent of clay, shale, and soft particles shall be calculated to the nearest 0.1 percent in accordance with the following formula:

$$X = \frac{R}{W} \times 100$$

where:

X = Percent of Clay, or Shale, or Soft Particles

R = Mass of Clay, or Shale, or Soft Particles

W = Total Dry Mass of Plus No. 4 Test Sample, Including Masses of Clay, Shale & Soft Particles

7. FINE AGGREGATE & SAND GRAVEL AGGREGATE

7.1. **Sample** - A representative portion of air-dried material of sufficient size to yield approximately 1000 grams of material after sieving over a No. 10 sieve shall be selected from the sample submitted for test by quartering or by use of a sample splitter. The material retained on the No. 10 sieve shall be considered the test sample, and the material passing the No. 10 sieve shall be discarded.

8. PROCEDURE

8.1. The test sample shall be spread in a flat pan and examined for lumps of clay. Any material identified as clay lumps shall be removed from the test sample and retained as a separate portion. When separation of clay lumps from aggregate is complete, the test sample and the separate portion of clay lumps shall be dried to substantially constant mass using an oven or other suitable drying equipment.

NOTE: *When drying a sample using equipment other than a thermostatically- controlled drying oven, extreme care must be taken to not overheat the sample. Overheating may remove material other than moisture, causing erroneous results.*

9. CALCULATIONS

9.1. The percent of clay lumps shall be calculated to the nearest 0.1 percent in accordance with the following formula:

$$X = \frac{R}{W} \times 100$$

where:

X = Percent of Clay Lumps

R = Mass of Clay Lumps

W = Total Dry Mass of Plus No. 10 Test Sample, Including Mass of Clay Lumps

1.7 NDT T 506 Determination of the Free Moisture Content of Aggregate

1. SCOPE

1.1. This method covers a procedure for determining the free moisture content *(surface moisture)* of an aggregate. The free moisture content of aggregates, as determined by this method, is the value necessary for the determination of the batch weight of aggregate proportioned in Portland cement concrete.

NOTE: *This method of test is not intended for use with lightweight aggregates or aggregates of highly porous or highly absorptive character.*

2. APPARATUS

2.1. **Balance** - A balance sensitive throughout the operating range to 1.0 gram or less.

2.2. **Sample Container** - A metal can or other suitable container of sufficient volume to contain the sample without damage of spilling. A container with a rounded bottom and devoid of cavities or indentations on the outer surface is preferred, in that this type of container is less likely to entrap air when immersed in water. *(See diagram.)*

2.3. **A Suitable Container** - For immersing the sample container in water and suitable apparatus for suspending the sample container from center of scale pan of balance.

2.4. The apparatus described above, when assembled for this method test is commonly referred to as the "Dunagan Apparatus". A typical setup is illustrated in the accompanying diagram.

3. SAMPLE

3.1. Secure a sample of the aggregate representative of the moisture content in the supply being tested and weighing not less than the amount listed in the table below.

Nominal Size, max[a] (sieves with square openings)		**Minimum Weight of Sample**
In.	**mm**	**kg**
≤ 3/8	9.5	1.5
1/2	12.5	2
3/4	19.0	3
1	25.0	4
1 1/2	37.5	6
2	5-	8

[a] Size of largest sieve upon which less than 10 percent will be retained.

4. PROCEDURE

4.1. Weight the sample to the nearest gram. Loss of moisture from the sample prior to obtaining this weight determination should be avoided to the extent possible.

4.2. After weighing, place the sample in the sample container. A sufficient quantity of water to cover the sample shall be placed in the container prior to adding the sample. Stir the aggregate as it is placed in the sample container to remove entrapped air.

4.3. The sample should stand for a moment in the sample container to allow most of the suspended fines to settle. Immerse the sample container and sample in the larger container, taking care to avoid entrapping air beneath the sample container. Determine the sample weight, in water, to the nearest gram.

5. CALCULATION

5.1. The percentage of free moisture shall be calculated from the following formula:

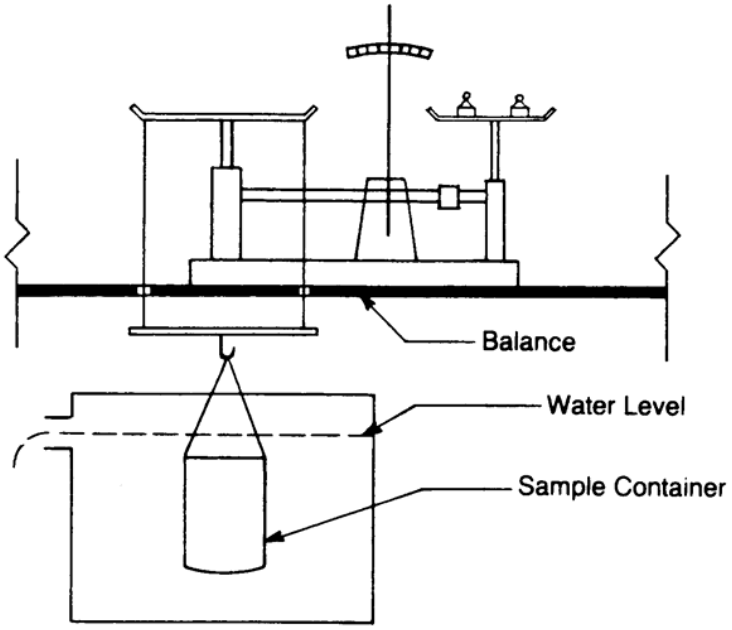
$$\text{Free Moisture, percent} = 100\ [\ (W/W_1)(G_{-1}/G)^{-1}]$$

where:

W = Weight of aggregate in air,

W_1 = Weight of aggregate in water, and

G = Saturated Surface-Dry Specific Gravity of the Aggregate



Dunagan Apparatus

2. Bituminous Aggregate Test Methods

3. Bituminous Rheology Test Methods

4. Chemical Test Methods

4.1 NDT C 25 Gravimetric Determination of Calcium Oxide in Traffic Paint

NDT C 25 is identical to **ASTM C 25** except for the following provisions:

Replace Sections 16.4 with the following:

16.4 Procedure:

16.4.1. Weigh 1 g of powdered sample in a 400 mL beaker with a glass stir rod and watch glass cover. Add 50 mL of H_2O and mix well. Add 15 mL of concentrated HCl and boil for about 5 minutes on the hot plate in the hood. Dilute to 100 mL with hot H_2O and heat to boiling again. Add a few drops of methyl red indicator. Add NH_4OH until the solution becomes yellow. Add a few extra drops of methyl red and a few extra drops of NH_4OH in excess. Put the solution on a steam bath. The water for the steam bath should be at a temperature of ~200°F. The watch glass cover should be replaced by a ribbed watch glass cover. Leave solution on the bath for 1 hour. Filter through #42 filter paper into a 250 mL beaker if a precipitate is present. Wash with hot 2% NH_4Cl. **NOTE: The filter paper and precipitate can be disposed.**

16.4.3. Heat to boiling and slowly add 35 mL of saturated ammonium oxalate solution. If the solution turns pink, add a few drops of NH_4OH. Continue to boil for 2-3 minutes and then let the precipitate settle for 30 minutes just under boiling. Filter through #42 filter paper, police the beaker and wash with five 10-mL portions of cold 0.1% solution of ammonium oxalate. Ignite the precipitate slowly and without a flame in a tared platinum crucible with a lid using a Bunsen burner. When the ashes turn white the crucible can be placed in the furnace set at 1000°C.

4.2 NDT E 70 pH of Waterborne Traffic Paint

NDT E 70 is identical to **ASTM E 70** except for the following provisions:

Replace Section 7.2 with the following:

7.2. *Meter* – The meter shall be brought to electrical balance in accordance with the manufacturer's instructions.

Replace Section 7.3 with the following:

7.3. *Glass Electrode* – The difference of potential of the combination electrode shall be determined in accordance with the manufacturer's instructions.

4.3 NDT D 522 Flexibility of Traffic Paint

NDT D 522 is identical to **ASTM D 522** except for the following provisions:

Replace Section 5.2.1 with the following:

5.2.1. Draw down the paint of a wet film thickness of 5 mil on a clean, bare, cold-rolled steel panel.

Replace 6.1 with the following:

6.1. Air-dry the panels for 24 hours at standard conditions, and then bake for 5 hours at 105°C ± 2°C, and finally condition the panel for 30 minutes at standard conditions.

Disregard Sections 7 through 11.

Replace Section 13.1 with the following:

13.1. Bend approximately 180° over a 0.5-inch diameter cylindrical mandrel at a uniform velocity in a time of 1 second. Remove and examine the panel immediately for cracking visible to the unaided eye.

Remove Sections 13.2 and 14.

4.4 NDT D 711 No-Pick-Up Time of Traffic Paint 2013

NDT D 711 is identical to **ASTM D 711** except for the following provisions:

Remove Section 4.6 and Subsections 4.6.1 and 4.6.2.

