FIELD SAMPLING AND TESTING MANUAL

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ND T 2 – SAMPLING OF AGGREGATES

Conduct this procedure according to ND T 2.

The AASHTO standard test procedure has a minimum size of the sample that is to be obtained. NDDOT modification changes the minimum size of the sample to be obtained.

AASHTO identifies a number of ways to collect samples. NDDOT adds an additional procedure to collect samples, which is sampling from a windrow.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test defines the procedures used to obtain samples that will show the nature and condition of the materials which they represent.

REFERENCED DOCUMENTS

AASHTO T 2, Sampling of Aggregates
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size

TERMINOLOGY

Maximum Size of Aggregate – the smallest sieve opening through which the entire amount of aggregate is required to pass.

Nominal Maximum Size – the smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

Maximum Aggregate Size (Superpave) – one size larger than the nominal maximum aggregate size.

Nominal Maximum Aggregate Size (Superpave) – one size larger than the first sieve that retains more than 10% aggregate.
APPARATUS
Containers, pails or bags
Shovel
Scoop or spoon
Brush
Sampling tubes

TEST SPECIMEN

The sample size is based on the type and number of tests to be performed. The following table gives the approximate sample size required for different aggregate sizes.

<table>
<thead>
<tr>
<th>SIZE OF SAMPLE</th>
<th>Nominal Size of Aggregate&lt;sup&gt;A&lt;/sup&gt;</th>
<th>Approximate Minimum Mass of Field Samples&lt;sup&gt;B&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Aggregate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td></td>
<td>25 lbs (10 kg)</td>
</tr>
<tr>
<td>No. 4 (4.74 mm)</td>
<td></td>
<td>25 lbs (10 kg)</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8&quot; (9.5 mm)</td>
<td></td>
<td>8 lbs (4 kg)</td>
</tr>
<tr>
<td>1/2&quot; (12.5 mm)</td>
<td></td>
<td>16 lbs (8 kg)</td>
</tr>
<tr>
<td>5/8&quot; (16.0 mm)</td>
<td></td>
<td>30 lbs (15 kg)</td>
</tr>
<tr>
<td>3/4&quot; (19.0 mm)</td>
<td></td>
<td>44 lbs (20 kg)</td>
</tr>
<tr>
<td>1&quot; (25.0 mm)</td>
<td></td>
<td>88 lbs (40 kg)</td>
</tr>
<tr>
<td>1½&quot; (37.5 mm)</td>
<td></td>
<td>132 lbs (60 kg)</td>
</tr>
</tbody>
</table>

<sup>A</sup> For processed aggregate, use the nominal maximum size as indicated by the appropriate specification or description. If the specification or description does not indicate a nominal maximum size use the maximum size (sieve indicating 100% passing).

<sup>B</sup> For combined coarse and fine aggregates, e.g., base or subbase, the minimum weight shall be the coarse aggregate minimums plus 25 lbs (10 kg).
PROCEDURE

When practicable, samples shall be obtained from the finished product. Sampling requires a number of individual samples that are combined to make a composite sample. Reduce the sample to the required size by quartering or splitting in accordance with ND T 248.

- SAMPLING FROM ROADWAY:

When sampling from the roadway material or in-place, take samples from at least three approximately equal increments across the roadway. Obtain samples from the full depth of the course. Take care to avoid including material from the underlying subgrade or base course. Combine the samples to form a composite sample.

- SAMPLING FROM A FLOWING AGGREGATE STREAM:

Obtain at least three approximately equal increments and combine to form the required size sample. Collect the samples in a pan or by use of a sampling device. Take the samples from the entire cross section as it is being discharged. The receptacle should be of sufficient size to intercept the entire stream and hold the material without overflowing.

- SAMPLING FROM A WINDROW:

Sample the windrow by removing the top one foot of material and obtain part of the sample from each side. Avoid the segregated coarser material at the bottom of the side slope. Combine three samples to form a composite sample.

- SAMPLING FROM A CONVEYOR BELT:

Obtain at least three approximately equal increments and combine to form the required size sample. Stop the conveyor belt and clean off a section of material from the belt. Insert a template that conforms to the shape of the belt. Carefully remove all the material from the template. Use a scoop to remove as much of the material as possible. A brush and dust pan may be used to remove the fine material. Make sure to include all of the fine material. Space the three samples apart.

- SAMPLING FROM A STOCKPILE:

Segregation often occurs when materials are stockpiled. Thus, it is difficult to ensure unbiased samples from stockpiles. For coarse or mixed coarse and fine aggregate, make every effort to enlist the services of power equipment to develop a separate, small sampling pile composed of material from various levels.
and locations in the main pile. Combine several increments to compose the sample.

Where power equipment is not available, combine material from at least three increments; the top third, middle third, and bottom third of the pile. Insert a board vertically into the pile just above the sampling point to aid in preventing further segregation. Remove the outer layer, which may be segregated, and sample the material beneath.

An alternate sampling method is to insert a sampling tube into the pile at a minimum of five random locations to extract material to form a sample. Sampling tubes are approximately 1¼" (minimum) in diameter by 6 ft. (minimum) in length.
ND T 11 - MATERIALS FINER THAN NO. 200 (75 µm) SIEVE IN MINERAL AGGREGATES BY WASHING

Conduct this procedure according to ND T 11.

The AASHTO standard test procedure reports the percentage of material finer than the No. 200 sieve to the nearest 0.1%, except if the result is 10% or more, than it reports to the nearest whole number. The NDDOT modification reports the accuracy to the same significant digit as the specification for the class of aggregate.

Consult the current edition of AASHTO for procedure in its entirety and the equipment specification details.

SCOPE

This test method determines the amount of material finer than the No. 200 sieve in aggregate by washing. Procedure A shall be used unless otherwise specified.

When accurate determinations of material finer than the No. 200 in fine or coarse aggregate are desired, this test method is used on the aggregate sample prior to dry sieving according to ND T 27. The results of this procedure are included in the calculations for ND T 27.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling Aggregates
AASHTO T 11, Materials Finer than No. 200 Sieve by Washing
ND T 27 and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregate
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying

APPARATUS

Balance
Sieves: No. 16 and No. 200
Sample splitter
Oven
Washing container
Spoon
TEST SPECIMEN

Obtain sample according to ND T 2. Thoroughly mix and reduce according to ND T 248.

Test specimen shall be a representative sample based on the following table.

<table>
<thead>
<tr>
<th>Nominal Maximum Size</th>
<th>Minimum Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4 (4.75 mm) or smaller</td>
<td>300 g</td>
</tr>
<tr>
<td>3/8&quot; (9.5 mm)</td>
<td>1000 g</td>
</tr>
<tr>
<td>3/4&quot; (19.0 mm)</td>
<td>2500 g</td>
</tr>
<tr>
<td>1½&quot; (37.5 mm)</td>
<td>5000 g</td>
</tr>
</tbody>
</table>

The sample size required for this test is a minimum after drying.

PROCEDURE

Record all information on SFN 9987 or SFN 2455. Weights are recorded to the nearest 0.1 g.

Oven dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Weigh and record as original weight of sample.

Place the sample into the washing container and add sufficient water to cover. Stir and agitate the sample with the spoon until all fines are in suspension.

Slowly decant the water into the stacked No. 16 and No. 200 sieves being careful not to lose the coarser material of the sample.

Add a second charge of water to the sample in the washing container and stir, agitate, and decant. Repeat this process until the wash water is clear.

Wash any remaining material on the sieve back into the sample. Do not decant any water from the container except through a No. 200 sieve to avoid loss of material. Any remaining water should be evaporated by the drying procedure.

Oven dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Weigh and record as weight after wash.
CALCULATIONS

If this test has been run for the purpose of accurate determination of material finer than the No. 200 in fine or coarse aggregate, the results of this procedure are determined by the calculations for ND T 27 on SFN 9987.

To calculate material passing the No. 200 sieve as percent of the total sample for coarse aggregate for concrete, subtract dry weight after washing from weight of total sample and divide result by weight of total sample. Multiply this result by 100 and record as material passing No. 200 sieve as percent of total sample.

The equation is as follows:

\[ A = \left( \frac{B-C}{B} \right) \times 100 \]

- \( A \) = percent of material finer than No. 200 sieve by washing
- \( B \) = weight of total sample before washing
- \( C \) = weight of dry sample after washing

REPORT

Report the percent of material finer than the No. 200 sieve to the same significant digit as the specification for the class of aggregate.

NOTES

A piece of rubber tubing may be attached to a water faucet and be used to rinse material from the sieves. The velocity of the water, which may be increased by pinching the tubing, should not be sufficient to cause splashing of the sample over the sides of the sieve.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
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ND T 23 - MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD

Conduct this procedure according to ND T 23.

Consult the current edition of AASHTO standard procedure in its entirety and equipment specification details.

SCOPE

This method covers procedures for making, curing, and transporting cylinder or flexural beam specimens made from representative samples of fresh concrete under field conditions.

REFERENCED DOCUMENTS

AASHTO T 23, Making and Curing Concrete Test Specimens in the Field
ND T 141 and AASHTO T 141, Sampling Freshly Mixed Concrete
ND T 309 and AASHTO T 309, Temperature of Freshly Mixed Hydraulic-Cement Concrete
ND T 119 and AASHTO T 119, Slump of Hydraulic Cement Concrete
ND T 152 and AASHTO T 152, Air Content of Freshly Mixed Concrete by Pressure Method
AASHTO M 201, Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

APPARATUS

Cylinder molds
Beam molds
Tamping rods
Internal vibrator
Mallet
Wood float
Trowel
Scoop
Shovel
Sampling and mixing receptacle
Calcium hydroxide storage tank

SAMPLING AND PREPARING CONCRETE SAMPLE

Obtain a concrete sample according to ND T 141. Obtain at least a 1-cu.ft. sample.
Transport the sample to the test specimens molding site and re-mix with a shovel to assure maximum uniformity. Protect the sample from moisture loss from the time the sample is taken to the time it is molded. Do not exceed 15 minutes.

Determine the temperature according to ND T 309, slump to ND T 119 and air content according to ND T 152.

The results of the slump test will determine the method of consolidation. Rod or vibrate concrete with a slump greater than 1" (25 mm). Vibrate concrete with a slump of 1" (25 mm) or less.

MOLDING AND CURING - GENERAL

Mold specimens on a level, rigid, horizontal surface that is free from vibration and other disturbances, and as near as practical to the place where they will be stored for the initial curing period. The supporting surface on which specimens will be stored for initial curing must be level to within 1/4" (6 mm) per foot.

Remix the concrete before molding.

Mold the specimens by placing the concrete in the number of layers indicated by the consolidation method. Move the scoop or shovel around the perimeter of the mold opening to distribute the concrete uniformly. Further distribute the concrete with a tamping rod. Attempt to place the final layer to exactly fill the mold after compaction.

If casting the specimens at the place of initial curing is not practicable, move them to the place of storage immediately after being struck off. Take care to avoid marring the surface when moving the specimen. If cylinders in single-use molds are moved, support the bottom. Immediately refinish if necessary.

PROCEDURE – CYLINDERS:

Consolidation by Rodding:

<table>
<thead>
<tr>
<th>Specimen Type and Size</th>
<th>Number of Layers of Approximately Equal Depth</th>
<th>Number of Insertions per Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Diameter:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4&quot; (100 mm)</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>6&quot; (150 mm)</td>
<td>3</td>
<td>25</td>
</tr>
</tbody>
</table>
Tamping Rod Requirements for Cylinder and Beam Molds:

<table>
<thead>
<tr>
<th>Cylinder Mold Diameter or Beam Width</th>
<th>Tamping Rod Diameter</th>
<th>Tamping Rod Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6&quot; (&lt; 150 mm)</td>
<td>3/8&quot; (10 mm)</td>
<td>12&quot; (300 mm)</td>
</tr>
<tr>
<td>6&quot; (150 mm)</td>
<td>5/8&quot; (16 mm)</td>
<td>20&quot; (500 mm)</td>
</tr>
</tbody>
</table>

Mold the test specimen in layers of approximately equal volume dependent of mold size. Rod each layer with 25 strokes of the tamping rod. Evenly distribute the strokes over the cross section of the mold. Add representative concrete to fill any surface voids during final consolidation.

Rod the first layer throughout its depth. For the following layers, penetrate the underlying layer about 1" (25 mm) with each stroke. After each layer is rodded, tap the outside of the mold 10 to 15 times with a mallet to close any voids. If using a single-use mold, tap with an open hand.

Consolidation by Internal Vibration:

<table>
<thead>
<tr>
<th>Specimen Type and Size</th>
<th>Number of Layers of Approximately Equal Depth</th>
<th>Number of Insertions per Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Diameter:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4&quot; (100 mm)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6&quot; (150 mm)</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Fill molds in two approximately equal layers. Do not overfill the second layer by more than 1/4" (6 mm). After each layer is added insert the vibrator at two different points. Allow to penetrate through the first layer. Do not allow the vibrator to rest on the bottom or sides of the mold. Take care when removing to avoid leaving air pockets. The second layer vibration should penetrate the first layer approximately 1" (25 mm).

Follow each layer by tapping the outside of mold at least 10 times with mallet. Tap single-use molds with an open hand. Add representative concrete to fill any surface voids during final consolidation.

Vibrate only long enough to achieve proper consolidation. Generally no more than 5 seconds should be required for each insertion.

Finishing:

After consolidating the top layer, strike off any excess concrete with the tamping rod when possible, or a wood float or trowel. The finished surface should have
no projections or depressions greater than 1/8" (3 mm). Cover the cylinder with a mold cover or a plastic bag drawn down snugly and fastened with a rubber band or string.

PROCEDURE - BEAMS

Consolidation by Rodding:

<table>
<thead>
<tr>
<th>Specimen Type and Size</th>
<th>Number of Layers of Approximately Equal Depth</th>
<th>Number of Insertions per Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Width:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6&quot; to 8&quot; (150 to 200 mm)</td>
<td>2</td>
<td>1 insertion per 2 sq.in.</td>
</tr>
<tr>
<td>&gt; 8&quot; (&gt; 200 mm)</td>
<td>3</td>
<td>1 insertion per 2 sq.in.</td>
</tr>
</tbody>
</table>

Form the test specimen with its long axis horizontal. Place the concrete in two approximately equal layers. Move the scoop or shovel around the perimeter of the mold to ensure an even distribution.

Rod each layer once for every 2 sq.in. (13 sq.cm.) of concrete surface area. Rod the first layer through its depth. Rod the second layer through its depth and approximately 1" (25 mm) into the first layer.

Tap the outside of the mold lightly 10 to 15 times with a mallet after each layer. After tapping, spade the concrete along the sides and ends of the molds with a trowel. Slightly overfill the top layer.

Consolidation by Internal Vibration:

<table>
<thead>
<tr>
<th>Specimen Type and Size</th>
<th>Number of Layers of Approximately Equal Depth</th>
<th>Number of Insertions per Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Width:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6&quot; to 8&quot; (150 to 200 mm)</td>
<td>1</td>
<td>6&quot; intervals</td>
</tr>
<tr>
<td>&gt; 8&quot; (&gt; 200 mm)</td>
<td>2 or more</td>
<td>6&quot; intervals</td>
</tr>
</tbody>
</table>

Form test specimen with its long axis horizontal. Fill the mold in one layer. Insert the vibrator at no more than 6" (150 mm) intervals along the centerline of the length. The initial insertion point shall be a minimum of 3" (75 mm) from the end of the mold. The shaft of the vibrator shall not contact bottom or sides of the mold. Take care not to over vibrate. When removing, withdraw slowly to avoid air voids. Tap the outside of the mold at least 10 times after vibration has been completed.
Finishing:

A wood float or trowel may be used to strike off the top after completing vibration. Finished surface should be level with the rim of the mold and have no projections or depressions greater than 1/8" (3 mm).

INITIAL CURING PROCEDURE

During the initial curing of up to 48 hours keep test specimens moist and at a temperature between 60° to 80°F (16° to 27°C).

Appropriate temperatures may be maintained by various methods, such as if the weather is hot, cover with wet burlap or wet sand. Check the temperature several times. In cold weather some means of heating may be required. Protect test specimens from damage at all times.

Cylinders may be kept moist by covering with plastic lids and placing in wood boxes or structures.

If the concrete is for a specified strength of 6000 psi or greater, the initial curing temperature is between 68° and 78°F (20° and 26°C).

FINAL CURING

Compression Test Cylinders:

After the initial curing remove cylinders from the molds. Within 30 minutes of removal, store in a water storage tank or moist room complying with the requirements of AASHTO M 201 for remainder of curing time.

Temperatures in the required range are easy to maintain at certain times of the year. Take extra care during the heat of summer or the cold of fall and winter to maintain the specified temperature. Deliver specimens to the testing laboratory in time for them to be stored under laboratory conditions for at least 24 hours.

Field Curing: Remove the molds from the test specimens for determining when a structure may be put into service at the end of initial curing time. Store as near to the point of sampling as possible so the specimens receive the same protection from environmental elements as the portions of the structure which they represent for the remainder of their curing time.
Flexural Test Beams:

Beams shall be cured the same as compression cylinders, except that they shall be stored in water saturated with calcium hydroxide at 73 ± 3°F (23 ± 2°C) for 20 hours prior to testing.

Field Curing: Cure test specimens for determining when a structure may be put into service in the same manner as the concrete in the structure. At the end of the initial 48 ± 4 hours cure time, take the specimens, still in the molds, to a location near the field laboratory. Remove the test specimens from the molds and store by placing them on the ground with their top surface up. Bank the sides and ends with earth or sand and keep damp, leaving the top surface exposed to the specified curing treatment.

For 24 ± 4 hours immediately before time of testing, remove all beams from field storage and store in water saturated with calcium hydroxide at 73 ± 3°F (23 ± 2°C) to ensure uniform moisture condition.

NUMBERING AND IDENTIFYING SAMPLES

The cylinder or beam is a representation of the in-place concrete. Note the location of the concrete. Use a permanent marker to mark all cylinders and beams with numeric/alpha identification. All cylinders cast from the same concrete sample are called a set. Assign a numeric designation to each set followed by a letter designation that changes with each cylinder or beam within the set (example: a set of two 7-day and two 28-day cylinders from the same concrete sample could be numbered 1-A, 1-B, 1-C, and 1-D. The next set would be 2-A, 2-B, 2-C, etc.).

TRANSPORTATION OF SPECIMENS

Specimens must be cured and protected prior to transportation. Specimens shall not be transported until at least 8 hours after final set. Specimens must be cushioned to prevent damage from jarring. In cold weather, the specimens shall be protected from freezing. Prevent moisture loss by either wrapping in plastic or wet burlap; surrounding with wet sand; or using tight-fitting plastic caps on plastic molds. Transportation time shall not exceed four hours.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum or whenever damage or repair occurs.
ND T 27 – SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

Conduct this procedure according to ND T 27.

The AASHTO standard test procedure reports the percentage of material finer than the No. 200 sieve to the nearest 0.1%; except if the result is 10% or more, than report to the nearest whole number. The NDDOT modification is for accuracy and reports to the same significant digit as specified in the specifications for the class of aggregate.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test method determines the particle size distribution of fine and coarse aggregates by sieving. The No. 4 sieve is designated as the division between the fine and coarse aggregate.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling Aggregates
ND T 11 and AASHTO T 11, Materials Finer than No. 200 (75 µm) Sieve in Mineral Aggregates by Washing
AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregates
ND T 89 and AASHTO T 89, Determining the Liquid Limit of Soils
ND T 90 and AASHTO T 90, Determining the Plastic Limit and Plasticity Index of Soils
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying

APPARATUS

Balance
Sieves: 8" round, 12" round, or 14" square
Mechanical sieve shaker
Oven
Bronze brush
Paint brush, approximately 1" wide
Sample splitters, small and large
Mortar and rubber tipped pestle
Spoons
Large pans required for drying and handling sample
TEST SPECIMEN

Obtain sample according to ND T 2. Thoroughly mix and reduce according to ND T 248.

PROCEDURE

Use SFN 9987 or SFN 2455 to record all information. All weights are recorded to the nearest 0.1 g.

Dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C).