4.5 NDT D 969 Degree of Bleeding in Traffic Paint

NDT D 969 is identical to **ASTM D 969** except for the following provisions:

Replace Section 6.2 with the following:

6.2. Draw the paint down over the specimen panel in such a manner that the entire width of the tape is covered, leaving the remainder of the film to the right of the tape in direct contact with the test panels. Apply the paint at a thickness of 15 mils.

Replace Section 6.4 with the following:

6.4. Immediately after completion of 48-h drying, observe the contrast in color between the portion of the film over the tape and that portion that is in direct contact with the test panels. Rate the degree of bleeding in accordance with the nearest photographic reference standard in Test Method D 868.

Add Section 6.5:

6.5. Determine the bleeding ratio by using the average value of the readings taken for the film in direct contact with the panel and dividing this value by the average value of the readings taken from the film over the tape (the non-bleeding contrast surface). The minimum bleeding ratio shall be 0.96.

4.6 NDT E 1349 Color of Yellow Traffic Paint

NDT E 1349 is identical to **ASTM E 1349** except for the following provisions:

Replace Section 7 with the following:

7. Test Specimen

7.1. Prepare the test specimen by making a draw-down of the paint at a thickness of 15 ± 1 mil over a Leneta black and white paper chart. Allow to dry for 4 hours prior to measurement.

Replace Section 8 with the following:

8. Standardization

8.1. Standardize the spectrophotometer following the manufacturer's instructions.

Replace Section 9.6 with the following:

9.6. Measure the specimen over the black portion of the chart, following the instrument manufacturer's instructions, at three different locations of the draw-down. Report the average of the three readings of the x and y coordinates.

4.7 NDT E 1349 Reflectance of Traffic Paint

NDT E 1349 is identical to **ASTM E 1349** except for the following provisions:

Replace Section 7 with the following:

7. Test Specimen

7.1. Prepare the test specimen by making a draw-down of the paint at a thickness of 15 ± 1 mil over a Leneta black and white paper chart. Allow to dry for 4 hours prior to measurement.

Replace Section 8 with the following:

8. Standardization

8.1. Standardize the spectrophotometer following the manufacturer’s instructions.

Replace Section 9.6 with the following:

9.6. Measure the specimen over the black portion of the chart, following the instrument manufacturer’s instructions, at three different locations of the draw-down. Report the average of the three readings of the Y value.

4.8 NDT D 1475 Density of Waterborne Traffic Paint

NDT D 1475 is identical to **ASTM D 1475** except for the following provisions:

Remove Section 8.

Replace Section 9 with the following:

9. Procedure
   - 9.1. Fill the metal cup with specimen at a temperature of 25°C. Cap the container, and immediately remove the excess overflow by wiping with absorbent material. Avoid occluding air bubbles in the container.
   - 9.2. Immediately weigh the filled container to the nearest 0.01 g. Record this weight as pounds per gallon.

4.9 NDT D 1640 Drying Time, Dry-Through of Traffic Paint

NDT D 1640 is identical to **ASTM D 1640** except for the following provision:

Replace Section 7.7.1 with the following:

7.7.1. The paint shall be applied to a non-absorbent substrate at a wet film thickness of 15 ± 1 mils and placed in a humidity chamber controlled at 90 ± 5% R.H. and 72.5 ± 2.5°F. The operator shall place their thumb over the film using the minimum pressure needed to maintain contact. The film is considered dry-through when there is no loosening, detachment, wrinkling, or other evidence of distortion of the film.

4.10 NDT 1952 Water Resistance of Traffic Paint

NDT 1952 is identical to Section 3.2.5 of **Federal Specification TT-P-1952F** except for the following provisions:

Replace Section 3.2.5 with the following:

3.2.5. Water Resistance. When tested as specified in 4.3.6, the paint film shall not soften, blister, wrinkle, lose adhesion, change color, or show other evidence of deterioration.

Replace Section 4.3.6 with the following:

4.3.6. Water Resistance. Prepare a 10 by 15 cm concrete panel from a mix of 1 part Portland cement (ASTM C150, Type I) and 1 part of graded Ottawa silica sand, conforming to the requirements of ASTM C778, by volume. Mix thoroughly with sufficient water to obtain trowelling consistency and cast into panels measuring 3 by 3 by ½ inch. The top surface of the panels shall be trowelled smooth, but not excessively; three trowellings are adequate. The panels shall be allowed to harden in air for at least 2 weeks. The panels may be prepared in advance and held ready for use; however, panels which have aged for more than 6 months shall not be used. The surface glaze shall be removed with No. 1 sandpaper before the panels are used. Draw down to a wet film thickness of 0.33 mm (0.013 in) and allow it to dry in a horizontal position at standard conditions for 72 hours. Immerse one-half of the painted panel in distilled water at 25°C ± 1°C. After 18 hours, remove the panel from the water and allow it to dry for 2 hours at standard conditions. Evaluate for conformance with 3.2.5.

4.11 NDT D 2369 Total Solids of Waterborne Traffic Paint

NDT D 2369 is identical to **ASTM D 2369** except for the following provisions:

Replace Section 5 with the following:

5. Apparatus

5.3. *Gravity Convection Oven*.

5.5. *Syringe*, 5-ml plastic disposable, capable of properly dispensing the coating under test, at a sufficient rate so that the specimen can be dissolved in the solvent.

5.6. *Paper Clips.*

Replace Section 7.10 with the following:

7.10. After the specimens are prepared, allow them to sit above the gravity convection oven until all the free-flowing liquid is evaporated. Place in the oven.

Replace Section 7.11 with the following:

7.11. Heat the aluminum foil dishes containing the specimens in the gravity convection oven for 60 min at 110 ± 5^{o}C.

4.12 NDT D 2805 Contrast Ratio of Traffic Paint

NDT D 2805 is identical to **ASTM D 2805** except for the following provisions:

Remove Section 6.5.

Replace Section 6.6 with the following:

6.6. Film Applicator that gives a 15 ± 1 mil wet film thickness.

Remove Sections 7.1.2 through 7.5.

Replace Section 7.6 with the following:

7.6. *Drying of the Films* – Immediately after application, place each drawdown horizontally with all drawdowns in close proximity to one another to assure identical drying conditions. Allow to dry for 4 hours.

Remove Sections 7.7 and 7.8.

Replace Section 8 with the following:

8. Procedure

8.1. Standardize the spectrophotometer following the manufacturer's instructions.

8.2. Measure the contrast ratio following the manufacturer's instructions.

Remove Sections 8.3 through 8.5.

Replace Section 9 with the following:

9. Report

9.1. Report the contrast ratio determined by the spectrophotometer.

Remove Sections 9.1.1 through 9.2.

4.13 NDT D 3723 Pigment Content of Waterborne Traffic Paint

NDT D 3723 is identical to **ASTM D 3723** except for the following provisions:

Replace Section 4.1 with the following:

4.1. *Oven,* gravity convection, maintained at 105 ± 2°C.

Replace Section 4.4 with the following:

4.4. *Aluminum Foil Dishes*, 58 mm in diameter by 15 mm high with a flat bottom. The bottom of the dish should be as nearly flat as possible so that a uniform film is produced.

Remove Sections 6.1 through 6.3.

Replace Section 6.4 with the following:

6.4. Transfer the dish previously weighed from NDT D 2369 to a muffle furnace and heat at 450 ± 25°C for 1 h. Remove from the furnace, cool in a desiccator and weigh.

4.14 NDT D 4764 Titanium Dioxide in Traffic Paint

NDT D 4764 is identical to **ASTM D 4764** except for the following provisions:

Remove Section 6.3.

Replace Table 1 with the following:

TABLE 1 Instrument Conditions

	Ti K_α	Br K_α
Analyzer crystal	LiF200	LiF200
Counter	Flow	Scintillation
Collimator	Fine (0.23dg)	Coarse (0.46dg)
Order	First	First
Tube KV/mA	20/150	60/50
Time, s	20	20
Peak, 2θ, °	86.166	29.972
Background, 2θ, °	85.00	29.00
PHA, %	67-142	56-158
Filter	50 µm Be	800 µm Al

4.15 NDT T 105 Determination of Chloride Content in Cement

NDT T 105 is identical to **AASHTO T 105** except for the following provisions:

Replace Section 21.4 with the following:

21.4.1 *Sodium Chloride, Standard Solution (0.01 N* NaCl*)* – Dry sodium chloride (NaCl) at 105^{O} to $110^{o}C$ to a constant mass. Weigh 0.5844 g of dried reagent. Dissolve in water and dilute to exactly 1 L in a volumetric flask and mix thoroughly. This solution is standard and requires no further standardization.

21.4.2 *Silver Nitrate, Standard Solution (0.03 N* AgNO3) – Dissolve 5.0964 g of silver nitrate (AgNO3) in water. Dilute to 1 L in a volumetric flask and mix thoroughly. Standardize against

25.0 mL of standard 0.01 N sodium chloride solution diluted to 150 mL with water following the titration test method given in Section 19.5.4 beginning with the second sentence. The exact normality shall be calculated from the average of three determinations as follows:

$$N = 0.25 / V$$

Where:

N = normality of $AgNO_3$ solution

0.25 = milliequivalents NaCl (25.0 mL x 0.01 N)

V = volume of $AgNO_3$ solution, mL

Replace Section 21.5.4 through 21.5.8 with the following:

21.5.4. Place the beaker on the automatic titrator carousel. To the cooled sample beaker from Section 21.5.2, begin the titration according to the manufacturer's instructions. The automatic titrator will dispense 3.00 mL of standard 0.01 N NaCl solution, followed by titrating with the standards 0.03 N silver nitrate solution. The titrator will end automatically when the titration is complete.

Replace Section 21.6 with the following:

19.6. Calculations – Calculate the percent chloride as follows:

$$Cl,\% = \frac{35.453(0.03)(V_1 - V_2)N}{W}$$

Where:

V_1 = mL of 0.03 N $AgNO_3$ solution used for sample titration (equivalence point)
V_2 = mL of 0.05 N $AgNO_3$ solution used for blank titration (equivalence point)
N = exact normality of 0.03 N $AgNO_3$ solution
0.03 = milliequivalents of NaCl added (3.00 mL x 0.01 N)
W = weight of sample, g

4.16 NDT T 260 Determination of Chloride Content in Cement Cores

NDT T 260 is identical to **AASHTO T 260** except for the following provisions:

Replace Section 4.4 with the following:

4.4. Standard 0.03 normality $AgNO_3$. – Dissolve 5.0964 g of silver nitrate ($AgNO_3$) in water. Dilute to 1 L in a volumetric flask and mix thoroughly. Standardize against 25.0 mL of standard 0.01 N sodium chloride solution diluted to 150 mL with water following the titration test method given in Section 5.4 beginning with the second sentence. The exact normality shall be calculated from the average of three determinations as follows:

$$N_{AgNO_3} = \frac{(V_{NaCl})(N_{NaCl})}{V_{AgNO_3}}$$

Where:

N_{AgNO3} = normality of $AgNO_3$ solution

V_{NaCl} = volume of NaCl solution, mL

N_{NaCl} = normality of NaCl solution

V_{AgNO3} = volume of $AgNO_3$ solution, mL

Replace Section 6.1 with the following:

6.1. Determine the mass to the nearest milligram of two 3-g powdered samples representative of the material under tests. Each sample will be tested in duplicate to verify precision.

Replace Section 6.2.1 with the following:

6.2.1. Transfer the sample quantitatively to a beaker; add 10 mL of distilled H_2O, swirling to bring the powder into suspension. Add 15 mL of 1:3 HNO_3 with continued swirling until the material is completely decomposed. (All other steps remain the same until the last sentence.) Remove from the hot plate and filter through double filter paper (Whatman No. 41 over No. 40 filter paper or equivalent) into a 100 mL volumetric flask.

Replace Section 6.2.2 with the following:

6.2.2. Wash the filter paper 10 times with hot distilled H_2O, being careful not to lift the paper away from the funnel surface. Finally, left the filter paper carefully from the funnel and wash the outside surface of the paper with hot distilled H_2O; then wash the tip of the funnel. The final volume of the filtered solution should be slightly less than 100 mL. Allow to cool to room temperature in an HCl fume-free atmosphere. Dilute to the mark with distilled water.

4.17 NDT T 290 Determination of Water-Soluble Sulfate Ion Content in Soil

NDT T 290 is identical to **AASHTO T 290 Method A** except for the following provisions:

Replace Sections 13.2 through 13.3 with the following:

> 13.2. Add 300 mL of distilled water. Stopper and shake vigorously for 30 seconds. After one hour repeat shaking. Allow to stand overnight.
>
> 13.3. Filter the sample by vacuum filtration through a 0.45-micron membrane filter.

Remove Section 13.9.

4.18 NDT T 291 Determination of Water-Soluble Chloride Ion Content in Soil

NDT T 291 is identical to **AASHTO T 291 Method A** except for the following provisions:

Replace Section 13.1 with the following:

13.1. Weigh 100 g of soil into a 500 mL Erlenmeyer flask. Add 300 mL of distilled water. Stopper and shake vigorously for 20 seconds. After one hour repeat shaking. Allow to stand overnight. Filter the sample by vacuum filtration through a 0.45-micron membrane filter.

Replace Section 13.2.1 with the following:

13.2.1. Check the pH with a meter. If the pH is in the range of six through eight, proceed immediately to the step in Section 13.2.2. If the pH is below six, add sodium carbonate or calcium carbonate to adjust to the above range; if the pH is above 8, add nitric acid to adjust to the above range.

4.19 NDT C 114 Alkali Content in Water

NDT C 114 is identical to **ASTM C 114** except for the following provisions:

Begin procedure at 19.2.1.2 and replace with:

19.2.1.2. Transfer a 100-mL aliquot of the sample using a pipette to a 250-mL beaker. Evaporate to about 70 mL on a hot plate. Add 1 mL HCl and transfer to a 100-mL volumetric flask. Rinse the beaker with water into the flask to ensure the entire sample is transferred. Dilute to the mark. Pipette 10 mL of this solution, 10 mL of 1000 ppm Lithium Reference Standard Solution, and 8 mL of $CalCl_2$ stock solution into another 100-mL volumetric flask. Dilute to volume. Prepare 0 ppm and 25 ppm standard solutions in accordance with flame photometer manufacturers' instructions. Determine Na_2O and K_2O by flame photometer using manufacturers' instructions.

4.20 NDT T 290 Determination of Water-Soluble Sulfate Ion Content in Mixing Water

NDT T 290 is identical to **AASHTO T 290 Method A** except for the following provisions:

Remove Sections 13.1 and 13.2.

Replace Section 13.3 with the following:

13.3. Filter the sample by vacuum filtration through a 0.45-micron membrane filter.

Remove Section 13.9.

4.21 NDT D 512 Standard Test Method for Chloride Ion in Water

NDT D 512 is identical to **ASTM D 512** except for the following provisions:

Reagent Section 18

Replace Section 18.4 with the following:

18.4. *Standard Solution, Silver Nitrate (0.03 N)* - Dry silver nitrate crystals at 40°C. Dissolve 5.1 g of the dried crystals in water and dilute to 1 L. Standardize against the 0.01 N NaCl standard solution to determine the exact normality.

4.22 NDT Clear Roads Method 1 Percent Calcium Chloride

NDT Clear Roads Test Method 1 is identical to Clear Roads Test Method 1 except for the following provisions:

Replace Section 3.2.(2) Calcium b.i. with the following:

i. Pipet aliquots of 2.0, 2.5, and 3.0 mL of the above 100 ppm Calcium solution into three separate 100 mL volumetric flasks.

Replace Section 3.2.(2) Quality Control Solutions a.ii. with the following:

ii. Add 1 mL of concentrated HNO_3 and dilute to volume with distilled water. From this solution, pipette 1.0 mL into a 100 mL volumetric flask, add 5 mL of the 10% Lanthanum Chloride solution and bring to volume with distilled water. This will be the working Quality Control Standard and have a value of 27.10 ppm Calcium. (Note: The 27.10 ppm Calcium concentration is equal to a 30% brine concentration of Calcium Chloride based on a 2.5-gram sample size.)

Replace Section 3.2.(3)b.i. with the following:

i. Pipette 0.5 mL of Solution A into a 100 mL volumetric flask.

Replace Section 3.2.(3)b.ii. with the following:

ii. Add 5 mL of 10% Lanthanum Chloride solution and dilute to volume with distilled water. Label as Solution B (Dilution factor of 200).

Replace Section 3.2.(4)a.ii. with the following:

ii.Calibrate the instrument using the blank, 2.0 ppm, 2.5 ppm, and 3.0 ppm standards for Calcium.

Replace Section 3.2.(5)i. with the following:

$$Factor = \frac{(110.99)(1)(200)(500)}{(40.08)(10{,}000)(10)}$$

Where:

110.99 = mol. weight of $CaCl_2$, g/mol

1 = 1%

200 = Solution dilution factor

500 = Initial volume, mL

40.08 = mol. weight of Ca, g/mol

10,000 = 10,000 ppm

10 = Instrument dilution factor

$$\%CaCl_2 = \frac{(X)(2.7692)}{W}$$

Where:

X = ppm from AA readings

W = Mass of sample, g

2.7692 = factor

4.23 NDT Clear Roads Method 1 Percent Magnesium Chloride

NDT Clear Roads Test Method 1 is identical to Clear Roads Test Method 1 except for the following provisions:

Replace Section 3.2.(2) Magnesium b.i. with the following:

i. Pipet aliquots of 1.0, 1.5, and 2.0 mL of the above 100 ppm Magnesium solution into three separate 100 mL volumetric flasks.

Replace Section 3.2.(2) Quality Control Solutions b.iii. with the following:

iii. From this solution, pipette 1.0 mL into a 100 mL volumetric flask, add 5 mL of the 10% Lanthanum Chloride solution and bring to volume with distilled water. This will be the working Quality Control Standard and have a value of 18.00 ppm Magnesium.