Select sieves to furnish the information required by the specifications covering the material to be tested. Use of additional sieves may be desirable to prevent the required sieves from becoming overloaded.

At the completion of the sieving operation, the quantity retained on any sieve with openings smaller than the No. 4 sieve shall not exceed 4 g/sq.in. of sieving surface area. If this occurs it is considered overloading of the sieve. The overload amount for an 8" diameter sieve is 200 g.

At the completion of the sieving operation, the quantity retained on any sieve with openings of No. 4 and larger shall not exceed 2.5 times sieve opening times effective sieve area. If this occurs, it is considered overloading of the sieve. The following table shows the maximum amount of material to be retained on a sieve before being considered overloaded.

<table>
<thead>
<tr>
<th>Maximum Allowable Quantity Of Material Retained*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Opening Size</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>2&quot; (50 mm)</td>
</tr>
<tr>
<td>1½&quot; (37.5 mm)</td>
</tr>
<tr>
<td>1&quot; (25.0 mm)</td>
</tr>
<tr>
<td>3/4&quot; (19.0 mm)</td>
</tr>
<tr>
<td>1/2&quot; (12.5 mm)</td>
</tr>
<tr>
<td>3/8&quot; (9.5 mm)</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
</tr>
</tbody>
</table>

*Table 1 of the current AASHTO T 27 standard shows a complete table of different size sieves of the maximum allowable quantities of material retained on a sieve.
Preventing overloading of material on an individual sieve can be accomplished by one of the following methods:

- Insert an additional sieve with opening size intermediate between the sieve that may be overloaded and the sieve immediately above that sieve.
- Split the sample into two or more portions, sieve each portion individually and combine the portions retained on the sieve before calculating the percentage of the sample on the sieve.
- Use sieves having a larger frame size and providing a greater sieving area.

The portion finer than the No. 4 sieve may be reduced using a mechanical splitter.

Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitate the sieves by hand or by mechanical apparatus until meeting the criteria for adequacy of sieving.

When using a mechanical shaker, place the sample in the stack of sieves and shake until not more than 0.5% by weight of the total sample passes any sieve during one minute. Approximately 10 minutes will be sufficient for most material. Use manual shaking of the material on any one sieve to check on the thoroughness of sieving by any mechanical shaker.

Remove the top sieve, brush the retained material into a pan, weigh and record. Be sure to thoroughly clean each sieve. Repeat this process with each succeeding sieve, brushing the material into individual pans, and record the non-cumulative weights.

**CALCULATIONS**

Add the non-cumulative weight retained on the largest sieve to the weight retained on the next smallest sieve and record in the cumulative column.

Calculate the percent retained on each sieve by dividing each weight by the original total dry weight and multiplying by 100. This is the percent retained. Subtract each of these values from 100 to obtain the percent passing each sieve. Continue this process for each sieve. The equations are as follows:

\[
\text{% retained on sieve} = \left(\frac{\text{Cumulative weight}}{\text{Total weight}}\right) \times 100
\]

\[
\text{% passing} = 100 - \text{% retained on sieve}
\]

This calculation is completed for both the coarse and fine aggregate.
If an accurate determination of the amount of material passing the No. 200 was accomplished by performing ND T 11, subtract the weight after wash from the original weight and record as wash loss.

Add together the cumulative weight retained on the No. 200, the weight of the Minus No. 200 material, and the wash loss, and record as the weight check.

To calculate the percent passing of the total sample for the fine portion of the aggregate, multiply the percent passing the No. 4 times the percent passing on each individual sieve in the fine aggregate portion and divide by 100.

The equation is as follows:

\[
\% \text{ total sample} = \left(\frac{\% \text{ passing No.4}}{\% \text{ passing smaller sieve}}\right) / 100
\]

Final calculations of percentages passing are reported to the nearest whole number with the exception of the No. 200, which is reported to same significant digit as specified by the specification for the class of aggregate.

For both the Plus No. 4 and Minus No. 4, compare the original weight to the weight check. Subtract the smaller value from the larger value, divide the result by the original weight, and multiply by 100, to obtain the percent difference. For acceptance purposes, the two must not differ by more than 0.3%.

NOTES

Accurate determination of material finer than the No. 200 sieve cannot be achieved by using this method alone. Test method ND T 11 for material finer than the No. 200 sieve by washing should be employed.

Sieves mounted in frames larger than standard 8" diameter are used for testing coarse aggregate to reduce the possibility of overloading the sieves.

When working with mixed materials that are coated, lumpy, or baked together, the material must be pulverized enough to separate the particles and remove the coating as much as possible. The idea is to pulverize enough to separate most of the particles, without breaking up any appreciable amount of individual material particles.

In brushing the material out of the sieves, use the bronze brush for approximately the No. 30 sieve and coarser, and the paintbrush for the finer sieves. Tapping the sieves lightly with a stick of wood on the retaining ring to facilitate removal of the particles is acceptable. Do not attempt to completely remove all the particles, but examine each sieve visually before and after sieving. The amount of aggregate particles stuck in the mesh must appear to remain approximately the same for accurate results.
Examine the sieves constantly for damage, which will affect the test results. A common occurrence is the separation of the mesh from the side of the sieve, especially in the finer sieves. Hold the sieves up to a light to inspect for damages.

Dry the sample according to ND T 255 using an oven at a temperature of 230 ± 9°F (110 ± 5°C). If the sample is used to determine ND T 89 for liquid limit, and ND T 90 for plastic limit, the sample must be dried using an oven at a temperature of 140°F (60°C).

**CALIBRATION**

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
Intentionally Left Blank
ND T 84 – SPECIFIC GRAVITY AND ABSORPTION
OF FINE AGGREGATE

Conduct this procedure according to ND T 84.

The AASHTO standard test procedure uses a 500 mL pycnometer (flask) while
the NDDOT modification uses a 1000 mL pycnometer and a glass cover plate.

AASHTO uses a 1000 g sample which is soaked 15 to 19 hours. NDDOT uses
an 1100 g sample which is soaked for 17±1 hours.

AASHTO specifies the aggregate is in a surface dry condition and the aggregate
slumps slightly when the mold is removed. NDDOT specifies the aggregate is in
a surface dry condition and 25% to 75% of the top diameter of the surface
slumps when the mold is removed.

AASHTO specifies the sample in the pycnometer may be immersed in circulating
water to adjust its temperature to 73.4°±3°F (23±1.7°C). NDDOT requires
placement of the sample in the pycnometer in a water bath for 60±15 minutes.

AASHTO specifies the calculated specific gravity be recorded to the hundredth
and the calculated absorption to the tenth of a percent. NDDOT specifies the
calculated specific gravity be recorded to the thousandths and the calculated
absorption to the hundredth of a percent.

Consult the current edition of AASHTO for procedure in its entirety and
equipment specification details.

SCOPE

This test method covers the determination of the bulk specific gravity and the
apparent specific gravity on the basis of mass of saturated surface dry aggregate
and absorption of a fine aggregate sample. Fine aggregate is defined as
material that passes the No. 4 sieve.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling of Aggregates
AASHTO T 84, Specific Gravity and Absorption of Fine Aggregate
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate
by Drying
APPARATUS

Balance
Pycnometer (1000 mL flask) and glass cover plate
Metal mold in the form of a frustum of a cone
Metal tamper with a mass of 340 ± 15 g and tamping face 25 ± 3 mm in diameter
Pan
Spoon
Small fan
Temperature-controlled water bath
Sieves: No. 4 (4.75 m)
Oven

TEST SPECIMEN

Obtain sample according to ND T 2. Thoroughly mix and reduce to testing size according to ND T 248.

Test specimen shall be a representative sample of approximately 1100 g of material passing the No. 4 sieve.

FLASK CALIBRATION

Calibrate the flask by determining the weight of the flask full of distilled water at 73.4 ± 3°F (23 ± 1.7°C). Overfill the flask so the water is convexed above the brim. Very carefully slide a cover plate over the brim of the flask. The flask should be free of any air bubbles. Wipe any moisture on the outside of the flask and weigh the flask, water, and cover plate. Record this weight as weight of flask, cover plate, and water. Empty the flask and repeat the calibration. Repeated weights should agree within 0.2 g.

PROCEDURE

Record all information on SFN 2199. Weights are recorded to the nearest 0.1 g.

Dry the sample according to ND T 255, at a temperature of 230 ± 9°F (110 ± 5°C). Allow the sample to cool to a comfortable handling temperature.

Place the sample in a pan, cover with distilled water, and soak for 17 ± 1 hours. After the soak period carefully remove excess water. Take care to avoid loss of any fines.
Spread the entire sample on a flat, non-absorbent surface and expose it to a gently moving current of warm air produced by the fan set at a low speed. Stir the sample frequently to obtain uniform drying.

The purpose of the slow, uniform drying is to bring the fines to a saturated surface dry condition. In this condition moisture fills the pores of each particle while the surface of the particle is dry. If non-uniform drying is allowed, the results may be in error because over-dried portions of the aggregate will not be saturated. Continue the process until the sample approaches a free flowing condition. It is intended the first trial of the cone test be made with some surface water in the sample.

Place the mold (large diameter down) on a smooth, level, firm, non-absorbent surface and fill with the partially dried material. Fill the cone to overflowing. Heap additional material above the top of the mold by holding the mold with cupped fingers and pouring material on top of the mold. Tamp the surface of the material in the mold 25 times with the tamper. Each drop of the tamper should start 0.2" (5 mm) above the top of the fine aggregate. Allow the tamper to fall freely during each drop. Adjust the starting height after each drop. Distribute the drop evenly over the entire surface.

Remove the material spilled around the mold and slowly lift the mold vertically.

If surface moisture is still present in the sample, the fine aggregate will retain the molded shape and additional drying is required. If the sample slumps on the first try, the material has dried past the saturated surface dry state. It is possible to get the fine aggregate too dry on the first attempt, but the test can be saved by adding a few mL of water to the sample, mixing it, covering, and allowing the sample to set for 30 minutes before rechecking. Only one recheck is permitted. Test the tamped fine aggregate at frequent intervals until 25% to 75% of the top diameter of the cone slumps. At this point the material has reached the saturated surface dry condition. Immediately weigh out exactly 500 g of the saturated surface dry material for introduction into the flask.

Partially fill the flask with distilled water. Immediately introduce 500 g of the saturated surface dry material into the flask. Add distilled water until the neck of the flask is partially filled. Roll and agitate the flask to eliminate the air bubbles. Periodically stop agitating and rolling the flask to allow the air bubbles to rise to the top and be eliminated. Continue the agitating, rolling, and bubble elimination procedures until all the bubbles are eliminated. It normally takes about 15 to 20 minutes to eliminate the air bubbles.

Place the flask in a water bath at 73.4 ± 3°F (23 ± 1.7°C) for 60 ± 15 minutes. To eliminate air bubbles, periodically remove the flask from the water bath, gently agitate it, and place it back in the water bath. All the air bubbles must be removed. This requires good technique and judgment. If the air bubbles are not
completely removed, the results will be erratic. After the flask has been in the water bath for the specified time, remove.

After removal from the water bath, add distilled water to bring the level to the top of the flask. Overfill the flask so that the water is convexed over the brim and slide the glass cover plate along the brim. The flask should be free of any air bubbles. Wipe any moisture from the flask and weigh the flask, cover plate, sample and water. Record this weight as weight of flask, cover plate, sample, and water to top of flask.

Carefully pour the sample and the water into a tarred pan. Rinse the residue from the flask into the pan with a squeeze bottle. Oven dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Cover and allow the sample to cool to room temperature for 30 to 90 minutes. Weigh and record as weight of oven dry sample.

**CALCULATIONS AND REPORTING**

To calculate bulk specific gravity, divide the dry weight in air by the results of the flask filled with water plus weight of the saturated surface dry sample minus the weight of the flask with sample and water to top of flask.

The equation is as follows:

\[
Bulk \ Specific \ Gravity = \frac{A}{(B + S - C)}
\]

- \(A\) = weight of oven dry sample
- \(B\) = weight of flask and cover plate filled with water
- \(C\) = weight of flask, cover, sample and water to top of flask
- \(S\) = weight of saturated surface dry sample (500 g)

Report the result to the 0.001.

To calculate bulk specific gravity (Saturated Surface Dry), divide the weight of saturated surface dry sample by the results of the flask filled with water plus weight of the saturated surface dry sample minus the weight of the flask with sample and water to top of flask.

The equation is as follows:

\[
Bulk \ Specific \ Gravity \ (Saturated \ Surface \ Dry) = \frac{S}{(B + S - C)}
\]

Report the result to the 0.001.
To calculate apparent specific gravity, divide the weight of oven dry sample in air by the results of the flask filled with water plus weight of oven dry sample in air minus the weight of the flask with sample and water to top of flask.

The equation is as follows:

\[
\text{Apparent Specific Gravity} = \frac{A}{B+A-C}
\]

Report the result to the 0.001.

To calculate absorption, subtract the weight of oven dry sample in air from the weight of saturated surface dry sample and divide the result by the weight of oven dry sample in air. Multiply this result by 100.

The equation is as follows:

\[
\text{Absorption} = \left(\frac{S-A}{A}\right) \times 100
\]

Report the result to the nearest 0.01%.

NOTES

Dipping the tip of a paper towel into the pycnometer has been found to be useful in dispersing the foam that sometimes builds up when eliminating the air bubbles.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
ND T 85 – SPECIFIC GRAVITY AND ABSORPTION
OF COARSE AGGREGATE

Conduct this procedure according to ND T 85.

The AASHTO standard test procedure soaks the sample for 15 to 19 hours. The NDDOT modification soaks the sample for 17±1 hours.

AASHTO specifies the calculated specific gravities be recorded to the hundredth and the calculated absorption be recorded to the tenth of a percent. NDDOT specifies the calculated specific gravity to be recorded to the thousandths and the calculated absorption to the hundredth of a percent.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test method for coarse aggregate covers the determination of bulk specific gravity, bulk specific gravity saturated surface dry, apparent specific gravity, and water absorption of coarse aggregates. Material retained on the No. 4 sieve and above is considered coarse.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling of Aggregates
ND T 27 and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregate
AASHTO T 85, Specific Gravity and Absorption of Coarse Aggregate
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying

APPARATUS

Balance, equipped with apparatus for suspending sample container
Suspended apparatus of the smallest practical size
Water tank with overflow outlet
Sieves: No. 4 (4.75 mm) or other sizes as needed
Oven
Thermometer
Absorbent towels
Sample container, either a wire basket made with No. 6 wire or finer mesh, or a bucket
TEST SPECIMEN

Obtain sample according to ND T 2. Thoroughly mix and reduce according to ND T 248.

Determine sample size needed from the following table.

<table>
<thead>
<tr>
<th>Nominal Maximum Size</th>
<th>Minimum Mass of Test Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; (12.5 mm)</td>
<td>4 lbs (2 kg)</td>
</tr>
<tr>
<td>3/4&quot; (19.0 mm)</td>
<td>7 lbs (3 kg)</td>
</tr>
<tr>
<td>1&quot; (25.0 mm)</td>
<td>9 lbs (4 kg)</td>
</tr>
<tr>
<td>1½&quot; (37.5 mm)</td>
<td>11 lbs (5 kg)</td>
</tr>
<tr>
<td>2&quot; (50 mm)</td>
<td>18 lbs (8 kg)</td>
</tr>
</tbody>
</table>

PROCEDURE

Record all information on SFN 10081. All weights are recorded to the nearest 0.1 g.

Dry sieve all material on the No. 4 sieve. Discard all material passing the No. 4 sieve. Wash the remaining sample to remove any dust or other coatings from the surface.

Dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Then allow the sample to cool to a comfortable handling temperature. Immense the aggregate in water at room temperature for a period of 17 ± 1 hour.

Remove the sample from water and roll in a large absorbent cloth until all visible films of water are removed. At this point the sample is in a saturated surface dry condition (SSD). Place the sample in a container. Weigh, and record as weight of saturated surface dry sample in air. Record to 0.1% of sample mass.

After weighing, place the saturated surface dry sample in the sample basket. Immerse in water that is at a temperature of 73.4 ± 3°F (23.0 ± 1.7°C). Take care to remove all entrapped air before weighing by shaking the basket while immersed. Determine the weight and record as weight of saturated sample in water.

Remove the sample from water and place in a pan.
Dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ±5°C). Allow the sample to cool until comfortable to handle. Weigh and record as weight of oven dry sample in air.

CALCULATIONS AND REPORTING

• To calculate bulk specific gravity, divide the dry weight in air by the results of the saturated surface dry weight minus the weight in water.

The equation is as follows:

\[
Bulk \ Specific \ Gravity = \frac{A}{B - C}
\]

\[
A = \text{Weight of oven dry sample in air}
\]

\[
B = \text{Weight of saturated surface dry sample in air}
\]

\[
C = \text{Weight of saturated sample in water}
\]

Report the result to 0.001.

• To calculate bulk specific gravity SSD, divide the saturated surface dry weight by the results of the saturated surface dry weight minus the weight in water.

The equation is as follows:

\[
Bulk \ Specific \ Gravity \ SSD = \frac{B}{B - C}
\]

Report the result to 0.001.

• To calculate apparent specific gravity, divide the dry weight in air by the results of the dry weight in air minus the weight in water.

The equation is as follows:

\[
Apparent \ Specific \ Gravity = \frac{A}{A - C}
\]

Report the result to 0.001.

• To calculate absorption, subtract the weight of oven dry sample in air from the saturated surface dry sample in air and divide result by the weight of oven dry sample in air. Multiply this result by 100.

• The equation is as follows:

\[
Absorption = \frac{(B - A)}{A} \times 100
\]

Report the result to the nearest 0.01%.
NOTES

If the sample is for use in concrete mixtures in which they will be used in their natural condition, the initial drying requirement is eliminated. Also, if the surfaces have been kept continuously wet until the test, the soaking time may also be eliminated.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
ND T 87 - DRY PREPARATION OF DISTURBED SOIL AND SOIL AGGREGATES SAMPLES FOR TEST

Conduct this procedure according to ND T 87.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

The following describes the “Alternate Method” using the No. 4 and 10 sieves.

SCOPE

Dry preparation of soil and soil-aggregate is used to prepare samples received from the field for mechanical analysis, physical tests, or moisture-density relation tests.

APPARATUS

Balance
Oven
Sample splitter
Pan
Pulverizing apparatus - mortar and rubber-covered pestle, or mechanical device
Sieves: 3/4" (19.0 mm), 3/8" (9.5 mm), No. 4 (4.75 mm), No. 10 (2.00 mm), No. 40 (0.425 mm)

SAMPLE SIZE

The initial sample size needed will be dependent upon the tests required.

For Particle Size Analysis:

Material passing the No. 10 sieve is required in the amount of 110 g for sandy soil and 60 g for silty or clayey soil. A sufficient amount of material retained on the No. 4 or No. 10 sieve is necessary to obtain a representative gradation. If the material is not being used in a base or subbase the following table (page 2) may not be needed.
For Physical Tests:

The final amount needed is approximately 300 g of material passing the No. 40 sieve. The breakdown for each physical test is listed below.

<table>
<thead>
<tr>
<th>Test</th>
<th>Sample Size Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Limit ND T 89</td>
<td>100 g</td>
</tr>
<tr>
<td>Plastic Limit ND T 90</td>
<td>20 g</td>
</tr>
<tr>
<td>Shrinkage Factors</td>
<td>30 g</td>
</tr>
<tr>
<td>Check and Referee Tests</td>
<td>100 g</td>
</tr>
</tbody>
</table>

For Moisture Density Tests:

The amount needed for a sample is approximately 7 lbs (3.2 kg) or more passing the No. 4 sieve.

PROCEDURE

Dry the material in air or by oven at a temperature that does not exceed 140°F (60°C).

Break up the clumps of soil with a mortar and rubber covered pestle without reducing the size of the individual grains.

Split the material with a sample splitter or by quartering to obtain a representative sample in the desired amount for testing.

Weigh portion selected and record as weight of total sample.

Method using No. 4 and No. 10 sieves:

Separate the sample into two portions by sieving through the No. 4 sieve. Set aside material that passes the sieve.
Pulverize the material remaining on the No. 4 sieve until the particles are broken into separate grains.

Separate again on the No. 4 sieve. When repeated grinding produces only a small amount of material passing the sieve, the retained material is set aside for use in coarse sieve analysis. The material passing the No. 4 sieve is added to the previously sieved material. Mix together all material passing the No. 4 sieve. Again split by the sample splitter or quartering to obtain a representative portion for the required tests.

Once again separate the material passing the No. 4 sieve into two portions by sieving through the No. 10 sieve. Set aside material that passes the sieve.

Pulverize the material remaining on the No. 10 sieve until the particles are broken into separate grains.

Separate again on the No. 10 sieve. When repeated grinding produces only a small amount of material passing the sieve, the retained material is set aside for use in coarse sieve analysis. The material passing the No. 10 sieve is added to the previously sieved material. Mix together all material passing the No. 10 sieve.

Again split by the sample splitter or quartering to obtain a representative sample in the desired amount for testing.

Once again separate the material passing the No. 10 sieve into two portions by sieving through the No. 40 sieve. Set aside material that passes the sieve.

Pulverize the material remaining on the No. 40 sieve until the particles are broken into separate grains.

Separate again on the No. 40 sieve. When repeated grinding produces only a small amount of material passing the sieve, discard the material that is retained on the sieve. The material passing the No. 40 sieve is added to the previously sieved material. Mix together all material passing the No. 40 sieve.

Again split by the sample splitter or quarter to obtain a representative sample in the desired amount for testing.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
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ND T 89 - DETERMINING THE LIQUID LIMIT OF SOILS

Conduct this procedure according to ND T 89, Method B.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

The liquid limit of a soil is the moisture content at which the soil passes from a plastic to a liquid state.

The numerical difference between the liquid limit and the plastic limit is the plasticity index.

REFERENCED DOCUMENTS

ND T 87 and AASHTO T 87, Dry Preparation of Disturbed Soils and Soil-Aggregate Samples for Test
AASHTO T 89, Determining the Liquid Limit of Soils
ND T 265 and AASHTO T 265, Laboratory Determination of Moisture Content of Soils

APPARATUS

Mixing dish
Spatulas
Liquid limit device, manual or mechanical
Gauge for the liquid limit device
Moisture proof container with covers
Balance
Oven
Distilled water
Grooving tool (Either a flat or curved grooving tool may be used but interchanging grooving tools during testing is prohibited.)

PROCEDURE

Take a sample of approximately 50 g from the thoroughly mixed portion of the 100 g obtained in accordance with ND T 87. The portion of the material used passes the No. 40 (0.425 mm) sieve.
Place the sample in the mixing dish and thoroughly mix with 8 to 10 mL of distilled water by alternately and repeatedly stirring, kneading, and chopping with a spatula. Add additional water in increments of 1 to 3 mL and thoroughly mix until a stiff uniform mass of soil and water is achieved. Once testing begins, do not add additional dry soil to the moistened soil. Do not use the cup of the liquid limit device to mix the soil and water. If too much moisture has been added to the sample, the sample is to be discarded or mixed and kneaded until natural evaporation lowers the moisture content into an acceptable range.

After obtaining a uniform mass of soil and water, place a sufficient quantity of the mixture in the cup above the spot where the cup rests on the base. Squeeze and spread the mixture level with the spatula and at the same time trim the material to a depth of 10 mm at the point of maximum thickness. Use as few strokes of the spatula as possible. Use care to prevent the entrapment of air bubbles within the mass. Return the excess soil to the mixing dish and cover to retain the moisture in the sample.

Divide the soil with a firm stroke of the grooving tool along the diameter through the centerline of the cam follower so that a clean, sharp groove is formed. Up to six strokes from the back to front are permitted to avoid tearing the sides of the groove or slipping of the soil cake on the cup. Increase the depth of the groove with each stroke and scrape the bottom of the cup with only the last stroke.

Lift and drop the cup containing the prepared sample by turning the crank at a rate of approximately two revolutions per second for 22 to 28 blows. If the two sides of the sample come in contact at the bottom of the groove along a distance of approximately 1/2" (13 mm) within 22 to 28 blows, stop and record the preliminary closure blow count.

Return the soil to the mixing dish, remix, and then repeat the procedure. If the second closure occurs in the acceptable range and is within two blows of the first, record the blow count and obtain a moisture content sample. This blow count will be used in the correction calculation.

If the two sides fail to come in contact at approximately 1/2" (13 mm) by 28 blows, return the soil to the mixing dish and add additional water in increments of 1 to 3 mL. If the sides come together at approximately 1/2" (13 mm) in less than 22 blows, the soil is too wet. Discard and start over with a new 50-g sample using less water or knead the sample until natural evaporation lowers the moisture content to an acceptable range.

Observe at least two groove closures before accepting the test results as the liquid limit. This is to ensure the accepted number of blows is truly characteristic of the soil under test.
When two groove closures have been achieved within the requirements of the test, obtain a moisture content sample.

To obtain the moisture content sample, remove a slice of soil approximately as wide as the spatula extending from edge to edge at right angles to the groove. Include that portion of the groove in which the material flowed together. Place in a suitable tared container and cover.

Weigh and record to the nearest 0.01 g.

Return the remaining soil to the mixing dish. Determine moisture content of the sample according to ND T 265.

**CALCULATIONS**

Calculate the percent moisture as follows:

\[ A = \left[ \frac{(B - C)}{C} \right] \times 100 \]

- \( A \) = Percent moisture
- \( B \) = Mass of original sample
- \( C \) = Mass of dry sample

Calculate moisture to the nearest 0.1%.

The percent moisture is the liquid limit.

Upon completion of the calculation, a correction factor is applied to determine the liquid limit at 25 blows.

The correction factor uses the percent of moisture multiplied by a factor \( k \) of the second closure blow count. Calculation of the liquid limit is shown at top of next page.

<table>
<thead>
<tr>
<th>Number of Blows</th>
<th>Factor for Liquid Limit ( k )</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>0.985</td>
</tr>
<tr>
<td>23</td>
<td>0.990</td>
</tr>
<tr>
<td>24</td>
<td>0.995</td>
</tr>
<tr>
<td>25</td>
<td>1.000</td>
</tr>
<tr>
<td>26</td>
<td>1.005</td>
</tr>
<tr>
<td>27</td>
<td>1.009</td>
</tr>
<tr>
<td>28</td>
<td>1.014</td>
</tr>
</tbody>
</table>
Liquid Limit corrected for closure at 25 blows = \((k) \times (W_N)\)

\[
k = Factor \ given \ in \ the \ table
\]
\[
W_N = Moisture \ content \ at \ number \ of \ blows
\]

Report the corrected liquid limit to the nearest whole number.

NOTES

If soil slides on the liquid limit cup surface instead of flows, return the sample to the mixing dish, add more water, re-mix and return to the cup. Cut with the grooving tool. If the sample continues to slide on the cup at less than 25 blows, the test is not applicable and a note should be made that the liquid limit cannot be determined.

The amount of time needed for a material to absorb the water will depend on the material being tested. Some soils are slow to absorb water and it is possible to add water so fast that a false liquid limit value is obtained.

Sandy or silty material may require less water than the initial amount of 8 to 10 mL of water, and increments of 1 to 3 mL.

CALIBRATION

Calibration is to be done annually as a minimum and whenever damage or repair is needed.

The center of the point of the cup, which comes in contact with the base, must be 10 ± 2 mm, above the base. The gauge is used for this measurement. Secure the adjustment plate by tightening the screws. With the gauge in place, check the adjustment by revolving the crank rapidly several times. If the adjustment is correct, a slight ringing sound will be heard when the cam strikes the cam follower. If the cup is raised off the gauge or no sound is heard, further adjustment is necessary.
ND T 90 – DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

Conduct this procedure according to ND T 90.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

The plastic limit of a soil is the lowest water content at which the soil remains plastic.

The plasticity index of a soil is the numerical difference between the liquid limit and the plastic limit. It is the moisture content at which the soil is in a plastic state.

REFERENCED DOCUMENTS

ND T 87 and AASHTO T 87, Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
ND T 89 and AASHTO T 89, Determining the Liquid Limit of Soils
AASHTO T 90, Determining the Plastic Limit and Plasticity Index of Soils
ND T 265 and AASHTO T 265, Laboratory Determination of Moisture Content of Soils

APPARATUS

Mixing dish
Spatula
Ground glass plate or unglazed paper
Plastic Limit Rolling device with unglazed paper (optional)
Moisture proof sample cans (3 oz. capacity)
Balance
Oven
Distilled water

PROCEDURE

Record information on SFN 9987 or SFN 10086.

Material passing the No. 40 (0.425 mm) sieve prepared according to ND T 87 is needed for this test.
If both the liquid and the plastic limits are required, take a test sample of approximately 8 g from the thoroughly wet and mixed portion of the soil prepared for ND T 89, the liquid limit. Take the sample at any stage the sample is plastic enough to be shaped into a ball without sticking to the fingers. Set aside and allow to air dry until completion of the liquid limit test. If the sample is too dry, add more water and re-mix.

If only the plastic limit is required, take a quantity of air-dried soil weighing about 20 g and mix with distilled or tap water in the mixing dish until the sample becomes plastic enough to be easily shaped into a ball. Use a portion of this ball that weighs approximately 8 g for the test sample.

Squeeze and form the 8-g test sample into an ellipsoidal-shaped mass. Sub-sample to 1.5 g to 2 g portions and roll between the palm or fingers and the ground glass plate or piece of paper with sufficient pressure to roll the sample into a uniform thread about 1/8" in diameter throughout its length. Roll at a rate of 80 to 90 strokes per minute. A stroke is a complete forward and back motion, returning to the starting place. A plastic limit rolling device may also be used. The rolling procedure should be completed in two minutes.

When the diameter of the thread reaches 1/8", break the thread into six or eight pieces and squeeze the pieces together between the thumbs and fingers of both hands into a roughly uniform ellipsoidal shape and re-roll. Continue this procedure until the thread crumbles under the pressure required for rolling and the soil can no longer be rolled into a thread. The crumbling may occur when the thread has a diameter greater than 1/8". This is considered a satisfactory end point provided that the soil has been previously rolled into a thread 1/8" in diameter.

Do not attempt to produce failure at exactly 1/8" in diameter by allowing the thread to reach 1/8", then reducing the rate of rolling or the hand pressure, or both, and continuing the rolling without further deformation until the thread falls apart. It is permissible to reduce the total amount of deformation for feeble plastic soils by making the initial diameter of the ellipsoidal shaped mass near the required 1/8" final diameter.

Gather the portion of the crumbled soil together and place in a container and cover.

Repeat this procedure until the entire 8-g specimen is completely tested. Weigh to the nearest 0.01 g and record. Determine the moisture content according to ND T 265.
CALCULATIONS

Calculate the percent moisture as follows:

\[ A = \left(\frac{B - C}{C}\right) \times 100 \]

\( A = \text{Percent moisture} \)
\( B = \text{Mass of original sample} \)
\( C = \text{Mass of dry sample} \)

Calculate moisture to the nearest 0.1%.

The percent moisture is the plastic limit.

Report the plastic limit to the nearest whole number.

PLASTICITY INDEX CALCULATION

The plasticity index of soil is the difference between its liquid limit and its plastic limit.

\[ \text{Plasticity Index} = \text{Liquid Limit} - \text{Plastic Limit} \]

Report the plasticity index to the nearest whole number.

NOTES

Report the plastic limit as non plastic (NP) when the plastic limit is equal to or greater than the liquid limit, or when the liquid limit or plastic limit cannot be determined.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
Conduct this procedure according to ND T 99 or ND T 180.

The NDDOT modifies this standard to only allow the use of Method A and D. Method D shall only be used in lieu of Method A when there is more than 5% by weight of material retained on the No. 4 sieve.

Method D shall be used without correction for all soil-aggregates which have all materials passing the 3/4" sieve. Corrections must be made according to ND T 224 for all materials which have 30% or less retained on the 3/4" sieve.

If the specified oversized maximum of 30% is exceeded, other methods of compaction control must be used.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

The moisture-density relationship test is also called the Proctor test. This test method determines the relationship between the moisture content and the density of soils compacted in a mold. Two different standards of moisture-density relationships are presently in use by the NDDOT. They vary mainly in the compaction energy applied to the soil in the mold. The two standards and their features are summarized below.

METHOD A

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>ND T 99</th>
<th>ND T 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Compaction Rammer</td>
<td>5.5 lbs</td>
<td>10 lbs</td>
</tr>
<tr>
<td>Distance of Drop</td>
<td>12&quot;</td>
<td>18&quot;</td>
</tr>
<tr>
<td>Number of Soil Layers</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Diameter of Mold</td>
<td>4&quot;</td>
<td>4&quot;</td>
</tr>
<tr>
<td>Soil Passing Sieve Size</td>
<td>No. 4</td>
<td>No. 4</td>
</tr>
<tr>
<td>Rammer, Blows/Layer</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>
METHOD D

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>ND T 99</th>
<th>ND T 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Compaction Rammer</td>
<td>5.5 lbs</td>
<td>10 lbs</td>
</tr>
<tr>
<td>Distance of Drop</td>
<td>12&quot;</td>
<td>18&quot;</td>
</tr>
<tr>
<td>Number of Soil Layers</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Diameter of Mold</td>
<td>6&quot;</td>
<td>6&quot;</td>
</tr>
<tr>
<td>Soil Passing Sieve Size</td>
<td>3/4&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>Rammer, Blows/Layer</td>
<td>56</td>
<td>56</td>
</tr>
</tbody>
</table>

REFERENCED DOCUMENTS

AASHTO T 99 and T 180 – Moisture Density Relations of Soils
ND T 217 and AASHTO T 217 - Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy)
ND T 265 and AASHTO T 265 - Laboratory Determination of Moisture Content of Soils
ND D 2167 and ASTM D 2167 - Density and Unit Weight of Soil in Place by the Rubber-Balloon Method
ND D 4643 and ASTM D 4643 - Determination of Moisture Content of Soil by Microwave Oven Heating

APPARATUS

Balance, readable to 0.01 lbs. (5 g)
Oven
No. 4 (4.75 mm) sieve
Mixing tools
Moisture sample cans with lids
Straightedge, 10" long
Knife
Compaction equipment including density mold, base and collar, and compacting rammer and guide

SAMPLE SIZE

Method A - A representative soil sample of approximately 35 lbs (15.9 kg) is required for the Multi-Point Moisture Density Relationship Test, and approximately 7 lbs (3.2 kg) is required for the One-Point Moisture Density Relationship Test.
Method D - A representative soil sample of approximately 125 lbs (55 kg) is required for the Multi-Point Moisture Density Relationship Test, and approximately 25 lbs (11 kg) is required for the One-Point Moisture Density Relationship Test.

PROCEDURE

Multi-Point Moisture Density Relationship - Mechanical and Manual

Record this information on SFN 10063, "Moisture Density Relationship Test." Calculate and record to the accuracy indicated.

If the soil is damp when received, dry until it is easily crumbled under a trowel. It can be air dried or oven dried at a temperature up to 140°F (60°C). Break up the soil chunks so that the entire sample passes through the No. 4 sieve. Avoid reducing the natural size of the particles. Discard any individual particles of material retained on the No. 4 sieve or organic material. Divide the sample into five representative samples of 7 lbs each.

Thoroughly mix the first test sample with water to dampen it approximately four percentage points below optimum moisture. A good indication of a soil being right for the first point is if the soil barely forms a "cast" when squeezed together. Specimen shall be placed in moisture proof container and covered to prevent moisture loss. Mix remaining specimens in the same manner as test sample one, increasing water content by approximately one or two percentage points (not exceeding 2.5%) over each preceding specimen. This can be accomplished by adding approximately 60 mL* of water. Allow soil samples to cure in moisture proof containers for a minimum of 12 hours.

*If using Method D, the water added to the sample must be increased from approximately 60 mL to approximately 215 mL.

Weigh the empty mold without the base plate or collar and record to the nearest 0.01 lb (5 g).

From test sample one: add sufficient material to the mold to produce a compacted layer of approximately 1-3/4" for ND T 99, or 1" for ND T 180. Gently level the soil surface in the mold. *Using a manual compaction rammer or a similar device with a 2" face (50 mm), lightly tamp the soil until it is no longer loose or fluffy. Compact the soil with **25 evenly distributed blows of the compaction rammer. After each layer, trim any soil along the mold walls that has not been compacted with a knife and distribute on top of the layer.

*When completing this process using a mechanical compactor, it is recommended to use a spare or extra replacement rammer.
**If using Method D, compact the soil with 56 evenly distributed blows.**

When using a manual compactor, remember to hold the rammer perpendicular to the base of the mold and lift the rammer to its maximum upward position.

Repeat this procedure adding more soil from the same sample each time so that at the end of the last cycle, the top surface of the compacted soil is above the top rim of the mold when the collar is removed.

Remove the collar and trim off the extruding soil level with the top of the mold. In removing the collar, rotate it to break the bond between it and the soil before lifting it off the mold. This prevents dislodging chunks of compacted soil when lifting the collar off. The trimming consists of many small scraping motions with a knife or straightedge.

After trimming the soil level with the top of the mold, clean all loose material from the outside of the mold. Weigh the soil and mold to the nearest 0.01 lb (5 g) and record. Subtract the weight of the mold from this weight and divide the result by the volume of the mold. Record results as wet density in pounds per cubic foot (pcf). Compute and record wet density to the nearest 0.1 pcf.

\[
\text{Wet Weight of Soil} = \text{Weight of Mold + Soil} - \text{Weight of Mold}
\]

\[
\text{Wet Density, pcf} = \frac{\text{Wet Weight of Soil}}{\text{Volume of Mold}}
\]

Remove the soil from the mold and slice through the center vertically. Obtain a representative sample of approximately 100 g from one of the cut faces. Take the sample from the full length of the inside of the soil cylinder. Place the moist sample in a container, cover and weigh. Record the weight of the wet soil. Record this and all moisture weights to the nearest 0.1 g.

Dry the sample to a constant weight according to ND T 265, Laboratory Determination of Moisture Content of Soils.

Calculate the percent moisture to the nearest 0.1%. Compute and record dry density to the nearest 0.1 pcf.

The formula is as follows:

\[
\text{Dry Density, pcf} = \frac{(\text{Wet Density} \times 100)}{(100 + \% \text{ Moisture})}
\]

Using specimen number two, repeat the compaction procedure previously described. Continue this process, with the remaining samples, until there is a decrease in the wet density per cubic foot.
The objective of this procedure is to determine the maximum dry density and optimum moisture content for this particular soil. Based on the results obtained from conducting consecutive Proctors with changes in moisture, plot each test result on the cross-ruled area on the form with the moisture content plotted on the abscissa (x) and the density on the ordinate (y).

After all the results are plotted, draw a smooth flowing curve through or close to the plotted points. From the peak of the curve, select the maximum dry density and optimum moisture. Report the maximum dry density to the nearest 1-lb./cu.ft. and the optimum moisture to the nearest 0.1%.

NOTES

During compaction, the mold shall rest firmly on a dense, uniform, rigid, and stable foundation or base. This base shall remain stationary during the compaction process. Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: (1) a block of concrete with a mass not less than 200 lbs (90 kg) supported by a relatively stable foundation; (2) a sound concrete floor; and (3) for field applications such surfaces are found in concrete box culverts, bridges, and pavements.

The moisture-density test is used to establish a value of density on which construction requirements can be based. It is a test conducted on a single identifiable soil and results may vary considerably between different soils.

Make every effort to space the moisture contents no further apart than 2.5% in order to accurately determine the maximum dry density and optimum moisture content.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.

One-Point Moisture Density Relationship with Typical Moisture-Density Curve Method

After analyzing a large number of both ND T 99 and ND T 180 moisture-density curves that generally represent statewide soil types, it was found the curves follow the trends shown on the graphs on the following pages. The graphs with the following procedure may be used in place of performing the entire moisture-density relationship test. It is recommended that the Multi-Point Moisture Density Relationship be used whenever possible.
PROCEDURE

The procedure that follows is written for a test using one sample of approximately 7 lbs (3.2 kg) of material. Thoroughly mix the soil sample with water and dampen it approximately to, but not over, Optimum Moisture. Conduct a Proctor test as previously described in the Multi-Point Moisture Density Relationship.