Replace Section 3.2.(3)b.i. with the following:

i. Pipette 0.5 mL of Solution A into a 100 mL volumetric flask.

Replace Section 3.2.(3)b.ii. with the following:

ii. Add 5 mL of 10% Lanthanum Chloride solution and dilute to volume with distilled water. Label as Solution B (Dilution factor of 200).

Replace Section 3.2.(4)b.ii. with the following:

ii. Calibrate the instrument using the blank, 1.0 ppm, 1.5 ppm, and 2.0 ppm standards for magnesium.

Replace Section VII with the following:

$$Factor = \frac{(95.211)(1)(200)(500)}{(24.305)(10{,}000)(10)}$$

Where:

95.211 = molec. weight of $MgCl_2$, g/mol
24.305 = molecular weight of Mg, g/mol
1 = 1%
10,000 = 10,000 ppm
200 = Solution dilution factor
10 = Instrument dilution factor
500 = Initial volume, mL

$$\%MgCl_2 = \frac{(X)(3.9173)}{W}$$

Where:

X = ppm from AA readings
3.9173 = factor
W = Mass of sample, g

4.24 NDT C 25 Gravimetric Determination of Calcium Oxide in Aggregate

NDT C 25 is identical to **ASTM C 25** except for the following provisions:

Replace Sections 16.4 with the following:

16.4 Procedure:

16.4.1. Weigh 1 g of sample in a 400 mL beaker with a glass stir rod and watch glass cover. Add 50 mL of H_2O and mix well. Add 15 mL of concentrated HCl and boil for about 5 minutes on the hot plate in the hood. Dilute to 100 mL with hot H_2O and heat to boiling again. Add a few drops of methyl red indicator. Add NH_4OH until the solution becomes yellow. Add a few extra drops of methyl red and a few extra drops of NH_4OH in excess. Put the solution on a steam bath. The water for the steam bath should be at a temperature of ~200°F. The watch glass cover should be replaced by a ribbed watch glass cover. Leave solution on the bath for 1 hour. Filter through #42 filter paper into a 250 mL beaker if a precipitate is present. Wash with hot 2% NH_4Cl. **NOTE: The filter paper and precipitate can be disposed.**

16.4.2. Heat to boiling and slowly add 35 mL of saturated ammonium oxalate solution. If the solution turns pink, add a few drops of NH_4OH. Continue to boil for 2-3 minutes and then let the precipitate settle for 30 minutes just under boiling. Filter through #42 filter paper, police the beaker and wash with five 10-mL portions of cold 0.1% solution of ammonium oxalate. Ignite the precipitate slowly and without a flame in a tared platinum crucible with a lid using a Bunsen burner. When the ashes turn white the crucible can be placed in the furnace set at 1000°C.

4.25 NDT D 4956 Testing of Retroreflective Sheeting

NDT D 4956 is identical to **ASTM D 4956** except for the following provisions:

Replace Section 7.4.2.2 with the following:

7.4.2.2. “If the measurement geometry is uniplanar, then four measurements shall be made on the same specimen at 0° and 90° each, and the measurement values shall be taken as averages.”

Replace Section 7.6 with the following:

7.6. *Outdoor Weathering* – Conduct outdoor exposures in accordance with Practice G7. During exposure, test panels shall be open backed and oriented at an angle of 45° from the horizontal and facing the equator in accordance with Practice G7. “Expose one panel per color for the number of months specified in Table 12.” Panel labeling, and conditioning and handling of panels prior to exposure and during evaluation periods shall be in accordance with Practice G147.

Remove the following from Section 7.6.2:

“After washing and drying, condition the panels at room temperature for at least 2 h prior to conducting any property measurements.”

Replace Section 7.6.3 with the following:

7.6.3. *Measurement of Coefficient of Retroreflection* – After panels have been washed and dried in accordance with 7.6.2, measure retroreflectance at 0.2° observation and -4° and 30° entrance angles. “Report the average of the coefficient of retroreflection measured at each geometry.”

5. Physical Test Methods

6. Portland Cement Concrete Test Methods

6.1 NDT C 1074 - Standard Practice for Estimating Concrete Strength by the Maturity Method

NDT C 1074 is identical to **ASTM C 1074** except for the following test method provisions:

1. In addition to Alternative devices under Section 7.2 is a *digital handheld thermometer* to monitor the concrete temperature.

Substitute Section 8 .1 Prepare at least 15 cylindrical specimens according to practice C 192\C192M with

Cast a minimum of ten (4 in. x 8 in.) concrete cylinders as per ASTM C 31.

Substitute Section 8.3 Moist cure specimens in a water bath or in a moist room meeting the requirement of specification C 511 with

- *Cure the cylinders accordingly at the test site for Summer and Winter conditions.*
- *Cylinders cast for paving or structures may be cured in an insulated container, container covered with curing blankets, in a temperature-controlled trailer (Figure 1.). Cylinders cast for Pavement Repair (PR) and High Early (HE) concrete shall be cured in an insulated box until the time of compressive strength testing.*

Figure 1. Curing Method Examples

6.2 NDT S 01 Method of Sampling Portland and Interground/Blended Cements

1. SCOPE

1.1. The following methods cover the procedures for sampling Portland Cement and Blended Cements.

2. SUMMARY OF SAMPLING METHOD

2.1. A sample of Portland Cement may be sampled from a bulk shipment of rail road car, or truck, or from the batch plant silo.

3. SIGNIFICANCE AND USE

3.1. Sampling is equally as important as the testing, and the sampler must use every precaution to obtain samples that will show the true nature and condition of the materials that they represent.

4. APPARATUS

4.1. When sampling, care shall be taken to prevent contamination of the sample. The following methods are allowed by NDOT- Materials & Research Division for Sampling of Portland Cement and Blended Cements.

4.1.1 Obtain samples of cement using a probe sampler (Figure 1). It shall be between 5 and 6 feet long and approximately 1 3/8 inch in outside diameter and consist of two polished brass telescopic tubes with registering slots that are opened or closed by rotation of the inner tube, the outer tube being provided with a sharp point to facilitate penetration. Take samples from well-distributed points and various depths of the cement so that the samples taken will represent the cement produced.

Figure 1. - Probe Sampler for Bulk Cement

4.1.2 Obtain samples of cement using a shoveling device (Figure 2) from bulk shipment of rail car or truck. The sample may be obtained from the delivery vehicle or rail car. When sampling from the delivery vehicle or rail car, the sample may be obtained from the top hatch openings of a full load. The sample shall be taken at different points and below the surface material.

Figure 2. - Shoveling Device

4.1.3 The sample maybe obtained midstream while the material is being unloaded from the truck by a device as shown in Figure 3. The device allows the continuous flow of material to the cement silo. A sample can be taken at any time during the delivery of the material.

Figure 3.

4.1.4 From Batch Plant Silo – The sample may be obtained from the scale hopper or by discharge as equipment will permit. Sampling from batch plant silos should only be done as a last resort when the identity of the material sample deems it necessary.

5. TEST SPECIMENS

5.1. Sample size and sample protection – As samples are taken, they shall be placed directly in moisture-proof, airtight, containers to avoid moisture absorption and aeration of the sample. Containers shall be completely filled and sealed immediately. A 10 pound sample shall be placed in a water proof bag and protected by a one gallon metal container, cotton duck bag (aggregate sample bag) or by other means.

5.2. Sample Identification – As samples are taken, they shall be identified before the sample is submitted to NDOR personnel. The sample bags must include the following:

- Name and Location of the producing cement mill
- Name and Location of Sample was taken (Project Number, Terminal Location, Ready mix Plant Name/Location)
- Date Sample was taken
- Railroad car or truck identification number
- Brand and type of cement

5.3. Sample according to the frequency in the Material Sampling Guide. The sample shall be taken by a Contractor's Certified Portland Cement Sampler and under the supervision of NDT certified personal.

CERTIFICATION OF PORTLAND & INTERGROUND/BLENDED CEMENT SAMPLING

To become CERTIFIED as a Portland Cement Sampler, the individual will review the Method of Sampling Portland Cement and Blended Cements, and demonstrate understanding of the procedures in the presence of a Certified & Trained NDOT Representative.

This document represents that I have reviewed and sampled with a NDOT Representative present and understand the following statements:

1. The sample of material must represent as nearly as possible the true nature and condition of the sample.
2. An NDT approved sampling apparatus will be used while sampling cementitious materials.
3. The 10 pound sample shall be free of contaminants and placed in a moisture proof, airtight container.
4. The sampler will document on the specimen container the required NDOT information.

Printed Name of Individual Sampling Cement	Signature Individual Sampling Cement	Date of Certification

Printed Name of Organization

Printed Name of NDOT Representative	Signature of NDOT Representative	Date of Certification

Note: The QA Manager will send this form to the Materials and Research Division SiteManager Section Staff upon completion.

7. Soils Test Methods

7.1 NDT T 205 Density of Soil in Place by the Rubber Balloon Method

ASTM Designation: D 2167-66

2. SCOPE

2.1. This method covers the determination of the density in-place of compacted or firmly bonded soil using a rubber-balloon apparatus. The apparatus described in

Section 3, however, is not suitable for very soft soil which will deform under slight pressure or in which the volume of the hole cannot be maintained at a constant value.