GRAPH

Use either of the following graphs, ND T 99 or ND T 180, whichever is appropriate, to locate the point defined by the two values obtained from the Proctor.

If the point lies directly on a curve, follow this curve to its peak and read off the maximum dry density and optimum moisture content. If the point lays in-between two curves, follow the two curves to their peaks and interpolate the maximum dry density and optimum moisture content. Report the maximum dry density to the nearest 1-lb./cu.ft. and report the optimum moisture to the nearest 0.1%.

NOTES

When the rubber balloon method is used for the density test, use the same material from the hole for the one-point determination. To get sufficient material, enlarge the hole after the rubber balloon test is complete and use the additional material collected.

In order to perform the test in conjunction with and at the same location as the in-place density test, there are steel-capped, wooden pedestals available to support the mold base plate. During compaction, place the mold and pedestal on firm level ground.

Perform moisture content test according to ND T 217, Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy). Or, if there is a field lab available to conduct the moisture determination, obtain the sample in the same manner described previously according to ND D 4643, Determination of Moisture Content of Soil by Microwave Oven Heating, and ND T 265, Laboratory Determination of Moisture Content of Soils.

When using the graphs, a soil on the wet side of optimum could result in a substantial error when selecting the maximum dry density. Most specifications require the moisture content to be at or above optimum, thus it can be assumed that this is the condition that most samples are in. If the sample is judged to be slightly wetter than optimum, dry it to a condition slightly drier than optimum before compacting.
Typical Moisture-Density Relationship Curves for ND T 99 Compaction
Typical Moisture-Density Relationship Curves for ND T 180 Compaction

- Moisture Content Percent
- Dry Density PCF

100% Saturation Specific Gravity 2.65
ND T 113 – LIGHTWEIGHT PIECES IN AGGREGATE

Conduct this procedure according to ND T 113.

The AASHTO standard test procedure uses saturated surface dry material. The NDDOT modification uses material that is dried to a constant weight.

AASHTO uses material for the fine aggregate that passes the No. 4 and is retained on the No. 50 sieve. NDDOT uses material for the fine aggregate that passes the No. 4 and is retained on the No. 30 sieve.

AASHTO uses a heavy liquid with a specific gravity of 2.00±0.01. NDDOT uses a heavy liquid with a specific gravity of 1.95±0.01.

AASHTO does not indicate a time period for stirring and resting the sample. NDDOT agitates the fine aggregate sample for 15 seconds and then allows resting for 30 seconds before removing the lightweight pieces. This is done a maximum of three times.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test method determines the percentage of lightweight pieces in aggregate by means of sink-float separation in a heavy liquid with a specific gravity of 1.95 ± 0.01. This test is performed separately on the coarse and fine portions of aggregate. The No. 4 sieve is designated as the division between the fine and coarse aggregate.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling Aggregates
ND T 27 and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregate
AASHTO T 113, Lightweight Pieces in Aggregate
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying
APPARATUS

Balance
Sieves: No. 4 (4.75 mm) and No. 30 (600 µm)
Specific gravity hydrometer
Zinc chloride
Enamel pans
Glass beaker
Fine strainer
Spoon
Oven

TEST SPECIMEN

Obtain a sample according to ND T 2 and reduce according to ND T 248.

Test specimen shall be a representative sample determined from the following table:

<table>
<thead>
<tr>
<th>Nominal Maximum Size of Aggregate</th>
<th>Minimum Mass of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4 (4.74 mm)</td>
<td>200 g</td>
</tr>
<tr>
<td>3/4&quot; (19.0 mm)</td>
<td>3000 g</td>
</tr>
<tr>
<td>1½&quot; (37.5 mm)</td>
<td>5000 g</td>
</tr>
<tr>
<td>3&quot; (75 mm)</td>
<td>10,000 g</td>
</tr>
</tbody>
</table>

If the nominal maximum size of the aggregate to be tested is not listed above, use the next larger size to determine the sample size.

Dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Cover the sample and cool to room temperature.

Perform sieve analysis according to ND T 27. The material retained on the No. 4 sieve will be used for the coarse aggregate portion. The material passing the No. 4 and retained on the No. 30 sieve will be used for the fine aggregate portion.

PROCEDURE

Record all information on SFN 9987. All weights are recorded to the nearest 0.1 g.

Coarse Aggregate:

Weigh the sample and record as weight of Plus No. 4 material.
Place the coarse portion into the zinc chloride solution. The volume of the liquid should be three times the volume of the aggregate.

Using the strainer, skim off floating particles and place the lightweight pieces into a pan. Repeatedly agitate, rest, and remove the floating particles from the sample until no additional particles float to the surface.

Use hot water to wash the zinc chloride solution from the lightweight pieces. Dry according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Weigh and record as weight of lightweight pieces in Plus No. 4 material.

**Fine Aggregate:**

Weigh the sample and record as weight of Minus No. 4 Plus No. 30 material.

Place the fine aggregate portion in a nonabsorbent container, preferably a glass beaker. Pour zinc chloride solution in with the sample. The volume of liquid should be three times the volume of the aggregate.

Agitate to bring all particles into suspension by stirring for a period of 15 seconds. Allow the sample to rest for 30 seconds.

After the rest period, decant the floating lightweight pieces onto a No. 30 sieve or smaller. Repeatedly agitate, rest, and remove the floating particles from the sample until no additional particles float to the surface. This process may be completed up to a maximum of three times.

Use hot water to wash the zinc chloride solution off the lightweight pieces. Dry according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Weigh and record as weight of lightweight pieces Minus No. 4 Plus No. 30 material.

**CALCULATIONS**

**Coarse Aggregate:**

- To calculate the percent of lightweight pieces in the coarse aggregate portion, divide the weight of material that floats by the weight of the Plus No. 4 material.

  The equation is as follows:

  \[ A = \frac{B}{C} \times 100 \]

  \( A = \text{Percent of lightweight pieces in the coarse aggregate} \)

  \( B = \text{Weight of coarse lightweight pieces} \)

  \( C = \text{Weight of sample of the coarse aggregate} \)
To determine the percent of coarse lightweight pieces in the total sample, multiply the percent of lightweight pieces in the coarse portion times the percent of the total sample retained on the No. 4 sieve. Multiply this result by 100.

The equation is as follows:

\[ D = \frac{(A \times E)}{100} \]

\( D = \text{Percent coarse lightweight pieces, total sample} \)
\( A = \text{Percent of lightweight pieces in the coarse aggregate} \)
\( E = \text{Percent of total sample retained on the No. 4} \)

**Fine Aggregate:**

To calculate the percent of lightweight pieces in the fine aggregate portion, divide the weight of material that floats by the total weight of the fine portion. Multiply this result by 100.

The equation is as follows:

\[ F = \frac{G}{H} \times 100 \]

\( F = \text{Percent of lightweight pieces in fine aggregate} \)
\( G = \text{Weight of fine lightweight pieces} \)
\( H = \text{Weight of sample of the fine aggregate} \)

To determine the percent of fine lightweight pieces in the total sample, multiply the percent of lightweight pieces in the fine portion times the result of the percent of the total sample passing the No. 4 sieve minus the percent passing the No. 30 total sample. Multiply this result by 100.

The equation is as follows:

\[ I = \frac{(F \times J)}{100} \]

\( I = \text{Percent fine lightweight pieces, total sample} \)
\( F = \text{Percent of lightweight pieces in fine aggregate} \)
\( J = \text{Result of the percent passing No. 4 minus the percent passing No. 30 total sample} \)

Report individual results to the nearest 0.01%.
Lightweight Pieces Total Sample:

- To determine the lightweight pieces in total sample combine the percent fine lightweight pieces total sample and percent coarse lightweight pieces total sample.

The equation is as follows:

\[ H = D + I \]

- \( H \) = Percent lightweight pieces total sample
- \( D \) = Percent coarse lightweight pieces, total sample
- \( I \) = Percent fine lightweight pieces, total sample

Report to the nearest 0.1%.

NOTES

Zinc chloride is a poison. Handle and store accordingly. Avoid zinc chloride dust or vapor from the solution by wearing an appropriate mask or work under a vent hood. The zinc chloride solution is corrosive to skin and clothing. Use safety goggles, rubber gloves, and a rubberized apron to avoid contact with skin or clothing.

To prepare a zinc chloride solution, mix zinc chloride with water at room temperature at a rate of approximately 3 parts zinc chloride to 1 part water. This would be a mix proportion of about 2800 g of zinc chloride to about 1100 mL of water. During mixing the solution heats up considerably so allow time for the solution to cool to room temperature. Use a specific gravity hydrometer to adjust the specific gravity to 1.95 ± 0.01 by adding water or zinc chloride in small quantities. Adding an additional amount of zinc chloride will increase the specific gravity or adding water will decrease the specific gravity.

To reuse the zinc chloride solution, check the specific gravity and adjust before each use.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
ND T 119 - SLUMP OF HYDRAULIC CEMENT CONCRETE

Conduct this procedure according to ND T 119.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

A sample of freshly mixed concrete is placed and compacted by rodding in a slump cone. The mold is raised and the concrete allowed to slump. The distance between the original and displaced position of the center of the top surface is measured and reported as the slump of the concrete. The slump measurement is used as an indicator of consistency.

This test is not considered applicable to non-cohesive (slumps greater than 9" or 230 mm) and non-plastic (slumps less than 1/2" or 15 mm) concrete or concrete batched with coarse aggregate over 1½" (38 mm) in size.

REFERENCED DOCUMENTS

AASHTO T 119, Slump of Hydraulic Cement Concrete
ND T 141 and AASHTO T 141, Sampling Freshly Mixed Concrete

APPARATUS

Slump cone and base plate, or nonabsorbent, rigid, flat surface
Scoop
Ruler
Sponge or brush
Tamping rod, 24" (600 mm) length, and 5/8" (16 mm) diameter, rounded to a hemispherical tip

TEST SPECIMEN

Obtain a concrete sample according to ND T 141.

Test must be started within five minutes of obtaining the final portion of the composite sample.

The entire test from the start of the filling through removal of the mold must be completed, without interruption, in 2½ minutes.
PROCEDURE

Dampen the mold and place it on a level nonabsorbent rigid surface or the base plate provided with the cone. Hold mold in place by standing on the 2-foot pieces or by clamps if using a base plate. Immediately fill the cone in three layers. Each layer should be approximately 1/3 the volume of the cone.

One third is approximately 2-5/8" (65 mm) depth; two thirds is approximately 6-1/8" (155 mm) depth.

Move each full scoop around the top edge of the cone as the concrete slides from it to ensure even distribution of the concrete within the cone.

Consolidate each layer of concrete 25 times with the tamping rod, rounded end down. Distribute the strokes in a uniform manner over the cross section of the cone. Incline the rod slightly to reach the perimeter. Distribute approximately half the strokes near the perimeter and progress to vertical strokes toward the center. Use a spiral pattern. Tamp the bottom layer through its full depth.

Fill the second layer. Consolidate 25 times with the tamping rod. Rod the layer through its full depth and just penetrate the first layer.

Fill the final layer. Keep the concrete above the top edge of the mold at all times when rodding the third layer. Add additional concrete if needed and continue rodding. Rod through the layer but just penetrate the previous layer.

After the consolidation of the top layer has been completed, strike-off the surface of the concrete with the tamping rod using a screeding and rolling motion. Continue to hold mold down firmly and remove any excess concrete from the area surrounding the base of the mold.

Loosen the clamps on the base plate if necessary, or step off the foot pieces. Remove the mold by pulling straight up and off with a steady lift. Do not use any lateral or twisting motion. The mold must be removed in 5 ± 2 seconds.

Immediately measure the slump by determining the vertical difference between the top of the mold and the displaced original center of the top surface of the specimen.

If you are using a slump cone without a base plate, turn the mold upside down and lay the tamping rod across its base extending over the slumped specimen. If using a base plate, lift the handle on the base plate.

If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample.
REPORT

Report the slump to the nearest 1/4" (5 mm).

CALIBRATION

As a minimum, slump cone measurements should be verified prior to use on a project for acceptance testing, or whenever damage or repair occurs.

For independent assurance, an annual verification should be completed as a minimum, or whenever damage or repair occurs.
ND T 121 – DENSITY (UNIT WEIGHT), YIELD, AND AIR CONTENT (GRAVIMETRIC) OF CONCRETE

Conduct this test according to ND T 121.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test method determines the weight per cubic foot of freshly mixed concrete and gives formulas for calculating the yield and cement content.

REFERENCED DOCUMENTS

AASHTO T 19, Bulk Density (“Unit Weight”) and Voids in Aggregate
ND T 119 and AASHTO T 119, Slump of Hydraulic Cement Concrete
AASHTO T 121, Density, Yield, and Air Content of Concrete
ND T 141 and AASHTO T 141, Sampling Freshly Mixed Concrete
ND T 152 and AASHTO T 152, Air Content of Freshly Mixed Concrete by the Pressure Method

APPARATUS

Balance
Strike-off plate
Mallet
Scoop
Internal vibrator
Tamping rod - 24" (60 mm) in length, and 5/8" (16 mm) in diameter, rounded to a hemispherical tip
Volume measure bucket - when Size 3, 4, or 5 aggregate is used in the mix, either use a 0.5 cu.ft (14 L) bucket or the air meter bowl

PROCEDURE

Sample concrete according to ND T 141. The test must be started within 5 minutes after the last sub-sample is added to the composite sample.

Slump is determined according to ND T 119. Rod concrete with a slump greater than 3". Rod or vibrate concrete with a slump of 1" to 3" (25 mm to 75 mm). Consolidate by vibrating concrete with a slump less than 1" (25 mm).
Dampen the inside of the bucket and place on a level, firm surface.

**Consolidation by Rodding:**

Fill the bucket with concrete in three equal layers. Rod the first layer through its depth but do not forcibly strike the bottom of the bowl. Rod the following layers, penetrating approximately 1" (25 mm) into the previous layer.

Uniformly rod each layer 25 times with the tamping rod, rounded end down. Follow the rodding of each layer by tapping the sides of the bowl 10 to 15 times with the mallet until the voids left by rodding are closed and to release any large air bubbles that may have been trapped. Add the final layer carefully to avoid overfilling. Take care to leave the bucket level full after rodding is complete.

**Consolidation by Internal Vibration:**

Fill and consolidate concrete in two layers. Place all concrete in each layer before vibrating. Insert the vibrator in three different locations of each layer. Do not touch or rest on the bottom or sides of the bowl. Carefully withdraw the vibrator making sure no air pockets are left. For the second layer, the vibrator should penetrate into the first layer by about 1" (25 mm). Length of consolidation will vary depending on concrete. Do not over consolidate as it may cause segregation. Usually sufficient consolidation has occurred when the surface of the concrete becomes smooth. Take care to leave the bucket level full.

**Strike Off Procedure:**

After consolidation of the concrete, the top surface shall be struck off. A small quantity of concrete may be added to correct a deficiency. If the bucket contains a large excess, remove a portion with a trowel or scoop before striking off.

Place the strike-off plate on approximately two-thirds of the surface area. Withdraw the plate with a sawing motion to finish the area originally covered. Again place the plate on the bowl covering the original area only. Advance it with a sawing motion and vertical pressure until the plate completely slides off the measure. You may use the inclined edge of the plate to produce a smooth finished surface.

Clean all excess concrete from the exterior of the filled bucket and weigh to the nearest 0.1 lbs (45 g).
CALCULATIONS

The buckets are calibrated and the multiplication factor is printed on the outside of the buckets. The volume of the bucket, instead of the multiplication factor, may be printed on some buckets. In this case divide the volume into one to get the multiplication factor.

• UNIT WEIGHT:

Calculate the weight of concrete by subtracting the weight of the bucket from the weight of concrete and bucket.

\[ C = A - B \]

\[ A = \text{Concrete and bucket (lbs)} \]
\[ B = \text{Weight of bucket (lbs)} \]
\[ C = \text{Weight of concrete (lbs)} \]

Calculate unit weight in lbs/cu.ft. by multiplying the weight of concrete by the multiplication factor.

\[ D = C \times \text{Multiplication Factor} \]
\[ D = \text{Unit weight (lbs/cu.ft.)} \]
\[ C = \text{Weight of concrete (lbs)} \]

Or the volume of the bucket may be used.

Weight of concrete divided by volume of bucket = unit weight

\[ D = \frac{C}{\text{Volume of bucket}} \]
\[ C = \text{Weight of concrete (lbs)} \]
\[ D = \text{Unit weight (lbs/cu.ft.)} \]

Report unit weight to the nearest 0.1 lbs/cu.ft.

• YIELD:

Calculate the yield in terms of cu.ft. per batch as follows:

\[ \text{Yield} = \frac{\text{Total weight of batch}}{\text{Unit weight}} \]

*Obtain the total weight of batch from the mix design on form SFN 9311.

Report yield to the nearest 0.01 cu.ft.
• **CEMENT CONTENT:**

Calculate the cement content in sacks per cu.yd. of concrete as follows:

\[ \text{Cement Content} = 27 \times \text{Sacks per batch/Yield} \]

Report the cement content to the nearest whole number.

• **AIR CONTENT:**

Determine air content according to ND T 152.

**CALIBRATION**

Calibration is to be done annually, as a minimum, and whenever damage or repair occurs.

Calibrate unit weight buckets for volume according to AASHTO T 19.

Air meter buckets must conform to the requirements of ND T 152. The top rim shall be smooth and plane within 0.01" (0.25 mm).

Other containers must meet the requirements of AASHTO T 19.
ND T 141 - SAMPLING FRESHLY MIXED CONCRETE

Conduct this procedure according to ND T 141.

The NDDOT modification allows procedures for sampling from a pump or conveyor placement system.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This method covers the procedures for obtaining representative samples of freshly mixed concrete from the project site.

APPARATUS

Buckets
Wheelbarrow
Cover for wheelbarrow (plastic sheeting or canvas)
Shovel
Cleaning Equipment

PROCEDURE

The elapsed time between obtaining the first and final portions of the sample should not exceed 15 minutes.

Transport the individual samples of concrete to the site where freshly mixed concrete tests are being performed or specimens molded. Combine and mix with a shovel.

Obtain at least 1 cu.ft. of concrete for strength tests. Smaller samples may be allowed for air content and slump tests as determined by the maximum aggregate size.

Start tests for slump, temperature, or air content within 5 minutes of obtaining the final sample for the composite. Start mold specimens for strength tests within 15 minutes of creating the composite sample.

Keep elapsed time between obtaining and using a sample as short as possible. Protect samples from sources of rapid evaporation (i.e., sun and/or wind), or any other contaminating elements.
• **SAMPLING FROM STATIONARY MIXERS EXCEPT PAVING MIXERS**

Do not sample from the very first or last portion of the batch discharge. Sample the concrete at two or more regularly spaced intervals during discharge of the middle portion of the batch and composite into one sample. Sample the concrete by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Do not restrict the flow of concrete.

• **SAMPLING FROM A PAVING MIXER**

After discharge obtain at least five samples from different portions of the pile. Make one composite sample from the samples obtained. Avoid contamination with subgrade material or prolonged contact with an absorptive subgrade.

Another method of sampling is to place three shallow containers on the subgrade and discharge across the containers. The containers must be large enough to result in the necessary size composite sample based on the maximum aggregate size.

• **SAMPLING FROM A REVOLVING DRUM TRUCK MIXER OR AGITATOR**

Do not sample until after all of the water has been added to the mixer. Do not obtain samples from the first or last portion of the batch. Sample at two or more regularly spaced intervals during discharge from the middle of the batch. Make one composite sample from the samples obtained. To sample, repeatedly pass a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Regulate the rate of discharge by rate of revolution of drum, not gate opening size.

• **SAMPLING FROM OPEN-TOP TRUCK MIXERS, AGITATORS, NON-AGITATING EQUIPMENT OR OTHER TYPES OF OPEN-TOP CONTAINERS**

Sample by the most applicable methods previously mentioned.

• **SAMPLING FROM A PUMP OR CONVEYOR PLACEMENT SYSTEM**

Sample after a minimum of a half cubic yard has been discharged and all pump slurry has been eliminated. **Do not** obtain samples from the very first or last portions of the batch or load. **Do not** lower pump from placement position to ground level for ease of sampling. Sample should be obtained from the point of final discharge. Obtain sample by repeatedly passing container through the entire discharge or by completely diverting the discharge without lowering it.
ND T 152 - AIR CONTENT OF FRESHLY MIXED CONCRETE

Conduct this procedure according to ND T 152.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This procedure describes test methods for determining the air content of freshly mixed concrete using Type A "Acme" air meter and the Type B "Forney" air meter methods.

REFERENCED DOCUMENTS

ND T 119 and AASHTO T 119, Slump of Hydraulic Cement Concrete
ND T 141 and AASHTO T 141, Sampling Freshly Mixed Concrete

APPARATUS

Air meter
Trowel
Tamping rod, 20" long, 5/8" diameter, with rounded end, or internal vibrator
Rubber mallet
Strike off bar or plate
Funnel
A measure for water
A rubber bulb syringe (type B meter)
Small scoop

PROCEDURE

Obtain sample of concrete according to ND T 141.

Determine slump according to ND T 119. Rod the concrete with a slump greater than 3". Rod or vibrate the concrete for a slump of 1" to 3". Consolidate by vibration for a slump less than 1".
Type A Meter:

Calibration instructions can be found at the end of this procedure.

- **Consolidation by Rodding:**

  Dampen the interior of the bowl. Place on a firm, level surface. Fill the bowl with concrete in three layers of approximately equal volume. Avoid overfilling the final layer.

  Rod each layer 25 times with the tamping rod. Rod the bottom layer through its full depth but do not forcibly strike the bottom. Rod the other two layers so that the rod penetrates approximately 1" through the layer below. Follow the rodding of each layer by sharply tapping the sides of the bowl 10 to 15 times with the mallet until the cavities left by rodding are leveled out and no large air bubbles appear on the surface of the rodded layer.

- **Consolidation by Vibration:**

  Place the concrete in the dampened measuring bowl in two equal layers. Place all concrete for each layer before vibrating. Avoid overfilling the final layer.

  Consolidate by three separate, evenly spaced insertions of the vibrator. Use care when removing the vibrator to avoid causing air pockets. Do not touch the bottom of the bowl when consolidating the first layer. The length of vibration needed will vary by workability of the concrete and equipment used. Do not over vibrate. Over vibration may cause segregation or loss of entrained air.

- **Strike-Off Procedure:**

  Either a strike-off plate or bar may be used to finish the surface.

  If using the strike-off bar, slide across the top flange using a sawing motion until the bowl is just full. Removing 1/8" is optimum. If the measure contains a large amount of concrete, use a scoop or trowel to remove a portion before striking off. A small quantity of representative concrete may be added to correct a deficiency.

  For the plate, place the strike-off plate on approximately two-thirds of the surface area, pull back and off using a sawing motion to finish only the area originally covered. Again place the plate on the bowl, covering the original area, and remove by pulling across untouched area.

- **Preparation for Test:**

  Thoroughly clean the flanges or rim of the bowl. Dampen the cover assembly to help ensure a pressure-tight seal is obtained.
Close the petcock at the bottom of the water glass and open the petcock and the funnel valve at the top. Add water over the concrete through the tube to the halfway mark in the standpipe. Incline the meter about 30° and pivot on the bottom of the bowl. Make several complete circles. Lightly tap the cover to remove air bubbles. Return to upright position and fill the water to slightly above the zero mark while tapping the sides of the bowl. Bring the water level to zero mark before closing the vent at the top of the water column.

Apply pressure with the pump and tap the sides of the measure sharply. When the gauge reads exactly the desired value as determined in the calibration section, read the subsidence of the water level and subtract the aggregate correction factor. The resulting value is the percentage of air in the concrete.

Gradually release the pressure by opening the top petcock and tap the sides of the bowl lightly for about 1 minute. Record the water level to the nearest division or half division.

- **Retest:**

  Repeat the steps without adding water to re-establish the water level at the zero mark. Two tests should be within 0.2% and shall be averaged.

  Remove the top and clean the apparatus at once and permit it to dry. It may be necessary to clean the water glass occasionally which, after removing the valve from the funnel valve assembly, may be done with a strip of cloth and one of the wire guards of the water glass. Oil the threads on the thumb screws and on the funnel valve occasionally.

  - Record reading as apparent air content to nearest 0.1%.

**Type B Air Meter**

- **Consolidation by Rodding:**

  Dampen the interior of the bowl. Place on a firm, level surface.

  Fill the dampened container with concrete in three equal layers. For each layer, rod 25 times with the tamping rod. Rod the bottom layer through its full depth but do not forcibly strike the bottom. Rod the other two layers so that the rod penetrates approximately 1" through the layer below. Follow the rodding of each layer by tapping the sides of the bowl 10 to 15 times with the mallet until the cavities left by rodding are leveled out and no large air bubbles appear on the surface of the rodded layer.
- **Consolidation by Vibration:**

  Place the concrete in the dampened measuring bowl in two equal layers. Place all concrete for each layer then vibrate that layer. Consolidate by three separate, evenly spaced insertions of the vibrator. Use care when removing the vibrator to avoid causing air pockets. Do not touch the bottom of the bowl when consolidating the first layer. The length of vibration needed will vary by workability of the concrete and equipment used. Do not overvibrate. Over vibration may cause segregation or loss of entrained air.

- **Strike-Off Procedure:**

  Either a strike-off plate or bar may be used to finish the surface.

  If using the strike-off bar, slide across the top flange using a sawing motion until the bowl is just full. Removing 1/8" is optimum. If the measure contains a large amount of concrete, use a scoop or trowel to remove a portion before striking off. A small quantity of representative concrete may be added to correct a deficiency.

  For the plate, place the strike-off plate on approximately two-thirds of the surface area, pull back and off using a sawing motion to finish only the area originally covered. Again place the plate on the bowl, covering the original area, and remove by pulling across untouched area.

- **Preparation for Test:**

  Wipe the contact surface clean, dampen, and clamp the top section of the apparatus firmly to the container. Close the air valve between the air chamber and the measuring bowl. Open both petcocks.

  Use a rubber syringe to inject water through one petcock until water comes through other petcock. Jar the meter gently to dispel all air from the same petcock.

  Close the air bleeder valve.

  Pump the air into the chamber until gauge hand is on the initial pressure line.

  Wait a few seconds and adjust the needle on the gauge to the initial pressure line by pumping up or bleeding off with the air release valve as needed and tapping the gauge lightly by hand.

  Close both petcocks. Open the air valve between the air chamber and the measuring bowl. Tap the sides of the bowl sharply with a mallet. Lightly tap the gauge by hand to stabilize the gauge hand.
Read the dial. Subtract the aggregate correction factor and record the results. The resulting value is the percentage of air in the concrete.

Close the main valve. Release the pressure. Empty and thoroughly clean the bowl, cover, and petcock openings.

Record reading as apparent air content to nearest 0.1%.

**DETERMINATION OF AGGREGATE CORRECTION FACTOR**

Determine the correction for air held within the particles of the aggregate at the beginning of the job. Although sufficiently accurate for the duration of work, "Check Determinations" from time to time are desirable. Determine the aggregate correction factor of the combined fine and coarse aggregate in approximately the same moisture condition, amount, and proportions occurring in the concrete. Prepare a sufficient amount of aggregate to fill the container and proceed as follows:

Fill the container about one-third full of water. Use a scoop to slowly pour a small amount of aggregate into the container. Add slowly to avoid trapping air. Additional water may be added if needed to keep all the aggregate covered. Tap the sides of the bowl and lightly rod the upper 1" of the aggregate about 8 to 12 times. Stir after each addition of aggregate to eliminate entrapped air. If air is entrapped between the particles, this test will show erroneous results.

Fill the container with water. Wipe the contact surfaces clean and clamp the top section of the apparatus firmly to the container.

Proceed according to instructions for the type of air meter you are using.

Read and record the subsidence of the water level. The subsidence of the water level is due to the air within the aggregate particles and is the correction factor to be applied in determining the air content of the concrete.

**CALCULATION OF AIR CONTENT**

Calculate the air content of concrete by subtracting the aggregate correction factor from the apparent air content.

\[ C = A - B \]

\[ A = \text{Apparent Air Content of Sample Tested} \quad (\%) \]
\[ B = \text{Aggregate Correction Factor} \quad (\%) \]
\[ C = \text{Air content of sample tested} \quad (\%) \]
CALIBRATION - TYPE A "ACME" AIR METER

The "Acme" air meter is designed to read in percentage of air entrained when the pressure gauge reads 15 psi. In cases where the pressure gauge is in error, however, determine a new pressure other than 15 psi to get the correct air content of the concrete.

To check if the pressure gauge is correct, first note the number and percentage value stamped on the calibration cylinder. Each air meter is furnished with a companion check cylinder. Both the cylinder and air meter have the same number and, to assure correct calibration, the cylinder from one air meter may not be used with any other air meter. Place the cylinder in the air meter pot with the open end down. Fill the container with water, clamp on the top of the air meter, and fill with water to the arrow mark.

Apply 15 psi pressure. The balance reading on the water glass should be within ±0.1% of that stamped on the calibration cylinder. If it is not, the pressure must be adjusted until the cylinder value is obtained. This pressure is noted and is used for all following air content determinations.

CALIBRATION - TYPE B "FORNEY" AIR METER

Supplied with each "Forney" air meter is a short piece of threaded straight tubing, a threaded curved tube, and a metal calibration vessel.

Fill the container full of water.

Screw the short piece of straight tubing into the threaded petcock hole on the underside of the cover. Clamp the cover on the base with the tube extending down into the water.

With both petcocks open, add water with the syringe through the petcock having the pipe extending below until all water is forced out the opposite petcock. Jar gently until all air is expelled. Leave both petcocks open.

Pump up the air pressure to a little beyond the predetermined initial pressure line on the gauge. Wait a few seconds for the compressed air to cool to normal temperature and then stabilize the gauge hand at the proper initial pressure line by pumping or bleeding off air as needed.

Close both petcocks and immediately press down on the thumb lever exhausting air into the base. Wait a few seconds until the gauge is stabilized. If all the air was eliminated and the initial pressure line was correctly selected, the gauge
should read 0%. If two or more tests show a consistent variation from 0% in the result, then change the initial pressure line to compensate for the variation. Use the newly established initial pressure line for subsequent tests.

Screw the curved tube into the outer end of the petcock, and by pressing on the thumb lever and controlling the flow with the petcock lever, fill the 5% calibrating vessel (345 mL) level full with water from the base.

Release the air at the free petcock. Open the other petcock and let the water in the curved pipe run back into the base. There is now 5% air in the base. With the petcocks open, pump the air pressure in the exact manner as outlined in paragraph 4. Close the petcocks and immediately press the thumb lever. Wait a few seconds for the needle to stabilize. The dial should now read 5%.

If two or more readings show that the gauge reads incorrectly at 5% air in excess of 0.2%, then remove the gauge glass and readjust the gauge to 5% by turning the recalibrating screw located just below the center of the dial.

When the gauge reads correctly at 5%, additional water may be withdrawn in the same manner to check results at 10%, 15%, 20%, etc.
ND T 166 - BULK SPECIFIC GRAVITY OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS

Conduct this procedure according to ND T 166, Method A.

The AASHTO standard test procedure specifies cores to be immersed for 4±1 minutes. The NDDOT modification specifies cores to be immersed for 3 to 3½ minutes.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test procedure determines the bulk specific gravity of specimens of compacted asphalt mixtures.

REFERENCED DOCUMENTS

AASHTO T 166, Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
AASHTO T 275, Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
AASHTO T 331, Bulk Specific Gravity and Density of Hot Mix Asphalt Using Automatic Vacuum Sealing Method

APPARATUS

Balance, readable to 0.1% of the sample weight
Suspension apparatus
Water bath with overflow outlet
Damp towel

TEST SPECIMEN

Test specimens may be either laboratory molded or cores taken from HMA pavements. They shall be free from foreign material such as seal coat, tack coat, or foundation material. Layers may be separated by sawing or other suitable means with care taken not to damage the specimen. Laboratory molded specimens may be cooled by a fan.
PROCEDURE

Record all weights to the nearest 0.1 g.

Dry the specimens to constant weight.

Samples saturated with water shall be initially dried overnight at 125 ± 5°F (52 ± 3°C) then weighed at two-hour intervals. Recently molded laboratory specimens which have not been exposed to moisture do not require drying.

Cool the specimens to 77 ± 9°F (25 ± 5°C) and weigh each specimen. Record this mass as specimen in air.

Immerse each specimen in water at 77 ± 1.8°F (25 ± 1°C) suspended beneath a balance for a period of 3 to 3½ minutes. Record this mass as specimen in water.

Remove the specimen from the water and surface dry by blotting with a damp towel. Weigh the mass as quickly as possible and record as surface-dry specimen in air.

CALCULATIONS

To calculate the bulk specific gravity, use the following formula:

\[
Bulk \; Specific \; Gravity \; (G_{mb}) = \frac{A}{(B - C)}
\]

\[
A = \text{Weight in grams of the specimen in air}
\]

\[
B = \text{Weight in grams, surface dry}
\]

\[
C = \text{Weight in grams, in water}
\]

Report the bulk specific gravity to the nearest 0.001.

The bulk specific gravity may be used to calculate the unit weight of the specimens by multiplying by 62.4. The results are in lbs/cu.ft.

Calculate the percent of water absorbed by the specimen (on a volume basis) as follows:

\[
\text{Percent of water absorbed by volume} = \left[ \frac{(B - A)}{(B - C)} \right] \times 100
\]

If the percent of water absorbed by the specimen exceeds 2%, use AASHTO T 275 or AASHTO T 331 to determine the bulk specific gravity.
NOTES

Constant weight is defined as when further drying does not change the weight by more than 0.05% at two-hour intervals.

Terry cloth has been found to work well for an absorbent cloth. Damp is considered to be when no water can be wrung from the towel.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
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ND T 176 – PLASTIC FINES IN GRADED AGGREGATES AND SOILS
BY USE OF THE SAND EQUIVALENT TEST

Conduct this procedure according to ND T 176, Alternate Method 2

Consult the current edition of AASHTO for procedure in its entirety and
equipment specification details.

SCOPE

This test is intended to serve as a rapid field test to show the relative
proportions of fine dust or claylike material in soils or graded aggregates.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling of Aggregates
AASHTO T 176, Plastic Fines in Graded Aggregates and Soils by
Use of the Sand Equivalent Test
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to
Testing Size

APPARATUS

Pan
Trowel
Damp cloth
Plastic splitting cloth
3-oz. sample tins
Spatula or straightedge
Graduated plastic cylinder
Stock calcium chloride solution
Funnel
Clock or stop watch
Rubber stopper
Mechanical sand equivalent
Shaker
Irrigation tube
Weighted foot assembly
No. 4 sieve (4.75 mm)

TEST SPECIMEN

Obtain a sample according to ND T 2. Thoroughly mix and reduce according
to ND T 248.

Test specimen should be approximately 1000 to 1500 g of unwashed soil or
graded aggregate that passes the No. 4 sieve. All aggregations of fine
grained soil should be pulverized to pass the sieve and all fines shall be
cleaned from the particles retained on the sieve and then included with the
material passing.
SAMPLE PREPARATION

Place the sample in the pan and use a trowel to mix. Add just enough water so that when a small portion of the sample is squeezed tightly a cast is formed. If the cast can be carefully handled without breaking, the correct moisture has been obtained. If the cast crumbles it will be necessary to add water and remix. If free water is visible the sample is too wet and must be drained and air dried.

Cover the sample with a damp cloth and let stand for a minimum of 15 minutes. Do not allow the cloth to touch the material.

If the original sample allows a cast without adding water, you may omit the 15 minute standing period and proceed with the test.

After the standing period, place the sample on a splitting cloth and mix by alternately lifting each corner of the cloth and pulling it over the sample toward the diagonally opposite corner, causing the material to be rolled. When the material appears homogeneous, finish the mixing with the sample in a pile near the center of the cloth.

Using one hand, push the 3-oz. tin through the base of the pile. Hold the other hand on the opposite side of the pile to cause the material to fill the tin. Press firmly with the palm to compact the maximum amount into the tin. Press off the top of the tin with a spatula or straightedge to create a level surface. Cover the sample.

Mix the remaining material on the splitting cloth as previously mixed, and again finish the mixing with the sample in a pile near the center of the cloth. Obtain a second sample using the same procedure as used to obtain the first sample.

Siphon 4 ± 0.1" (101.6 ± 2.5 mm) of calcium chloride solution into the graduated cylinder.

PROCEDURE

Record all information on SFN 51730. Record readings to 0.1.

The complete procedure will be run twice. The results of each test will be averaged. The average is reported as the sand equivalent.

Using a funnel, pour the sample from the tin into the cylinder. Tap the bottom of the cylinder sharply with the heel of the hand several times to remove air bubbles. Allow the wetted specimen to stand undisturbed for 10 ± 1 minutes.
Stopper the cylinder and shake gently to loosen the material. This can be achieved by partially inverting the cylinder and shaking it simultaneously. After loosening the material, place the cylinder in a mechanical shaker for 45 ± 1 seconds.

Following the shaking, set the cylinder upright and remove the stopper. Using the irrigation tube, rinse material on the cylinder wall down with the calcium chloride solution as the irrigation tube is being lowered in the cylinder. Force the irrigation tube through the material to the bottom of the cylinder using a gentle stabbing and twisting motion. Continue to gently stab and twist the irrigation tube until the calcium chloride solution approaches the 15" (381 mm) mark. Then raise the irrigation tube slowly at a rate that maintains the liquid level at about the 15" (381 mm) mark as the irrigation tube is being removed. Stop the flow of the calcium chloride solution just before the irrigation tube is entirely withdrawn. Adjust the calcium chloride solution level to 15".

Allow the cylinder to sit undisturbed for 20 minutes ± 15 seconds. Read the level of the top of the clay suspension. This is referred as the clay reading. If no clear line is visible, allow the sample to stand for up to 10 more minutes. If the line is still not clear, discard the sample and rerun the test with three samples from the same material. Read and record the clay column height requiring the shortest sedimentation period only.

Next determine the sand reading. This is done by gently lowering the weighted foot into the cylinder until it comes to rest. Take the reading of the extreme top edge of the indicator and subtract 10" from this value to obtain the sand reading. Record this as the sand reading.

Report the clay and sand readings to the nearest 0.1 of an inch. If the reading falls between the 0.1 of an inch graduations, report to the next higher reading.

Repeat this process for the second sample obtained and record the clay and sand readings.

CALCULATIONS

Calculate the sand equivalent by dividing the sand reading by the clay reading and multiply the results by 100. The equation is as follows:

\[ \text{Sand Equivalent} = \left( \frac{\text{Sand reading}}{\text{Clay reading}} \right) \times 100 \]

Complete the calculations for both tests. If the calculated sand equivalent is not a whole number, round up to the next higher whole number.
REPORT

Average the two test results. If the average is not a whole number, raise it to the next whole number.

NOTES

A one-gallon bottle of calcium chloride solution shall be placed on a shelf 36 ± 1" above the work surface.

Prepare the calcium chloride solution by diluting one measuring tin (85 ± 5 mL) of stock calcium chloride to 1 gal. (3.8 L) of distilled or demineralized water. The working solution has a maximum shelf life of 30 days.

The temperature of the calcium chloride solution should be maintained at 72 ± 5°F (22 ± 3°C).

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
ND T 191 – DENSITY OF SOIL IN-PLACE BY THE SAND CONE METHOD

Conduct this procedure according to ND T 191.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This method covers the determination of the in-place density of compacted soil or soil-aggregate mixtures. The in-place dry density is expressed as a percentage of the soils maximum dry density and can be compared to specification requirements.