2.2. The following applies to all specified limits in this standard: For the purpose of determining conformance with these specifications, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding-off method of AASHTO R 11, "Recommended Practice for Indicating Which Places of Figures are to be Considered Significant in Specified Limiting Values".

3. APPLICABLE DOCUMENTS

3.1. AASHTO Standards:

T 180	"Moisture-Density Relations of Soils using a 10-lb. (4.54 kg) Rammer and an18-in. (457 mm) Drop"
M 231	"Weighing Devices used in the Testing of Materials"
T 99	"Moisture-Density Relations of Soils using a 5.5-lb. Rammer and a 12-in. Drop"

4. APPARATUS

4.1. **Calibrated Vessel** - A calibrated vessel designed to contain a liquid within a relatively thin, flexible, elastic membrane (rubber balloon) for measuring the volume of the test hole under the conditions of this method (See Figure 1). The apparatus shall be equipped so that an externally controlled pressure or partial vacuum can be applied to the contained liquid. It shall be of such weight and size that it will not cause distortion of the excavated test hole and adjacent test area during the performance of the test. Provision shall be made for placing weights (surcharge) on the apparatus. There shall be a volume indicator for determining to the nearest 6.0 cc any change in volume of the test hole. The flexible membrane shall be of such size and shape as to fill the test hole completely without wrinkles or folds when inflated within the test hole, and its strength shall be sufficient to withstand such pressure as is necessary to ensure complete filling of the test hole.

NOTE: *The description and requirements given in 3.1 are intended to be nonrestrictive. Any apparatus using a flexible (rubber) membrane and liquid that can be used to measure the volume of a test hole in soil under the conditions of this method to an accuracy within 1.0 percent is satisfactory.*

4.2. **Balances** - Balances conforming to the requirements of AASHTO M 231, Classes G 20 and G 2.

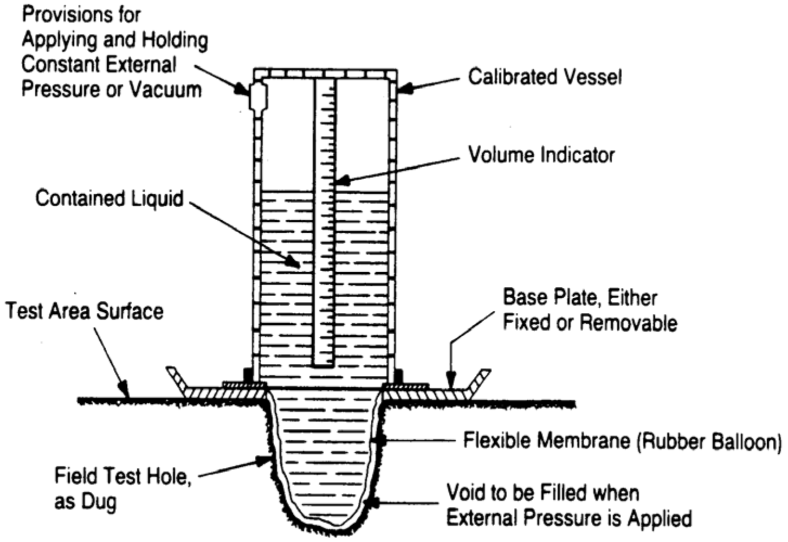


Figure 1 – Schematic Drawing of Calibrated Vessel Indicating Principle

4.3. **Drying Apparatus** - A stove, oven, or other apparatus proven suitable for drying soil or moisture samples.

4.4. **Miscellaneous Equipment** - Small pick, chisels, or spoons for digging test holes; plastic bags, buckets with lids, or other suitable metal containers that can be closed for retaining the soil taken from the test holes; thermometer for determining temperature of water; small paint brush.

5. CALIBRATION CHECK OF VOLUME INDICATOR

5.1. Verify the procedure to be used and the accuracy of the volume indicator by using the apparatus to measure containers or molds of determinable volume that dimensionally simulate test holes that will be used in the field. The apparatus and procedure shall be such that these volumes will be measured to within 1.0 percent. Containers of different volumes shall be used so that the calibration of the volume indicator covers the range of anticipated test hole sizes.

NOTE: *The 4- and 6-inch molds described in AASHTO T 180 and in NDT T 99, or other molds prepared to simulate actual test holes may be used. Where several sets of apparatus are used, it may be desirable to cast duplicates of actual test holes. These sets should represent the range of sizes and irregularities in the walls of test holes that will be encountered. These fabricated holes can be used as standards for the calibration check of the volume indicator. This can be accomplished by forming plaster of Paris negatives in the test holes and using these as forms for Portland cement concrete castings. After removing the plaster of Paris negative from the concrete casting, the inside surface of the fabricated holes should be sealed watertight, and their volume determined as indicated in Section 4.*

5.1.1 **Volumes of Containers** - Determine the mass of water, in grams, required to fill one of the containers. Slide a glass plate carefully over the top surface of the container in such a manner as to ensure that the container is filled completely with water. Determine the temperature of the water in the container. A thin film of cup grease smeared on the top surface of the container will make a watertight joint between the glass plate and the top of the container. Compute the volume of the container in cubic centimeters.

NOTE: *Compute the volume of the container in cubic centimeters. This is done by multiplying the weight of the water, in grams, used to fill the container by the unit volume of water, in milliliters* *per gram, at the observed temperature, taken from Table I. Repeat this procedure until three values are secured for the volume of the container having a maximum range of variation of 2.8 cubic centimeters. (Since one milliliter is equal to 1.000027 cc and one gram of water at approximately 20 C (68 F) occupies a volume of 1.00177 cc, within the limits of accuracy of the equipment used, these units can be assumed to be equal and for the purpose of computation can be used interchangeably.)*

5.1.2 **Calibration Check Test** - Place the rubber-balloon apparatus on a relatively smooth horizontal surface and take an initial reading on the volume indicator. Transfer the apparatus to one of the containers and take the reading on the volume indicator when the rubber balloon completely fills the container. Apply pressure to the liquid in the apparatus until there is no change indicated on the volume indicator. Note and define, in repeatable terms, the pressure applied. It will usually be necessary to add mass (surcharge) or other force to the apparatus to prevent it from rising. Note and record the total amount of mass or define, in repeatable terms, the force added. The difference between the initial and final readings of the volume indicator is the indicator volume value for the container. The membrane may be withdrawn from the container by applying a partial vacuum to the liquid in the apparatus. Repeat the procedure for the other containers.

NOTE: *If the calibration container or mold is airtight, it may be necessary to provide an air escape, since the rubber membrane can entrap air within the container and cause an erroneous volume measurement. After the volume of the container has been determined with water and prior to the insertion of the rubber balloon, small air escape-holes may be provided by placing lengths of small-diameter string over the edge of the container and down the inside wall slightly beyond the bottom center. This will permit air leakage during the filling of the container with the membrane. If such a procedure is necessary in the laboratory, it may be necessary to use a similar procedure on tightly bonded soil in the field.*

Before any measurements are made, it may be necessary to distend the rubber balloon and remove air bubbles adhering to the inside of the membrane by kneading.

In field tests, the additional weights (surcharge) will increase the stress in the unsupported soil surrounding the test hole and will tend to cause it to deform. The stress may be reduced by using a base plate.

TABLE I

Volume of Water Per Gram Based on Temperature[a]

Temperature		Volume of Water, ml per g
Centigrade	Fahrenheit	
12	53.6	1.00048
14	57.2	1.00073
16	60.8	1.00103
18	64.4	1.00138
20	68.0	1.00177
22	71.6	1.00221
24	75.2	1.00268
26	78.8	1.00320
28	82.4	1.00375
30	86.0	1.00435
32	89.6	1.00497

[a] Values other than shown may be obtained by referring to Handbook of Chemistry and Physics, Chemical Rubber Publishing Co., Cleveland, Ohio.

***6.* PROCEDURE -** *Refer to Figure 2*

6.1. Prepare the surface of the test hole site so that it is reasonably plane. Set the apparatus on the test hole site and take an initial reading on the volume indicator of the calibrated vessel using the same pressure on the liquid in the vessel and the same amount of surcharge weight as was used in the calibration check. After taking this initial reading on the volume indicator, scribe the outline of the apparatus on the test hole site. Make notes of the pressure used, record the amount of the surcharge and the initial volume reading. If the apparatus was calibrated with a base plate, the base plate shall remain in place throughout the field test.

6.2. Remove the apparatus from the test hole site and dig a hole centered within the outline scribed for the apparatus. Exercise care in digging the test hole so that soil around the top edge of the hole is not disturbed. Place all the soil removed from the test hole in an airtight container for mass and moisture content determinations. The test hole shall be of the minimum volume shown in Table II. Larger holes will provide improved accuracy and shall be used when practicable. The dimensions of the test hole are related to the apparatus design and the pressure used. In general, the dimensions shall approximate those used in the calibration check procedure.