REFERENCED DOCUMENTS

AASHTO T 19, Bulk Density (“Unit Weight”) and Voids in Aggregate
AASHTO T 191, Density of Soil In-Place by the Sand Cone Method
ND T 265 and AASHTO T 265, Laboratory Determination of Moisture Content of Soils
ASTM D 4643, Determination of Moisture Content of Soil by the Microwave Oven Method

APPARATUS

- Sand density apparatus and base plate
- Clean, free-flowing sand consisting of -No.10 +No.200
- Balance, readable to 0.1 grams
- Pins, shovel, trowel, spoon, hammer, and knife
- Auger, 4” diameter
- Sealable container

EQUIPMENT PREPARATION

Filling the apparatus

1. Place the empty apparatus upright on a firm level surface, close the valve and fill the funnel with sand.

2. Open the valve and keep the funnel at least half full with sand during filling. When the sand stops flowing into the apparatus, close the valve sharply and empty the excess sand.

3. Determine and record the mass of the apparatus filled with sand ($m_1$).
Determining the mass of sand required to fill the funnel and base plate (Cone Correction)

1. Place the base plate on a clean, level, plane surface. Invert the sand cone filled with sand, and seat the funnel in the recess of the base plate.

2. Open the valve fully and allow the sand to flow until the sand stops flowing.

3. Close the valve sharply, remove the apparatus, and determine the mass of the apparatus and the remaining sand \((m_2)\).

4. The mass of sand required to fill the cone and base plate is calculated by the difference between the initial mass and final mass. Record this mass as the cone correction:

\[
(C_c = m_1 - m_2).
\]

Where:
- \(C_c\) = Cone correction
- \(m_1\) = Mass of the apparatus filled with sand
- \(m_2\) = Mass of the apparatus and remaining sand

Notes:

- For each container/bag of sand there will be a unique cone correction and sand calibration factor. Each sand-cone and matched base plate will also have a set of unique cone corrections and bulk sand densities. If more than one sand-cone apparatus is available, the sand-cone and base plate should be marked and the associated correction/density factors recorded.

- Vibration of the sand during any mass-volume determination may increase bulk density of the sand and decrease the accuracy of the determination. Appreciable time intervals between the bulk density determination of the sand and its use in the field may result in change in the bulk density caused by a change in the moisture content or effective gradation.

Determining the bulk density of sand \((D_B)\)

1. Replace the sand removed in the funnel determination according to the procedure for filling the apparatus, close the valve, and determine the mass of the apparatus and sand \((m_3)\).

2. Position the calibration container on a clean, level, plane surface. Place the base plate on the calibration container. Invert the apparatus and seat the funnel in the recess of the base plate.

3. Open the valve fully and keep open until the sand stops flowing.
4. Close the valve sharply, remove the apparatus and determine the remaining mass of the apparatus and sand \((m_4)\).

5. Calculate the mass of the sand needed to fill the container, funnel and base plate. Subtract the final mass (Step 4), from the initial mass (Step 1).

6. The mass of the sand needed to fill the container only is determined by subtracting the mass of the cone correction (Step 4) from the total mass required to fill the container with the funnel and base plate (Step 5).

7. Determine the bulk density of the calibration sand (sand calibration factor). Divide the mass of the sand needed to fill the container (Step 6), by the volume of the calibration container as determined according to AASHTO T 19.

\[
DB = \frac{(m_3 - m_4 - CC)}{VC}
\]

Where:
- \(DB\) = Bulk density of the sand in g/cm\(^3\)
- \(m_3\) = Mass of the apparatus and sand
- \(m_4\) = Remaining mass of the apparatus and the sand
- \(CC\) = Cone correction
- \(VC\) = Volume of the calibration container

8. Record this factor for future reference.

**PROCEDURE**

All information is recorded on SFN 59725 and SFN 59724.

Fill testing apparatus with sand and record the total mass.

Select the area of compacted lift to be tested. Because the surface of a compacted area is generally loose or disturbed due to compaction operations, remove loose material and level off an area slightly larger than the base plate.

Place the base plate over the smoothed area and fasten down with the accompanying pins. Plate must stay in this position and be stable throughout the test.

Dig a test hole within base plate opening, with the auger, trowel, or other tools. Soils that are granular require extreme care and may require the digging of a conical-shaped hole. Place all of the loosened material from the hole into an aggregate balance pan, or a moisture-tight container if not weighed right away.
**Minimum Test Hole Volumes and Moisture Content Samples Based on Maximum Size**

<table>
<thead>
<tr>
<th>Maximum Particle Size</th>
<th>Minimum Test Hole Volume</th>
<th>Minimum Sample Size for Moisture Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>0.025 ft³</td>
<td>100 g</td>
</tr>
<tr>
<td>1/2&quot; (12.5 mm)</td>
<td>0.050 ft³</td>
<td>250 g</td>
</tr>
<tr>
<td>1&quot; (25.0 mm)</td>
<td>0.075 ft³</td>
<td>500 g</td>
</tr>
<tr>
<td>2&quot; (50.0 mm)</td>
<td>0.100 ft³</td>
<td>1000 g</td>
</tr>
</tbody>
</table>

Place testing apparatus on the base plate and open valve. After the sand has stopped flowing, close the valve; remove apparatus, and record final mass.

Weigh the wet soil or soil-aggregates removed from the hole to the nearest 0.01 lbs and record.

Use a representative portion of the soil for moisture determination. Do not use material containing particles large enough to be retained on the No. 4 (4.75 mm) sieve. Moisture can be determined by the use of ND T 265 or ND D 4643. Calculate moisture to nearest 0.1%.

**CALCULATIONS**

Complete calculations as follows:

- \((V_H)\) **Volume of Test Hole** = \((\text{Initial Mass} - \text{Final Mass} - C_C)/D_B\)

  Calculate the volume of test hole to the nearest 0.0001 ft³.

- \((M_{DS})\) **Dry Mass of Material removed from test hole** = \((\text{Moist Mass removed from test hole}/[1 + (% moisture /100)])\)

  Calculate dry mass of material to the nearest 0.01 lbs.

- \((D_D)\) **Dry Density** = \(M_{DS}/V_H\)

  Calculate in-place dry density to the nearest 0.1 lbs/ft³.

**CALIBRATION**

All new devices should be calibrated prior to being used. A calibration check should be performed annually as a minimum, or whenever damage or repair occurs.
ND T 209 - THEORETICAL MAXIMUM SPECIFIC GRAVITY
AND DENSITY OF HOT MIX ASPHALT

Conduct this procedure according to ND T 209.

The AASHTO standard test procedure specifies flasks are agitated for 15 ± 2 minutes and, after agitation, the flasks are immersed in water for 10 ± 1 minutes. The NDDOT modification specifies flasks to be agitated for 15 minutes ± 30 seconds and, after agitation, the flasks are immersed in water for 10 minutes ± 30 seconds.

AASHTO allows for a wetting agent such as Aerosol OT to facilitate the release of entrapped air. NDDOT does not allow any wetting agent.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test determines the theoretical maximum specific gravity and density of uncompacted bituminous paving mixtures at 77°F (25°C).

REFERENCED DOCUMENTS

NDDOT 5, Sampling and Splitting Field Verification Hot Mix Asphalt (HMA) Samples
AASHTO T 209, Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt

APPARATUS

Vacuum container
Volumetric flasks,* two at 2000 mL each
Vacuum gage, capable of measuring 30 mm Hg (4 kPa)
Vacuum pump, capable of evacuating air from a flask to a pressure of 30 mm Hg (4 kPa)
Thermometers
Water bath
Orbital shaker
Pan
Glass cover plate
Balance

*Flasks shall be sufficiently strong to withstand a partial vacuum and shall have a cover fitted with a rubber stopper with a hose connection. A smooth
piece of fine wire mesh covering the hose opening will minimize the possibility of loss of fine material. The top surfaces of the flasks shall be smooth and substantially plane.

TEST SPECIMEN

Material used for this test procedure may be obtained from behind the paver as outlined in NDDOT 5, or from laboratory prepared samples. An approximate 2000 g sample of hot mix asphalt is needed.

PROCEDURE

Weigh and record all masses to the nearest tenth of a gram on SFN 7925.

Cure laboratory prepared samples in an oven at 275 ± 9°F (135 ± 5°C) for a minimum of 2 hours or until constant** mass is achieved.

Paving mixtures that have not been prepared in a laboratory with oven-dried aggregates shall be dried to constant** mass at a temperature of 221 ± 9°F (105 ± 5°C).

**Constant is defined as when mass repeats within 0.1%.

Determine the weight of each flask full of distilled water, with a matching glass plate, at a temperature of 77 ± 1°F (25 ± 0.5°C).

To obtain the weight, overfill the flask so the water is convexed above the brim. Then slide the cover plate over the brim of the flask. The flask should be free of any air bubbles. Dry the outside. Weigh and record.

Spread in a large pan. Cool to room temperature. While this mixture is cooling, periodically, carefully separate the particles so that clumps of the fine aggregate portion are no larger than 1/4” (6.3 mm).

Place the flask on a scale and tare the scale. Place half of the hot mix asphalt sample in the flask and weigh. After recording weight, add sufficient distilled water that is at approximately 77°F to cover the sample completely. Repeat this process with the remaining half of the material using the second flask.

Remove entrapped air by subjecting the contents of both flasks to a partial vacuum of 30 mm Hg (4 kPa). Maintain the partial vacuum and agitate the containers and contents with an orbital shaker that is set at 225 to 250 rpm with a 3/4" throw for 15 minutes ± 30 seconds.

Note: Problems have been encountered with some mixes clumping and forming a mass instead of freely moving particles during the 15-minute agitation period. If this happens, it is probable that all the
entrapped air will not be removed. (This is more likely to happen when the sample is not adequately cooled before putting it in the flasks). The mix will have to be broken up before agitation continues. This can be done by:

- Shutting off the vacuum to the flask while keeping the vacuum pump running.
- Maintain all hose connections.
- Vigorously hand shake the flask until the sample is free moving.
- Take care so vacuum is not lost to the flask.
- Return the flask to the shaker and turn on the vacuum to the flask.
- Do not stop the timer through this procedure.

After removing from orbital shaker, release the vacuum by increasing the pressure at a rate not to exceed 60 mm Hg (8 kPa) per second. Remove flasks from shaker. Fill flasks (slightly overfill) with distilled water that is at a temperature of 77 ± 1°F (25 ± 0.5°C). Place in a water bath at a temperature of 77 ± 2°F (25 ± 1°C) for 10 minutes ± 30 seconds.

Remove from water bath, slide the glass cover plate over the flask, and remove from the bath. Dry the outside. Weigh and record.

Flask Calibration

Determine the weight of each flask full of distilled water, with a matching glass plate, at a temperature of 77±1°F (25±0.5°C).

To obtain the weight, overfill the flask so the water is convexed above the brim. Then slide the cover plate over the brim of the flask. The flask should be free of any air bubbles. Dry the outside. Weigh and record.

**CALCULATIONS**

The theoretical maximum specific gravity weight in air is calculated as follows:

\[
\text{Theoretical Maximum Specific Gravity} = \frac{A}{A + D - E}
\]

\[
A = \text{mass of oven-dry sample in air}
\]

\[
D = \text{mass of container filled with water at 77°F (25°C)}
\]

\[
E = \text{mass of container filled with sample and water at 77°F (25°C)}
\]
The difference in maximum specific gravity results of two properly conducted tests on the same sample shall not exceed 0.011. Use the average of the results from the two flasks of the passing test for the final maximum specific gravity.

If the difference exceeds 0.011, rerun the test.

NOTES

The specified cure time in the oven is a minimum of two hours for laboratory prepared specimens only. Plant produced materials should not be cured since absorption takes place during production.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
ND T 217 - DETERMINATION OF MOISTURE IN SOIL BY MEANS OF CALCIUM CARBIDE GAS PRESSURE MOISTURE TESTER (SPEEDY)

Conduct this procedure according to ND T 217.

The AASHO standard test procedure specifies for the moisture content to be recorded to the nearest whole number. The NDDOT modification specifies the moisture content to be recorded to the nearest 0.1.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test used to determine the moisture content of soils by means of a calcium carbide gas pressure moisture tester in the field. The tester is referred to as the “Speedy”. This method shall not be used for granular material having particles retained on the No. 4 (4.75 mm) sieve.

Use care when performing this test and working with the calcium chloride reagent. The reagent has an expiration date and should be verified before using. Tightly close reagent cans when not in use.

Use DOT 13942, “Conversion Chart for the Speedy Tester,” to convert the reading on the tester dial.

REFERENCED DOCUMENTS

AASHTO T 217, Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy)
ND T 265 and AASHTO T 265, Laboratory Determination of Moisture Content of Soils

APPARATUS

Calcium carbide pressure moisture tester, “Speedy,” which includes a balance, steel balls, and cleaning brush.

Calcium carbide reagent and scoop to measure reagent.

PROCEDURE

Instructions are written for a 20 to 26 g tester. There are various models of the “Speedy” in use with slight variations in instructions. Some models include 1.25"
steel balls, others use 1" steel balls. Manufacturer’s instructions may tell you to put the reagent in the body, others the cap. Either method may be used as long as the soil and reagent are not mixed before securing the cover.

Read and follow ND T 217 and the manufacturer’s instructions to conduct this test.

The following describes the ND T 217 method for conducting the test.

- Before beginning the test, verify the inside of the body and cap are free from residue of any previous test.

- Place the steel balls into the body.

- Take three full measures of reagent and place in body of vessel. For bulky materials, use three to five measures to ensure adequate coverage.

- Measure your sample. The sample size needed is determined by the manufacturer of your tester.

- Your tester kit may have an electronic balance or a beam balance. For a beam balance, lift into an upright position and add material to the pan. The correct amount of material is determined when the red markings on the balance and beam coincide.

- Place the sample in the cover of the “Speedy”.

- Hold the “Speedy” in a horizontal position and place the cover on the end. Bring the stirrup in position and tighten. This should be completed without the sample and reagent coming in contact with each other.

- Hold vertically so that the material in the cap falls into the “Speedy” body. Return the instrument to a horizontal position, shake to break all lumps, and mix the soil and reagent. Shake with a rotating motion to put the steel balls into ‘orbit’ around the inside circumference. Rotate for 10 seconds, rest for 20 seconds. The rest time allows for dissipation of the heat generated by the chemical reaction. Continue this cycle for a minimum of 3 minutes.

- When the needle stops moving, hold the instrument horizontal at eye level with the dial facing you. Read and record the dial reading to the nearest 0.1.

- Hold tester away from your body. Point the directional release away from you and anyone else, then slowly release the pressure. Avoid breathing the fumes. Empty the contents and examine for lumps. If material contains lumps, repeat the test.
• Thoroughly clean the tester with the brush provided.

CALCULATIONS

The dial reading is percent moisture by wet mass and needs to be converted to dry mass using form DOT 13942.

REPORT

Report the percent moisture to the 0.1%.

NOTES

If the moisture content of the soil sample is greater than the ability for the gauge to read, run the test using a one-half size sample. The dial reading is multiplied by two and then converted to dry mass using DOT 13942.

CALIBRATION

Calibration is to be done annually as a minimum, and whenever damage or repair occurs. This can be accomplished by comparing the “Speedy” results to a sample oven-dried according to ND T 265. Calibration will result in verifying DOT 13942, “Conversion Chart for the Speedy Tester.”
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ND T 224 – CORRECTION FOR COARSE PARTICLES IN
THE SOIL COMPACTION TEST

Conduct this procedure according to ND T 224.

The NDDOT requires the use of Method A or D when conducting moisture-density relation tests, therefore, a correction is required for the oversize removed.

When Method D is used, a correction shall be applied to soil-aggregates which contain more than 5% by weight of oversize. When the oversized maximum of 30% is exceeded, other methods of compaction control must be used.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This method describes a procedure for adjusting densities of soil and soil-aggregates to compensate for differing percentages of oversize particles retained on the 19.0 mm (3/4") sieve.

REFERENCED DOCUMENTS

ND T 99 and ND T 180 and AASHTO T 99 and T 180, Moisture Density Relations of Soils
AASHTO T 224, Correction for Coarse Particles in the Soil Compaction Test
ND T 265 and AASHTO T 265, Laboratory Determination of Moisture Content of Soils
ND D 4643 and ASTM D 4643, Determination of Moisture Content of Soil by Microwave Oven Heating

CALCULATIONS

Calculate the Corrected Moisture Content (MC_T)

\[ MC_T = \frac{[(MC_F) \times (P_f) + (MC_c) \times (P_c)]}{100} \]

Where:

- \( MC_T \) = corrected moisture content of combined fine and oversized particles, expressed as a percentage of moisture.
- \( MC_F \) = moisture content of fine particles, expressed as a percentage of moisture.
- \( MC_c \) = moisture content of oversized particles, expressed as a percentage of moisture.
of moisture (2.0%).

- $P_f =$ percent of fine particles, by weight.
- $P_c =$ percent of coarse particles, by weight.

Calculate moisture content to nearest 0.1%.

**Example of Calculation of Corrected Moisture Content:**

$$10.5\% = \frac{(12.0 \times 85) + (2.0 \times 15)}{100}$$

**Calculate the Corrected Dry Density of the Total Sample ($D_d$)**

$$D_d = 100 \times (D_f) \times (k)/[(D_f) \times (P_c) + (k) \times (P_f)]$$

Where:

- $D_d =$ corrected dry density of combined fine and oversized particles, expressed as lbs/ft$^3$.
- $D_f =$ dry density of fine particles expressed as lbs/ft$^3$, determined in lab.
- $P_c =$ percent of coarse particles, by weight.
- $P_f =$ percent of fine particles, by weight.
- $k =$ 62.4$^*$ Bulk Specific Gravity (2.650).

Calculate in-place dry density to the nearest 0.1 lbs/ft$^3$.

**Example of Calculation of Corrected Dry Density:**

$$127.2 \text{ lbs/ft}^3 = 100 \times 122.0 \times 165.4 / [(122.0 \times 15) + (165.4 \times 85)]$$

**NOTES**

Unless the actual moisture content of the oversize particles is known, 2.0% shall be used in calculating corrected moisture. Unless the actual bulk specific gravity of the oversize is known, 2.650 shall be used in calculating corrected dry density.

Each dry density and moisture content shall be calculated and plotted to determine optimum moisture content and maximum dry density, as specified within ND T 99 and ND T 180.
ND T 245 - RESISTANCE TO PLASTIC FLOW OF BITUMINOUS MIXTURES USING MARSHALL APPARATUS

Conduct this procedure according to ND T 245.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details

SCOPE

This procedure is used to prepare cylindrical specimens of bituminous paving mixture loaded on the lateral surface by means of a Marshall apparatus.

REFERENCED DOCUMENTS

NDDOT 5, Sampling and Splitting Field Verification Hot Mix Asphalt (HMA) Samples

APPARATUS

Mold cylinders, base plate and extension collars
Triple compaction hammer and apparatus
Compaction pedestal
Extrusion jack
Oven or hot plate
Fan (optional)
Balance
Paper disks
Spoons
Spatula
Colored grease pencil
Pans
Mixing Bowl
Mechanical mixing apparatus
Thermometers
Gloves
Breaking head
Marshall Stability machine
Water bath

TEST SPECIMEN

Material used to prepare at least three specimens may be obtained from behind the paver as outlined in NDDOT 5.
PROCEDURE

Heat the sample in an oven to 270 ± 5°F.

Heat the molds and hammer faces to a temperature between 200° to 300°F (93° to 149°C). Once heated, the hammer may be placed in a sand bath or on a hot plate to maintain the temperature.

Enough material shall be used that will result in a compacted specimen 2.5 ± 0.05" (63.5 ± 1.27 mm) in height. This will take approximately 1200 g.

Assemble the mold and collar on the base plate. Place the assembled mold on a scale and place a paper disk in the bottom of the mold. Add approximately 1200 g of mix into the mold.

Position the mold assembly on the mold holder of the triple Marshall Mix compaction machine. Using a heated spatula, spade around the outer perimeter of the mold 15 times. Then spade the interior portion of the mix 10 times.

Form the top of the mix into a smooth, slightly-rounded mound. Place a paper disk on the top of the mix.

Repeat the same steps for the two remaining molds.

Position and attach the Marshall hammers. Verify that the machine counter is set for the correct number of blows required by the mix design. This may be either 50 or 75 blows with the compaction hammer having a free fall of 18". Push the start button on the counter and wait for the machine to complete its blows.