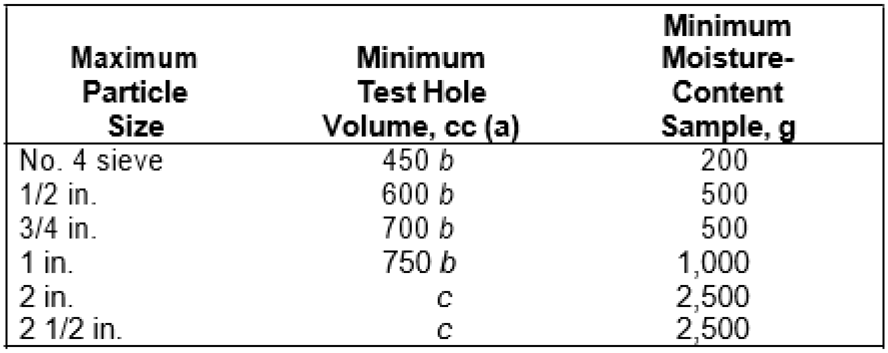
6.3. After the test hole has been dug, place the apparatus over the test hole in the same position used for the initial reading and inflate the flexible membrane in the hole. Apply the same surcharge mass and pressure on the liquid in the vessel as used and recorded during the calibration check procedure. Take and record the reading on the volume indicator. The difference between this reading and the initial reading obtained in 5.1 is the volume of the test hole.

NOTE: *Attention is called to instances in weak soils where the pressure applied to the liquid in the vessel can deform the test hole to such an extent as to give an erroneous volume. In such instances, the apparatus shall be modified and recalibrated using less surcharge weight and pressure on the liquid in the vessel, or it may be necessary to resort to another method.*

TABLE II

Minimum Field Test Hole Volumes and Minimum Moisture Content Samples

Based on Maximum Size of Particle



Maximum Particle Size	Minimum Test Hole Volume, cc (a)	Minimum Moisture-Content Sample, g
No. 4 sieve	450 *b*	200
1/2 in.	600 *b*	500
3/4 in.	700 *b*	500
1 in.	750 *b*	1,000
2 in.	*c*	2,500
2 1/2 in.	*c*	2,500

6.3.1 The type of rubber-balloon volume measures used by the Nebraska Department of Transportation does not have the capacity for measuring volumes greater than approximately 900 cc, without rupturing the rubber membrane. Therefore, care should be taken that the volume of the hole is not larger than this.

6.3.2 If the thickness of the layer being tested is such that the minimum volume cannot be obtained, the volume of the test hole should represent the entire layer and may be smaller than the recommended size.

6.3.3 If in-place density tests are required in material having these gradations, another method shall be used to determine the volume.

6.4. Determine the weight of all the moist soil removed from the test hole, mix this material thoroughly, select a moisture-content sample in accordance with Table II, determine its wet weight, then dry it to substantially constant weight, and determine the dry weight. The drying temperature shall be such that the material is not overheated. Overheating may remove material other than moisture, causing an erroneous moisture reading.

7. CALCULATIONS

7.1. Calculate the moisture content, w (expressed as a percentage of the weight of the dry soil), of the soil as follows:

$$w = (\text{weight of moisture}) / (\text{weight of dry soil}) \times 100$$

7.2. Calculate the volume, wet and dry density of the soil as follows:

$$V = V_2 - V_1$$

where:

V_1 = Volume measure initial reading, cubic centimeters

V_2 = Volume measure final reading, cubic centimeters

V = Volume of hole, cubic centimeters

W = Weight of wet soil taken from test hole, grams

DW = Wet density, g/cc

D = Dry density, g/cc

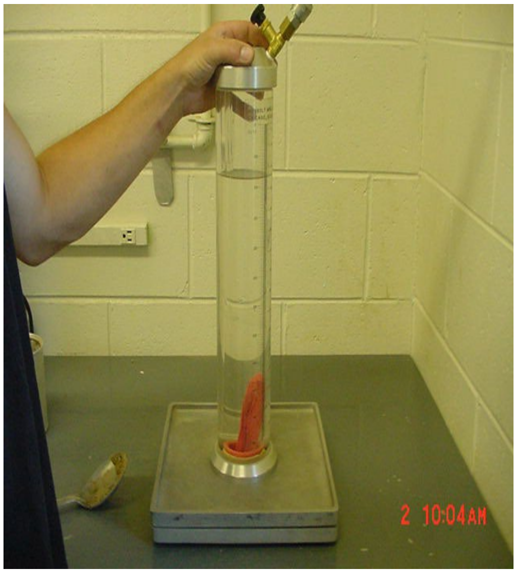
w = Moisture content of sample expressed as a percentage of the weight of the dry soil.

8. REPORT

8.1. The moisture content shall be reported to one decimal place. The dry density shall be reported in grams per cubic centimeter (g/cc) to two decimal places.

Figure 2 – Volume Determination – Rubber Balloon Method

After initial reading has been taken, dig the density hole using the field density plate as a template.



Pumping the balloon into the density hole. Operator takes reading at lowest point on the graduated cylinder.

Replacing the actuator bulb in the quick coupler changing from a pressure operation to a vacuum operation, pump water and balloon back into the cylinder.

7.2 NDT T 238 Standard Test Methods for in Place Moisture Density of Soils by Nuclear Method

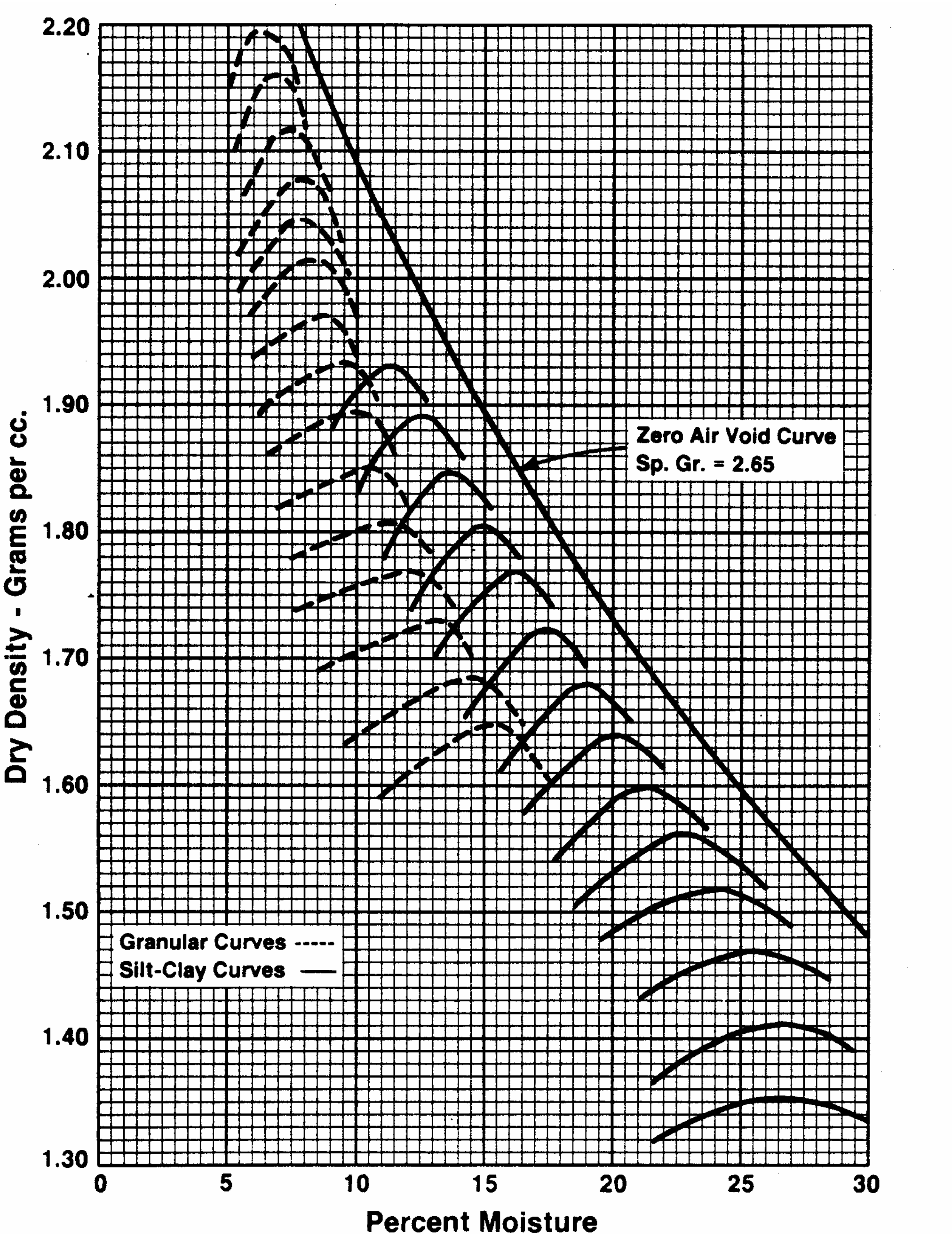
1. SCOPE

1.1. Follow AASHTO T 310 to determine moisture density of soils.

7.3 NDT T 505 Moisture Density Relations of Soils Using the One Point Method

NDT T 505 is identical to **AASHTO T 272** except for the following provision:

Replace Figure 1-Example of Curves with the following:



TYPICAL MOISTURE-DENSITY CURVES

Based on AASHTO T-99

7.4 NDT T 2835 Deflection Measurement of Soils Using a Lightweight Deflectometer (LWD)

ASTM Designation: E 2835

1. SCOPE

1.1. This method covers the measurement of soil deflection by use of a type of plate-bearing test. A force is generated by a falling weight dropped onto a plate which is resting on the material to be tested.