Remove the base plate and collar. Turn the molds over and reassemble the mold with the base plate and collar. Apply the same number of compaction blows as on the reverse side.

When the compaction blows are complete, remove the hammers from the apparatus. Take the molds off the bases and remove the paper disks. Keep the last side compacted facing up.

Mark the specimens on the last side compacted at each asphalt content with a colored grease pencil. As an example, mark them 5-A, 5-B, or 5-C.

Position the mold in the extrusion jack. With the last side pounded facing up, remove the specimen from the mold and set it aside on a smooth, flat surface at room temperature overnight. A fan can be used for rapid cooling if necessary.
TESTING FLOW AND STABILITY OF A SPECIMEN

If the specimens are to be tested for plastic flow, place the specimens in a water
bath 30 to 40 minutes or in an oven for 2 hours. Maintain the bath or oven at 140
± 1.8°F (60 ± 1°C).

The testing head apparatus temperature shall be between 70° to 100°F
(21.1 to 37.8°C).

Guide rods shall be thoroughly clean and lubricated so that the upper test head
slides freely over them.

Remove the specimen from the water bath or oven and place in the lower
segment of the breaking head. Place the upper segment of the breaking head on
the specimen and insert assembly into the compression machine. Adjust the
measuring dial to zero in the proving ring to measure maximum load and place
the flow meter dial on a guide rod to measure flow.

Apply the load to the specimen with a constant rate of movement for the testing
machine head of 2" (50.8 mm) per minute until the maximum load is reached.
When applying load hold when maximum load is reached, obtain the dial reading
in the proving ring and remove the flow meter dial from its location. Record both
values.

The elapsed time for the test from removal of the test specimen from the water
bath to the maximum load determination shall not exceed 30 seconds.

CALCULATIONS

To determine the stability of the specimen, the dial reading is converted to a
maximum load by a chart supplied with the compression machine.

When core specimens vary from the 2.5" depth, a correction factor must be
applied to the maximum load.

To determine stability, use the following formula:

\[ Stability = \text{Maximum Load} \times \text{Correction Factor} \]

Stability is recorded to the nearest whole number.

Flow is a direct reading of the flow meter dial and recorded to 0.01".
Correction factors are found in the following table.

**CORRECTION FACTOR TABLE**

<table>
<thead>
<tr>
<th>Volume of Specimen (cm³)</th>
<th>Thickness of Specimen (in.)</th>
<th>mm</th>
<th>Correlation Ratio</th>
<th>Volume of Specimen (cm³)</th>
<th>Thickness of Specimen (in.)</th>
<th>mm</th>
<th>Correlation Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 to 213</td>
<td>1</td>
<td>25.4</td>
<td>5.56</td>
<td>406 to 420</td>
<td>2</td>
<td>50.8</td>
<td>1.47</td>
</tr>
<tr>
<td>214 to 225</td>
<td>1 1/16</td>
<td>27.0</td>
<td>5.00</td>
<td>421 to 431</td>
<td>2 1/16</td>
<td>52.4</td>
<td>1.39</td>
</tr>
<tr>
<td>226 to 237</td>
<td>1 1/8</td>
<td>28.6</td>
<td>4.55</td>
<td>432 to 443</td>
<td>2 1/8</td>
<td>54.0</td>
<td>1.32</td>
</tr>
<tr>
<td>238 to 250</td>
<td>1 3/16</td>
<td>30.2</td>
<td>4.17</td>
<td>444 to 456</td>
<td>2 3/16</td>
<td>55.6</td>
<td>1.25</td>
</tr>
<tr>
<td>251 to 264</td>
<td>1 1/4</td>
<td>31.8</td>
<td>3.85</td>
<td>457 to 470</td>
<td>2 1/4</td>
<td>57.2</td>
<td>1.19</td>
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<td>265 to 276</td>
<td>1 5/16</td>
<td>33.3</td>
<td>3.57</td>
<td>471 to 482</td>
<td>2 5/16</td>
<td>58.7</td>
<td>1.14</td>
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<td>277 to 289</td>
<td>1 3/8</td>
<td>34.9</td>
<td>3.33</td>
<td>483 to 495</td>
<td>2 3/8</td>
<td>60.3</td>
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<td>290 to 301</td>
<td>1 7/16</td>
<td>36.5</td>
<td>3.03</td>
<td>496 to 508</td>
<td>2 7/16</td>
<td>61.9</td>
<td>1.04</td>
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<td>302 to 316</td>
<td>1 1/2</td>
<td>38.1</td>
<td>2.78</td>
<td>509 to 522</td>
<td>2 1/2</td>
<td>63.5</td>
<td>1.00</td>
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<tr>
<td>317 to 328</td>
<td>1 9/16</td>
<td>39.7</td>
<td>2.50</td>
<td>523 to 535</td>
<td>2 9/16</td>
<td>65.1</td>
<td>0.96</td>
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<td>329 to 340</td>
<td>1 5/8</td>
<td>41.3</td>
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<td>2 5/8</td>
<td>66.7</td>
<td>0.93</td>
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<td>341 to 353</td>
<td>1 11/16</td>
<td>42.9</td>
<td>2.08</td>
<td>547 to 559</td>
<td>2 11/16</td>
<td>68.3</td>
<td>0.89</td>
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<td>354 to 367</td>
<td>1 3/4</td>
<td>44.4</td>
<td>1.92</td>
<td>560 to 573</td>
<td>2 3/4</td>
<td>69.9</td>
<td>0.86</td>
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<td>368 to 379</td>
<td>1 13/16</td>
<td>46.0</td>
<td>1.79</td>
<td>574 to 585</td>
<td>2 13/16</td>
<td>71.4</td>
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<td>380 to 392</td>
<td>1 7/8</td>
<td>47.6</td>
<td>1.67</td>
<td>586 to 598</td>
<td>2 7/8</td>
<td>73.0</td>
<td>0.81</td>
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<td>393 to 405</td>
<td>1 15/16</td>
<td>49.2</td>
<td>1.56</td>
<td>599 to 610</td>
<td>2 15/16</td>
<td>74.6</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>611 to 625</td>
<td>3</td>
<td>76.2</td>
<td>0.76</td>
</tr>
</tbody>
</table>

**NOTES**

Put the compaction hammers on the Marshall machine by attaching them to the pins at the top of the pedestal. There is a hook on one side of the hammer. This hook must be attached to the chain drive on the machine to maintain the proper sequence.

**CALIBRATION**

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
ND T 248 – REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

Conduct this procedure according to ND T 248.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This method covers the reduction of large samples of aggregate to the appropriate size for testing. Techniques used should minimize variation in measured characteristics between the test samples selected and the entire sample. The end product should be a sample representative of the source.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling Aggregates
AASHTO T 248, Reducing Samples of Aggregate to Testing Size

APPARATUS

Sample splitter
Straightedge shovel
Broom
Canvas or cloth
Brush

TEST SPECIMEN

Obtain sample according to ND T 2.

PROCEDURE

Two methods for reducing a sample are acceptable and either method may be used. A mechanical splitter is faster and more convenient than quartering. When reducing a sample by either method, do not attempt to obtain a sample of a predetermined weight. Divide and re-divide a large sample until the size of sample is within a desired range.
“Method A” - Mechanical Splitter

Sample splitter shall have an even number of equal width chutes, but not less than a total of eight for coarse aggregate, or 12 for fine aggregate. The chutes must discharge alternately to each side of the splitter. For coarse aggregate and mixed aggregate, the minimum chute width shall be approximately 50% larger than the largest particle in the sample to be split. For dry fine aggregate with 100% passing the 3/8" sieve, use a splitter with chutes 1/2" to 3/4" wide.

Use a splitter with two receptacles and a hopper or straight-edged pan with a width equal to, or slightly less, than the overall width of the assembly of chutes. The receptacles hold the two sample halves following splitting. The hopper or straight-edged pan allows sample feeding at a controlled rate into the chutes.

Mix the sample thoroughly. Place the receptacles under the splitting chutes. Close the chute shut-off valve. Pour the sample into the chute hopper and distribute the sample evenly over the full length and width of the hopper. Pull the lever to allow the material to free flow through the chutes into the receptacles below. To further reduce the sample to the desired size, repeat the process using the material from one of the receptacles.

“Method B” - Quartering

Place the sample on a firm, fairly smooth surface, such as a floor, board, a piece of cloth, or canvas. Mix the material thoroughly by turning the entire sample over three times. While turning the sample the last time, deposit each shovelful on top of the preceding one to form a conical pile. If a canvas is used, alternately lift the corners and pull over the sample as if preparing to fold the canvas diagonally.

Flatten the material into a circular layer of uniform thickness by pressing down the apex with a shovel. The diameter shall be approximately four to eight times the thickness.

Divide the sample into approximately four equal parts by striking two perpendicular lines through the center of the sample. If a canvas is used, the separation may be accomplished by passing a broom handle underneath the canvas and lifting slightly. This must be done twice to form the two perpendicular lines of separation. Separate the four parts completely. Use a brush to make sure that all the fines are included in each part.
Next discard the two diagonally opposite quarters. Be careful to discard all the remaining fines from the discarded sections. Re-mix the remaining quarters and repeat the process until you obtain the desired sample size from the diagonally opposite quarters.

NOTES

For a very dry sample, uniformly dampen the material to prevent segregation and loss of fines.

A sample that has free moisture may be dried to at least surface-dry condition at a temperature that does not exceed those specified in any of the tests that will be completed on the sample.

A quick method to determine surface-dry is if the fine aggregate retains its shape when molded in the hand, it is wetter than surface-dry.
ND T 255 – TOTAL EVAPORABLE MOISTURE CONTENT
OF AGGREGATE BY DRYING

Conduct this procedure according to ND T 255.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying both surface moisture and moisture in the pores.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling of Aggregates
AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying

APPARATUS

Balance
Sample container
Spoon or spatula
Hot plate, stove, oven, or microwave (It is preferable the microwave oven has a vented chamber and a power rating of about 700 watts with variable power control.)

TEST SPECIMEN

Obtain sample according to ND T 2. Sample size may be determined by the following table:

<table>
<thead>
<tr>
<th>Nominal Max Size of Aggregate</th>
<th>Mass of Normal Weight Aggregate Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.4 (4.75 mm)</td>
<td>1 lb (0.5 kg)</td>
</tr>
<tr>
<td>3/8&quot; (9.5 mm)</td>
<td>3 lbs (1.5 kg)</td>
</tr>
<tr>
<td>1/2&quot; (12.5 mm)</td>
<td>4 lbs (2 kg)</td>
</tr>
<tr>
<td>3/4&quot; (19.0 mm)</td>
<td>7 lbs (3 kg)</td>
</tr>
<tr>
<td>1&quot; (25.0 mm)</td>
<td>9 lbs (4 kg)</td>
</tr>
<tr>
<td>1½&quot; (37.5 mm)</td>
<td>13 lbs (6 kg)</td>
</tr>
<tr>
<td>2&quot; (50 mm)</td>
<td>18 lbs (8 kg)</td>
</tr>
<tr>
<td>2½&quot; (63 mm)</td>
<td>22 lbs (10 kg)</td>
</tr>
<tr>
<td>3&quot; (75 mm)</td>
<td>29 lbs (13 kg)</td>
</tr>
</tbody>
</table>
Sample should be representative of the moisture content of the supply being tested and should not have mass less than the amounts listed in the above table. Protect the sample from moisture loss until the initial weight is determined.

PROCEDURE

Dry the sample by means of a selected source of heat. An oven capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C) may be used.

Unless an oven is used, stir during drying to accelerate the process and avoid localized overheating. If a microwave oven is used, stirring is optional.

When drying a sample on a hot plate or stovetop, great care must be taken to keep from burning the sample or losing material when the sample is stirred.

Dry the sample until constant weight is achieved.

CALCULATIONS

Calculate the percent moisture as follows:

\[ A = \left( \frac{B - C}{C} \right) \times 100 \]

\( A = \text{Percent moisture} \)
\( B = \text{Mass of original sample} \)
\( C = \text{Mass of dry sample} \)

Report percent moisture to the nearest 0.1%.

NOTE

Constant weight is defined as when further drying will cause less than 0.1% additional loss in mass.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
ND T 265 - LABORATORY DETERMINATION OF MOISTURE CONTENT OF SOILS

Conduct this procedure according to ND T 265.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This procedure is used to determine the total moisture content of a soil. The soil is dried to remove all free moisture. This test measures the weight of the moisture removed from the soil.

APPARATUS

Oven
Balance
Sample containers with cover

PROCEDURE

Record all weights to the nearest 0.1 g or 0.1%.

Weigh a clean, dry, and empty container including the cover and record as tare weight.

Determine sample size needed from the table below. The sample obtained must be representative of the soil.

<table>
<thead>
<tr>
<th>Maximum Particle Size</th>
<th>Minimum Mass of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 40 (0.425 mm) sieve</td>
<td>10 g</td>
</tr>
<tr>
<td>No. 4 (4.75 mm) sieve</td>
<td>100 g</td>
</tr>
<tr>
<td>1/2&quot; (12.5 mm)</td>
<td>300 g</td>
</tr>
<tr>
<td>1&quot; (25.0 mm)</td>
<td>500 g</td>
</tr>
<tr>
<td>2&quot; (50 mm)</td>
<td>1000 g</td>
</tr>
</tbody>
</table>

Place sample in container and cover to prevent moisture loss. Weigh sample and record as mass of original sample.
To dry sample, remove cover and place in oven at temperature of 230 ± 9°F (110 ± 5°C). A sample allowed to dry overnight, or 15 to 16 hours, is considered dried to a constant weight. Remove the sample from the oven, cover, and allow it to cool before placing on balance. Weigh the sample with cover and record this weight as dry weight.

If the sample is not allowed to dry overnight, place the sample in the oven for a period of time. Remove sample from the oven, cover, and allow to cool before placing on balance. Weigh the sample and record the reading. Repeat the process until two successive readings show a constant weight. Record the final weight as mass of dry sample.

Discard sample after test.

CALCULATIONS

Calculate the percent moisture as follows:

\[ A = \left(\frac{B - C}{C - D}\right) \times 100 \]

\( A \) = Percent moisture
\( B \) = Mass of original (wet) sample, and container
\( C \) = Mass of dry sample, and container
\( D \) = Mass of container

REPORT

Report moisture to the nearest 0.1%.

NOTES

Constant weight is defined as when further drying will cause less than 0.1% additional loss in mass when weighed at specified intervals. Specified weighing interval for oven drying of samples is one hour.

CALIBRATION

Calibration is to be done annually, as a minimum, and whenever damage or repair is needed.
ND T 304 – UNCOMPACTED VOID CONTENT
OF FINE AGGREGATE

Conduct this procedure according to ND T 304, Method A

The AASHTO standard test procedure specifies the uncompacted voids be reported to the nearest 0.1%. The NDDOT modification specifies the uncompacted voids be reported to the nearest whole number.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

Method A determines the loose uncompacted void content of a sample of fine aggregate. When measured on any aggregate of a known grading, uncompacted void content provides an indication of the aggregate’s angularity, spherical shape, and surface texture compared to other fine aggregates tested in the same grading. This test is also referred to as the "Fine Aggregate Angularity Test."

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling of Aggregates
ND T 11 and AASHTO T 11, Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing
AASHTO T 19, Bulk Density (Unit Weight) and Voids in Aggregate
ND T 27 and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregate
ND T 84 and AASHTO T 84, Specific Gravity and Absorption of Fine Aggregate
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying
AASHTO T 304, Uncompacted Void Content of Fine Aggregate

APPARATUS

Balance, accurate to 0.1 g
100 mL Cylinder
200 mL Funnel
Funnel stand, 3 or 4 legged
Glass plate, 60 x 60 mm by 4 mm thick
Grease
Pan, large enough to contain cylinder and funnel stand
Metal spatula with straight edge
Pans
TEST SPECIMEN

Obtain a sample of aggregate according to ND T 2. Thoroughly mix and reduce according to ND T 248. Test specimen shall be a representative sample of approximately 1000 g of fine aggregate.

Wash the sample over a No. 100 or No. 200 sieve according to ND T 11. Dry the sample according to ND T 255. Perform a gradation according to ND T 27.

Remove the individual fractions as defined by table below. Place the material from each fraction into separate containers.

A 190-g sample is needed and portions retained from each individual sieve are combined in the following amounts:

<table>
<thead>
<tr>
<th>Individual Size Fraction</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 8 to No. 16</td>
<td>44 g</td>
</tr>
<tr>
<td>No. 16 to No. 30</td>
<td>57 g</td>
</tr>
<tr>
<td>No. 30 to No. 50</td>
<td>72 g</td>
</tr>
<tr>
<td>No. 50 to No. 100</td>
<td>17 g</td>
</tr>
</tbody>
</table>

PROCEDURE

All information is recorded on SFN 51701. The cylinder calibration procedure is included at the end of this procedure.

Weights are recorded to the nearest 0.1 g.

Thoroughly mix the 190-g sample with the spatula.

Weigh the empty cylinder and record as weight of cylinder.

Set up the funnel apparatus with a pan underneath to catch any loose aggregate. Place the empty cylinder under the funnel. Funnel must be 115 ± 2 mm (4.53 ± 0.08") above the top of the cylinder.

Hold your finger over the bottom of the funnel and pour the sample into the top. Level the material in the funnel with the metal spatula. Release your finger allowing the sample to flow into the cylinder.

Strike off the top of the cylinder by a rapid single pass with a straightedge. The blade of the spatula must be vertical, keeping the edge horizontal and in light contact with the top of the measure. Brush away any loose material from the
outside and weigh the cylinder plus aggregate. Weigh and record as weight of cylinder plus aggregate.

Retain and recombine all material for the second trial. Repeat the procedure.

CALCULATIONS

The percent of uncompacted voids content of fine aggregate is calculated as follows:

\[
\text{Uncompacted Voids in Percent} = \frac{[V - (F/G)]}{V} \times 100
\]

\[V = \text{Volume of calibrated cylinder in mL}\]

\[F = \text{Net weight of sample in cylinder, gross weight mass of empty cylinder}\]

\[G = \text{Bulk specific gravity, dry, as determined by ND T 84}\]

Average the results of the two trials.

REPORT

Report the percentage of uncompacted voids to the nearest whole percent.

NOTES

After strike-off, the cylinder may be tapped lightly to compact the sample to make it easier to transfer the container to the balance without spilling any of the sample.

If the specific gravity of fine aggregate is not known, determine by ND T 84.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.

CYLINDER CALIBRATION

Calibrate the cylinder according to ND T 304. Record the information on SFN 51729. Record the weights to the nearest 0.1 g. Use AASHTO T 19 as a reference to determine the density of the water.
Apply a light coat of grease to the top edge of the dry, empty cylinder. Weigh the cylinder, grease, and glass strike-off plate. Record the weight.

Fill the cylinder with freshly boiled, deionized water cooled to a temperature of 64° to 75°F (18° to 24°C). Record the temperature of the water.

Slide the glass plate on the measure making sure no air bubbles remain. Dry the outside of the cylinder and weigh, including the strike-off plate. Record the weight.

The volume of the cylinder is calculated as follows:

\[ V = 1000 \times \frac{M}{D} \]

\( V = \text{Volume of cylinder, mL} \)
\( M = \text{Net mass of water, g} \)
\( D = \text{Density of water} \)

Density of water is determined by using AASHTO T 19. The following table can be used to determine the density of water.

<table>
<thead>
<tr>
<th>°F</th>
<th>°C</th>
<th>kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>15.6</td>
<td>999.01</td>
</tr>
<tr>
<td>65</td>
<td>18.3</td>
<td>998.54</td>
</tr>
<tr>
<td>70</td>
<td>21.1</td>
<td>997.97</td>
</tr>
<tr>
<td>73.4</td>
<td>23.0</td>
<td>997.54</td>
</tr>
<tr>
<td>75</td>
<td>23.9</td>
<td>997.32</td>
</tr>
<tr>
<td>80</td>
<td>26.7</td>
<td>996.59</td>
</tr>
</tbody>
</table>

Calculate volume to nearest 0.1 mL.