1.2. The falling weight is raised to a preset height of 720 mm (28 in.). When dropped, the weight will apply the required force pulse. The weight is dropped, and the resultant surface deflection is measured using the LWD's instrumentation.

1.3. The deflection values resulting from the applied force at each test location is recorded in millimeters, or as appropriate.

1.4. The drop height of the falling weight is fixed and shall not be changed by the user.

2. EQUIPMENT

The LWD consists of the following components (See Figure 1).

1. Handle Grip

   Used to hold the LWD guide rod vertical and to limit upward movement of the falling weight. Note, there is a bubble level at the top to help hold the guide rod plumb.

2. Release Mechanism

   Holds the falling weight at a constant height and when the release mechanism is pressed, allows the falling weight to drop freely.

3. Guide Rod

   Allows the falling weight to drop freely the required distance of 720 mm (28 in.).

4. Falling Weight Grip

   Provides a grip for the operator to catch the falling weight after it impacts the plate and to raise the falling weight to the top release mechanism.

5. 10-kg Falling Weight

   Is manually raised to the bottom of the grip and held in place with the release mechanism.

6. Lock Pin

   When pushed in the pin keeps the weight from moving up the guide rod during storage and transport. When pin is pulled the weight is free to move up and down the guide rod.

7. Steel Spring

   Provides a buffer system that transmits the load to plate resting on the material being tested. The steel spring is protected by a sealed rubber boot.

8. Anti-Tipping Fixture

   Prevents the guide rod and falling weight from tipping when standing freely on the load center ball.

9. Load Center Ball

   Serves as a connector between the anti-tipping fixture and the loading plate.

10. Carry Grip

   Provides handles for easier carrying of the loading plate by the operator.

11. Loading Plate

   Provides an approximate uniform distribution of the load applied from the falling weight to the surface being tested. Loading plate has a diameter of 300 mm (11.8 in.).

12. Cable

   Used to connect the loading plate sensor to the recording and storage instrument.

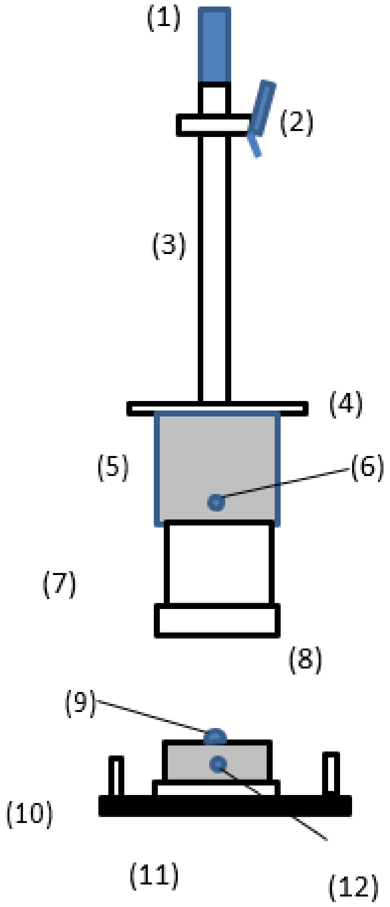


Figure 1. LWD individual components.

13. Measuring Instrument

   Data processing device that records, displays, and stores deflection data (See Figure 2).

Figure 2. Hand-Held Measuring Instrument

3. STANDARDIZATION

3.1. Repeatability testing shall be performed:

- 3.1.1 Upon receipt of a newly purchased device.
- 3.1.2 Prior to recommissioning a device after calibration.
- 3.1.3 When measurements are questionable or are no longer repeatable.
- 3.1.4 Annually or after 10,000 test measurements.

4. REQUIREMENTS

4.1. Designate a test pad location at the office or location in which the device is being stored that is bare, sound concrete with a minimum thickness of 6 inches.

4.2. Using the load plate as a template mark the circular location of the test pad area for future reference of the test pad location.

4.3. Position the loading plate on the prepared test surface.

4.4. Place the upper portion of the LWD (falling weight and guide rod) on top of the loading plate, using the load center ball as a guide.

4.5. Plug in chord from the hand-held measuring instrument into load plate and turn on measuring instrument.

4.6. Press “OK” to start measurements. Turn off Pre-Load Settings[1].

4.7. Perform 9 falling weight drops using the following procedure for each drop:

- a. Raise the falling weight to the preset drop height and snap falling weight into the release mechanism.
- b. Adjust guide rod to plumb, using the bubble level as a guide.
- c. Release the falling weight, allowing it to free-fall.
- d. Catch the falling weight after it rebounds off the load plate.
- e. Snap weight into release mechanism.[2]

[1]**Note:** *Refer to LWD Repeatability Form.*

[2]**Note:** *Record deflection measurements after drops 1 through 9.*

4.8. Use the following calculations to determine the repeatability of deflection measurements:

a. $S_{max} - S_{min} < 0.04$ mm

i. S_{max}= max of (S_1,S_2,S_3,S_4,S_5 ,S_6,S_7,S_8,S_9)

ii. S_{min}= min of (S_1,S_2,S_3,S_4,S_5 ,S_6,S_7,S_8,S_9)

iii. Definitions:

S_{max} = maximum deflection measurement, mm.

S_{min} = minimum deflection measurement, mm.

b. $|S_{mean} - S_i| < 0.02$ mm

i. S_{mean} = average deflection for tests (S_1,S_2,S_3,S_4,S_5 ,S_6,S_7,S_8,S_9)

ii. S_i = deflection measurements for drop *i* (where *i* = 1 to 9)

4.9. Repeat testing on test pad when the calculations in step 8 are not met. This step is taken to remove operator errors or extraneous factors, if any, that may have caused non-repeatable results.

4.10. Submit device for calibration when the calculations in step 8 are still not met after repeat testing.

5. TESTING CONSTRAINTS

5.1. Perform tests immediately after compaction.

5.2. Perform testing in an air temperature range of 32 to 120 degrees Fahrenheit.

5.3. Ensure soil is not frozen.

6. SITE TESTING LOCATION AND PREPARATION

6.1. Create a smooth and level spot that allows the LWD guide rod to remain vertical and prevents the loading plate from sliding during testing.

6.2. Prepare a test area that is 1.5 times larger than the diameter of the loading plate (1.5-ft square).

6.3. Remove any disturbed material and any additional material as necessary to expose the top of the material to be tested.

6.4. Position the loading plate on the prepared test surface. Using the loading plate handles, turn the loading plate left and right to help seat the plate.

6.5. Place the upper portion of the LWD (falling weight and guide rod) on top of the loading plate, using the load center ball as a guide.

6.6. Plug in chord from the hand-held measuring instrument into load plate and turn on measuring instrument.

6.7. Press “OK” to start measurements.

6.8. Perform six falling weight drops using the following procedure for each drop:

a. Raise the falling weight to the preset drop height and snap falling weight into the release mechanism.

b. Adjust guide rod to plumb, using the bubble level as a guide.

c. Release the falling weight, allowing it to free-fall.

d. Catch the falling weight after it rebounds off the load plate.

e. Snap weight into release mechanism.[1,2]

[1]**Note:** *Record deflection measurements after the 4th, 5th, and 6th drops and the average deflection after the sixth drops. The device automatically saves the data to the memory card.*

[2]**Note**: *Press "OK" after test is complete to view the average test result.*

6.9. Write down LWD test number from measurement device (result #) and record all pertinent information onto LWD field Test Form.

6.10. Repeat deflection measurements at another location (move approximately 1.5-ft longitudinally) when the following conditions occur during the test:[3]

a. The falling weight is not caught after rebound.

b. The load plate slides.

c. The falling weight is not dropped from the calibrated height.

[3]**Note:** *A faulty test cannot be repeated at the same location.*

6.11. Obtain the moisture content sample from approximately 3 to 9 inches below the surface of the LWD test location. Perform moisture content test using either the burner/stove, hot-plate, speedy, microwave, or oven-dry method. Record the moisture content on the LWD Field Test Form.

7. SAFETY

7.1. Keep back straight and lift with legs to help prevent injury when elevating and dropping the falling weight.

7.2. Keep hands and extremities from beneath the falling weight or load plate to avoid injury.

7.3. Secure falling weight into lower position with lock pin prior to transport to prevent injury from movement of the falling weight.

8. MAINTENANCE AND HANDLING

8.1. Inspect equipment for necessary repairs. Ensure rubber boot around steel spring provides a tight seal.

8.2. Store LWD in dry place when not in use.

8.3. Make sure guide rod is not directly resting on soils.

8.4. Clean the LWD by removing any dirt with a dry cloth or with compressed air. Do not use grease or oil on the guide rod.

8.5. Check the drop height to ensure that slippage of the release mechanism has not occurred. If slippage has occurred, correct the drop height and tighten setscrews on release mechanism.

8.6. Recharge battery after 3 to 12 hours of use or at 3-month intervals when not in use.

8.7. Charge or replace the battery when charging level is less than 50 percent.

9. CALIBRATION

9.1. Calibrate the force generation device and deflection sensor as recommended by the Manufacturer, when deflection measurements are no longer repeatable, or after 10,000 measurements, whichever comes first.

7.5 NDT T 587 Standard Test Methods for Density of Bituminous Concrete in Place by Nuclear Method

1. SCOPE

1.1. This test method describes a test procedure for determining the density of bituminous concrete by the attenuation of gamma radiation where the source and detector remain on the surface. (Backscatter Method)

2. APPLICABLE DOCUMENTS

2.1. ASTM Standards:

D 2950	"Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods."
AASHTO 166	"Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens."
AASHTO T 209	"Maximum Specific Gravity of Bituminous Paving Mixes"

2.2. NDT Standards:

NDTT 572	"Selection of Sampling Locations of Asphaltic Concrete."

3. PROCEDURE

3.1. Turn the nuclear gauge on for 10 minutes (15 minutes in cold weather) prior to use to allow it to stabilize and leave power on during the day's testing.

3.2. Standardize the nuclear gauge at the start of each day's work according to manufacturer's recommendations. Keep a permanent record of the standard count.

3.3. Select a test location in accordance with Random Sampling Schedule/NDT T 572. If the nuclear gauge will be closer than 10" (250 mm) to any vertical mass that may influence the result, follow the manufacturer's correction procedure.

3.4. The maximum air void between the nuclear gauge and asphalt surface shall not exceed 1/4" (6 mm). Use 20/40 masonry sand or finer to fill voids and level with scraper plate.

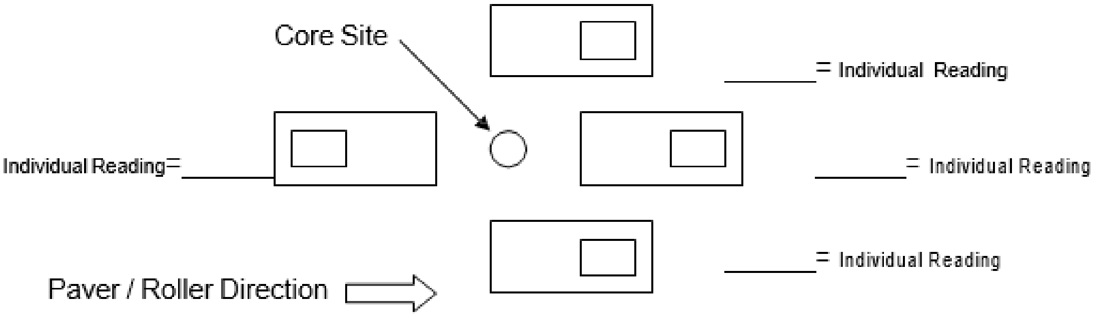
3.5. Use the Backscatter method to take 4 density readings while keeping the gauge turned parallel to the direction of the roller as shown in 3.8 below. The final nuclear density reading shall be the average of the 4 readings. Store all readings internal to the gauge. Mark reading location for possible core correlation.

3.6. The final percent density for a specific location shall be determined by calculations using the Theoretical Maximum Specific Gravity of the mix (Rice), Gmm, for the value of that sublot and the final nuclear reading (the average of 2 taken at 180 degrees of each) of the Nuclear Density Gauge gravity-once the required correction factor (sometimes referred to as offset) has been applied.

Percent Density = (Nuclear Density Gauge Gravity / Gmm) x 100.

3.7. Core first 5 Nuclear Density Gauge density reading locations of each mix type in each lift of each project or when aggregate percentages or sources change. The time between the nuclear gauge readings and corresponding corings shall be held to a minimum. Cut core to lift thickness being measured by gauge. Test core for bulk density per AASHTO 166. Compare core Bulk Specific Gravity, Gmb, with the average of the 4 Nuclear Density Gauge Gravity, readings to manufacturer's measurement specifications. Determine the correction factor if required and enter it into the nuclear gauge memory if possible. Record the correction factor on report of test form. The correction factor shall be verified with another core for every 15 density readings that are to be recorded. The correlation would be considered acceptable if the densities were found to be within 2 lbs/cu.ft., upon which no correction factor is required.

3.8. Procedure for calculating the correction factor(s):



Note: Not to scale, nuclear gauge will be placed directly adjacent to core hole.

lbs./cu. ft.

Nuclear Bulk Specific Gravity (Gmb) in lbs/cu. ft. (average of 4 readings) = __________

Laboratory Gmb of Roadway Core = ___________ x 62.3 = __________

Difference in Density Measurement = __________*

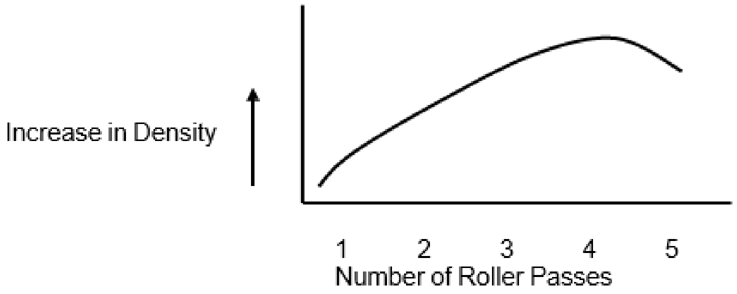
Correction Factor * (also known as offset value input into Nuclear gauge) = __________

3.9. For each reportable and identified density location, after the correction factor has been established and entered in the nuclear gauge, take two nuclear readings at the same location. The Average of the readings will be the reported density for that location.

3.10. ROLLER PATTERN SET-UP

The use of the nuclear gauge to help establish an efficient roller pattern should be considered. It's a very simple procedure that just requires a nuclear reading after each pass of the roller. There is no real need to have the nuclear gauge even calibrated, you just want to detect the changes in relative density.

An example of what you will find:



This example shows that the maximum density is achieved after 4 roller passes. You may want to record the nuclear readings after each pass of the roller and do some follow up readings to see if any changes in the rolling pattern are needed.

Field Report of Nuclear Density Tests for Asphalt

NDOR
Nebraska Department of Roads

Project:		Control No.	
Location:		Report No.	
Type of Work:	☐ Mainline ☐ Shoulder	☐ Parking ☐Temporary	☐ Wedging ☐ Misc.

Gauge Number	Rolling Pattern:

Date					
Lot Number					
Sublot Number					
Mix Type					
Voidless Density					
Req. % of Voidless Density					
Station					
Offset Rt/Lt Centerline					
Thickness					
Lift (Bottom, Top, etc.)					
Density Standard Cnt.					
Density 1					
Density 2					
Average Density					
Correction Factor					
Corrected Density					
% of Voidless Density					
Lot Average					
Pay Factor					
Test Status	Pass/Fail/Deduct Comments:	Pass/Fail/Deduct Comments:	Pass/Fail/Deduct Comments:	Pass/Fail/Deduct Comments:	Pass/Fail/Deduct Comments:

Contractor:		Technician:	
Inspector:		Project Manager:	

Distribution:
Project Manager
District Engineer
Materials & Research Division

Asphaltic Concrete Nuclear Density Correction Factor

NDOR
Nebraska Department of Roads

Project:		Control No.	
Location:			
Gauge No.			

Date					
Lot Number					
Sublot Number					
Mix Type					
Station					
Offset (ft) Lt/Rt of Centerline	☐ Lt ☐ Rt	☐ Lt ☐ Rt	☐ Lt ☐ Rt	☐ Lt ☐ Rt	☐ Lt ☐ Rt
Thickness					
Lift (Bottom, Top, etc.)					
Nuclear Density Readings					
Density Standard Cnt.					
Density 1 (lb/ft^3)					
Density 2 (lb/ft^3)					
Density 3 (lb/ft^3)					
Density 4 (lb/ft^3)					
A) Ave. Nuclear Density					
Bulk Density of Roadway Cores					
B) Weight in Air					
C) S.S.D Weight					
D) Weight in Water					
E) Volume (C - D)					
F) Roadway Core Density (B / E) x 62.3					
Correction Factor Calculation					
Individual Correction Factor (A - F) Show +/-					
Correction Factor (average of 5 above) to be applied to Nuclear Density Readings, only if 2 pcf or larger					

Contractor:	
Technician:	
Inspector:	
Project Manager:	

Distribution: Project Manager
QA Manager
District Engineer
Materials & Research Division

Gage Positioning