If the volume is greater than 100.0 mL, the upper edge may be ground until the volume is exactly 100.0 mL.
ND T 309 – TEMPERATURE OF FRESHLY MIXED HYDRAULIC CEMENT CONCRETE

Conduct this procedure according to ND T 309.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test method covers the determination of temperature of freshly mixed hydraulic-cement concrete. This test method may be used to verify conformance to specifications if a temperature requirement is indicated.

REFERENCED DOCUMENTS

ND T 141 and AASHTO T 141, Sampling Freshly Mixed Concrete
AASHTO T 309, Temperature of Freshly Mixed Hydraulic Cement Concrete

APPARATUS

Sample container
Temperature measuring device accurate to ±1°F (0.5°C) and at a readable range of 30° to 120°F (1° to 50°C).

TEST SPECIMEN

Obtain a concrete sample according to ND T 141.

It is acceptable to measure the temperature of the concrete in transport equipment, such as, a wheelbarrow, or within forms immediately after discharge or placement. Other containers may be used if they allow 3” (75 mm) coverage in all directions of the thermometer. If any other container is used, dampen with water immediately prior to introducing the concrete sample.

Complete temperature measurement within 5 minutes of obtaining sample.

PROCEDURE

Introduce temperature measuring device into fresh concrete so the bulb of the thermometer or temperature sensor is submerged a minimum of 3” (75 mm)
below the surface. Gently press the concrete around the thermometer to ensure the ambient temperature does not affect the reading. Allow the thermometer to remain in concrete undisturbed for a minimum of 2 minutes or until the temperature stabilizes.

Read and record.

REPORT

Report the temperature to the nearest 1°F (0.5°C).

CALIBRATION

Calibration is to be done annually, as a minimum, and whenever damage or repair occurs.
ND T 312 - PREPARING AND DETERMINING DENSITY OF HOT MIX ASPHALT (HMA) SPECIMENS BY MEANS OF THE SUPERPAVE GYRATORY COMPACTOR

Conduct this procedure according to ND T 312.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification and details.

SCOPE

This test is used to prepare specimens for determining the mechanical and volumetric properties of Hot Mix Asphalt (HMA) using the Superpave gyratory compactor. The specimens simulate the density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedure is used in the placement paving mix.

REFERENCED DOCUMENTS

NDDOT 5, Sampling and Splitting Field Verification Hot Mix Asphalt (HMA) Samples
AASHTO T 312, Preparing and Determining Density of Hot Mix Asphalt (HMA) Specimens by Means of the SuperPave Gyratory Compactor

APPARATUS

Gyratory Compactor
Molds
Thermometers
Paper disks
Oven
Spoon
Pans
Funnel
Fan
Balance
Extrusion jack

TEST SPECIMEN

Material used to prepare at least three specimens is obtained from behind the paver as outlined in NDDOT 5.
PROCEDURE:

Mixture Preparation:

Immediately prior to the time the HMA is ready for compaction, turn on the power to your compactor for the warm up period recommended by the manufacturer.

Next verify the settings on the compactor and, if you are using a computer to record your data, enter your header information.

The mold, base plate, and funnel should be preheated in an oven at 200° to 300°F (93° to 149°C) for 30 to 60 minutes. This will prevent the asphalt mix from sticking to molds during the compaction process and sticking in the funnel during sample preparation.

Heat the asphalt mixture in an oven at 270 ± 5°F (132 ± 3°C).

Compaction Procedure:

When the asphalt mixture reaches 270 ± 5°F (132 ± 3°C), remove the heated mold and base plate from the oven and place a paper disk in the bottom of the mold.

Mix the entire sample, approximately 4700 g, to be compacted with a heated spoon and then carefully put the sample in a funnel. With the funnel, place all the mixture into the mold in one lift.

With a heated spoon or spatula level the mix in the mold and place a paper disk on the top. Load the mold into the compactor and center the loading ram.

Set the pressure, angle setting, and gyrations per minute. Push the start button on the compactor and wait for the compaction process to finish.

When completed, retract the loading ram and remove the mold assembly from the compactor.

The specimens can be removed immediately from the mold after compaction for most HMA mixes. In order to insure the specimen does not get damaged, a cooling period of 5 to 10 minutes in front of a fan may be necessary.

Remove the specimen with an extrusion jack. Remove the paper disks from the top and bottom of the specimen.

Procedures for "Pine" brand portable gyratory compactors vary from the procedure listed above.

Place the mold in the machine using the mold tongs, rotating clockwise to the
stops before starting the test. If it is in the correct position, you will be able to see a mold pin in the middle of the retainer cylinder port.

Place the base plate in the mold, beveled side facing down, place paper filter on top, place the funnel on top of mold and pour mix into mold.

Place second filter paper on leveled mix then second base plate beveled side up.

Before closing the compaction chamber, make certain the ram is fully retracted and the gyratory head is parked. Close the machine and clamp it into place. Set the pressure, angle setting, and gyrations per minute. Push the start button on the compactor and wait for the compaction process to finish.

When the compaction process is complete, the gyratory head and hydraulics automatically shut off. At this point the specimen may be extruded from the mold.

The funnel cap is used to hold the mold down in the compaction chamber as the ram pushes the specimen out of the mold. Press the UNLOAD function key twice. The ram pushes the specimen up and out of the mold. Press the Reverse function key to assure that the gyratory head is parked properly. Remove top paper, carefully unclamp and remove the funnel cap. Move the specimen to a nearby flat surface and remove bottom paper. Press the RESET button to lower the ram.

NOTES

Before testing, the gyratory compactor should be calibrated periodically for pressure, height, angle, and rotation to make sure compactor is within specifications.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
Intentionally Left Blank
Conduct this procedure according to ND T 318.

The NDDOT modification uses approximately 1500 grams of concrete.

Consult the current edition of AASHTO for procedure in its entirety and equipment specification details.

SCOPE

This test method is used to determine total water content of fresh concrete. Water content per unit volume of concrete can be determined by knowing the unit weight of that concrete.

REFERENCED DOCUMENTS

AASHTO T 318, Water Content of Freshly Mixed Concrete Using Microwave Oven Drying
ND T 141 and AASHTO T 141, Sampling Freshly Mixed Concrete
ND T 121 and AASHTO T 121, Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

APPARATUS

Microwave oven with a minimum 900-watt power setting, turntable, and defrost cycle
Microwave safe container, approximately 9" x 9" x 2" deep
Fiberglass cloth, approximately 20" x 20" and 14 mils in thickness
Metal spatula
Grinding pestle
Moisture containers with tight-fitting lids
Balance

TEST SPECIMEN

Obtain a concrete sample according to ND T 141. Use a sample size of approximately 1500 g. Place the sample in a moisture proof container with a tight-fitting lid until ready for testing. Test shall begin as soon as possible after sampling, not exceeding one hour.

PROCEDURE

Place fiberglass cloth on microwave safe container and determine its mass to the nearest 0.1 g. Place the fresh concrete sample on fiberglass cloth and completely wrap sample within it. Weigh and record as wet sample. Dry the
sample in a microwave oven set on the defrost cycle; for 5.0 ± 0.5 minutes. Immediately remove sample from microwave and unwrap specimen. Break up sample with metal spatula and grind the mortar with a pestle, avoiding any material loss. This process shall not take longer than 60 seconds before re-wrapping and beginning second cycle of 5.0 ± 0.5 minutes. After second cycle is complete, remove sample from microwave, unwrap, stir the specimen, and weigh and record.

The sample will be re-wrapped and placed in the microwave for a third cycle of 2.0 ± 0.5 minutes. Remove sample from microwave, unwrap, stir the specimen, and weigh and record. Dry the sample at the 2.0 ± 0.5 minute intervals until constant weight is achieved. Weigh sample and record as dry sample.

CALCULATIONS

Record all weights on SFN 18456.

Calculate the water content percentage as follows:

\[
A = \left[\frac{(B - C)}{B - D}\right] \times 100
\]

\[A = \text{Water Percentage}\]

\[B = \text{Mass of wet sample, container, and cloth}\]

\[C = \text{Mass of dry sample, container, and cloth}\]

\[D = \text{Mass of container and cloth}\]

Calculate the total water content as follows:

\[
E = \left[\frac{27 \times (A) \times (F)}{100}\right]
\]

\[E = \text{Total Water Content}\]

\[A = \text{Water Percentage}\]

\[F = \text{Unit Mass of Fresh Concrete}\]

REPORT

Report the percent water content to the nearest 0.1%; and the total water content to the nearest lb/cu.yd.

NOTES

This test can be used to check the water content of as-delivered concrete, and to calculate the water/cement ratio if the cement content of the tested concrete is known.

CALIBRATION

Calibration is to be done annually, as a minimum, and whenever damage or repair occurs.
ND D 2167 - DENSITY AND UNIT WEIGHT OF SOIL IN PLACE
BY THE RUBBER-BALLOON METHOD

Conduct this procedure according to ND D 2167.

The NDDOT modified the ASTM standard by decreasing the minimum requirement for test hole volume.

Consult the current edition of ASTM for procedure in its entirety and equipment specification details.

SCOPE

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

Embankment compaction is controlled by requiring the density of each different soil, after compaction, be a specified minimum percentage of the maximum dry density. The maximum dry density is determined for each different soil on the project. When a particular soil is encountered in the excavation and transferred to and compacted in the embankment, it is tested by the method given in this section to determine its dry density. The in-place dry density is expressed as a percentage of the soils maximum dry density and can be compared to specification requirements.

REFERENCED DOCUMENTS

ND T 217 and AASHTO T 217, Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy)
ND T 265 and AASHTO T 265, Laboratory Determination of Moisture Content of Soils
ND D 4643 and ASTM D 4643, Determination of Moisture Content of Soil by the Microwave Oven Method

APPARATUS

Rubber-balloon apparatus and base plate
Balance, readable to 0.01 lbs
Pins, shovel, trowel, spoon, hammer, and knife
Auger, 4" diameter
Appropriate size container with lid
PROCEDURE

All information is recorded on SFN 2454. Record the balloon volume readings to 0.00000 cu.ft.

The following chart shows the minimum of test hole volume required.

<table>
<thead>
<tr>
<th>Maximum Particle Size</th>
<th>NDDOT Minimum Test Hole Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>0.025 cu.ft.</td>
</tr>
<tr>
<td>1&quot;</td>
<td>0.03 cu.ft</td>
</tr>
<tr>
<td>1½&quot;</td>
<td>0.035 cu.ft</td>
</tr>
</tbody>
</table>

Select the area of compacted embankment to be tested. Because the surface of a compacted area is generally loose or disturbed due to rolling operations, remove loose material and level off an area slightly larger than the base plate.

Place the base plate over the smoothed area and fasten down with the accompanying pins. Plate must stay in this position and be stable throughout the test.

Place the volume measure on the base plate for the initial reading, noting its position with regard to the base plate. Using the bulb-type pump, and while holding down the volume measure, force the water down into the balloon until resistance is felt. Apply the calibrated pressure and note the reading on the glass cylinder. Record the reading.

Dig a hole with the auger, trowel, or other tools. Hole must be approximately 4" in diameter and 5" deep. Place all of the loosened material from the hole into an aggregate balance pan, or a moisture-tight container if not weighed right away. Clean the sides and bottom of the hole being very careful not to lose any material. Check to be certain that no jagged edges or points remain that may puncture the balloon. Do not disturb the soil around the top edge of the hole.

Place the volume measure on the base plate in the same initial position. Pump the balloon down into the hole and apply the calibrated pressure. Read and record the final reading. The volume of the test hole is determined by the difference between the initial and final reading.

Weigh the soil removed from the hole to the nearest 0.01 lb and record.

Use a representative portion of the soil for moisture determination. Do not use material containing particles large enough to be retained on the No. 4 (4.75 mm) sieve. Moisture can be determined by the use of ND T 217, ND T 265, or ND D 4643.
CALCULATIONS

Complete calculations as follows:

Volume of Hole = Final Reading - Initial Reading

Wet Density = Wet Weight of Soil / Volume of Hole

Dry Density = \((\text{Wet Density} \times 100) / (100 + \text{Percent Moisture})\)

REPORT

Report dry density to the nearest 0.1 lbs/cu.ft.

CALIBRATION

All new devices should be calibrated prior to being used. A calibration check should be performed annually as a minimum, or whenever damage or repair occurs.
ND D 4643 - MICROWAVE METHOD OF DRYING SOILS

Conduct this procedure according to ND D 4643.

Consult the current edition of ASTM for procedure in its entirety and equipment specification details.

SCOPE

This procedure is used to determine the total moisture content of a soil. The soil is dried to remove all free moisture. This test measures the weight of the moisture removed from the soil.

APPARATUS

Balance, readable to 0.1 g
Microwave safe dish
Glass rod, spatula or knife
Oven mitts
Heat sink
Microwave oven (It is preferable the microwave oven has a vented chamber, and a power rating of about 700 watts with variable power control.

PROCEDURE

Record all weights to the nearest 0.1 g. Weigh a clean and dry microwave safe dish and record the weight as tare weight.

Determine the sample size needed from the table below. Place the sample in the container and immediately weigh. Record this weight as wet weight.

<table>
<thead>
<tr>
<th>Sieve Retaining Not More Than About 10% of Sample</th>
<th>Recommended Mass of Moist Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 10 (2.0 mm)</td>
<td>100 to 200 g</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>300 to 500 g</td>
</tr>
<tr>
<td>3/4&quot; (19 mm)</td>
<td>500 to 1000 g</td>
</tr>
</tbody>
</table>

Place the container in the microwave oven with a heat sink, set power to defrost setting, set timer for 3 minutes and start (See Notes). The 3-minute initial time is a minimum.

When the microwave oven stops, remove from the oven and weigh to the nearest 0.1 g and note. Use a small spatula, glass rod, or knife and carefully mix the soil. Take care not to lose any soil.
Return the container and soil to the oven and reheat for 1 minute. Remove, weigh, and again mix with spatula, glass rod, or knife. Repeat this process until a constant weight has been achieved. Use the final weight to calculate the moisture content. Record this weight as dry weight.

Discard sample after test.

**CALCULATIONS**

Calculate the percent moisture as follows:

\[
A = \frac{(B - C)}{(C - D)} \times 100
\]

\(A = \text{Percent moisture}\)

\(B = \text{Mass of original (wet) sample, and container}\)

\(C = \text{Mass of dry sample, and container}\)

\(D = \text{Mass of container}\)

**REPORT**

Report moisture to the nearest 0.1%.

**NOTES**

Initial power setting may be higher than defrost. The proper power setting can be determined only through the use of, and experience with a particular microwave.

Soils that are high in moisture and contain a large portion of clay take a longer time to dry. Initial heating time for this type of soil may be 12 minutes. Care should be taken to reduce cohesive samples to 1/4" particles to speed drying and prevent crusting or overheating of the surface while drying the interior.

Constant weight is defined as when further drying will cause less than 0.1% additional loss in mass when weighed at specified intervals. Specified weighing interval for microwave drying is one minute.

**CALIBRATION**

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
ND D 4791 – FLAT PARTICLES, ELONGATED PARTICLES, OR FLAT AND ELONGATED PARTICLES IN COARSE AGGREGATE

Conduct this procedure according to ND D 4791.

Consult the current edition of ASTM for procedure in its entirety and equipment specification details.

SCOPE

The test method covers the determination of the percentages of flat particles, elongated particles, or flat and elongated particles in coarse aggregate.

REFERENCED DOCUMENTS

ND T 2 and AASHTO T 2, Sampling of Aggregates
ND T 27 and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregate
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying
ASTM D 4791, Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

APPARATUS

Balance
Pan
Proportional Caliper Device
Oven
Sieves: 1½"(37.5 mm), 1"(25.0 mm), ¾"(19.0 mm), ½"(12.5 mm), ⅜"(9.5 mm)

TEST SPECIMEN

Obtain sample according to ND T 2. Thoroughly mix and reduce according to ND T 248. The following table helps determine the initial sample size needed.

<table>
<thead>
<tr>
<th>Nominal Maximum Size</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot; (9.5 mm)</td>
<td>2 lbs (1 kg)</td>
</tr>
<tr>
<td>1/2&quot; (12.5 mm)</td>
<td>4 lbs (2 kg)</td>
</tr>
<tr>
<td>3/4&quot; (19.0 mm)</td>
<td>11 lbs (5 kg)</td>
</tr>
<tr>
<td>1&quot; (25.0 mm)</td>
<td>22 lbs (10 kg)</td>
</tr>
<tr>
<td>1½&quot; (37.5 mm)</td>
<td>33 lbs (15 kg)</td>
</tr>
</tbody>
</table>
PROCEDURE

Record the information on SFN 51700. All weights are recorded to the nearest 0.1 g. Dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Weigh and record as weight of total sample.

Run a dry sieve analysis according to ND T 27. Discard material passing the 3/8" (9.5 mm) sieve. For each size sieve with at least 10% retained, reduce the sample according to ND T 248 until about 100 particles remain. Weigh and record.

If a sieve has less than 10% retained, do not test it.

Use the 5:1 setting on the proportional caliper device. Use the longest dimension of the particle to set the large gap on the device. Tighten the lever. If the particle can fit through the small gap, it is flat or elongated. Set aside all flat or elongated particles from each individual sieve size. Weigh and record each portion after the entire sample has been tested.

CALCULATIONS

To calculate for a single sieve, divide the weight of particles determined to be flat and elongated by the weight of the 100 particles then multiply the result by 100. The equation is as follows:

\[ A = \frac{B}{C} \times 100 \]

\[ A = \text{Percent flat and elongated particles} \]
\[ B = \text{Weight of flat and elongated material} \]
\[ C = \text{Total weight of sample on sieve} \]

If a sieve has less than 10% retained, use the value for the next size larger or smaller sieve that retained 10%. If both a larger and smaller size retained 10%, use the average.

Refer to SFN 51700 for remainder of calculations.

REPORT

Report the results of flat or elongated particles to the nearest whole percent.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
NDDOT 1 - SAMPLING OF BITUMINOUS MATERIALS

Conduct these procedures according to NDDOT defined standards.

SCOPE

The following sampling and testing procedures are for emulsified asphalt materials, performance graded asphalt cement, asphalt cutbacks, and crack and joint sealants.

REFERENCED DOCUMENTS

- AASHTO M 81, Cutback Asphalt (Rapid-Curing Type)
- AASHTO M 82, Cutback Asphalt (Medium-Curing Type)
- AASHTO M 320, Performance-Graded Asphalt Binder
- AASHTO M 324, Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavement

APPARATUS

- One gallon plastic, wide-mouth jar with a plastic cap with liner
- One liter metal, screw-top containers
- Manufacturer’s original unopened container, either two 30-lb single sample boxes or one 55-lb double sample box.

PROCEDURE

EMULSIFIED ASPHALT:

The following is a description of the NDDOT’s procedure for sampling and testing emulsified asphalt materials in the Districts and Materials and Research Laboratory.

A sample is defined as two one-gallon plastic containers filled with the material to be tested. One gallon is tested as the original sample and the second gallon is used as a check if the original fails.

District Sampling and Testing:

- The District samples each truck load delivered to the project.
- Each sample will be retained until all testing is completed.
• The District labs test the Saybolt viscosity and sieve on one sample from the first truck load delivered to the project and then one random sample from the next four trucks delivered. The testing rate then goes to two random samples from each additional five truck lot, or fraction of a five truck lot.

• For CRS-2P emulsions the sampling rate will remain at one sample from each truck load delivered to the project. The sieve and Saybolt viscosity will not be tested unless the Engineer determines that there is a consistency problem with the emulsion.

• For all emulsions, one sample is randomly selected from the first and second halves of the project and sent to the Materials and Research Laboratory for assurance testing.

• Samples should be submitted in a timely manner because there is a time frame in which testing can be done.

• Label each sample container with the following information.
  - Project number
  - PCN number
  - Date sampled
  - Field sample number
  - Manifest number
  - Manufacturer
  - Grade of emulsion
  - Original or check

Materials and Research Laboratory Testing:

• The Materials and Research Laboratory tests the random sample from both halves of the project. If the samples pass, the entire project is accepted with no further testing.

• If one sample passes from either half of the project then that half is accepted with no further testing.

• If one sample fails, then all samples from that half of the project are submitted to the Materials and Research Laboratory for testing.

• The Materials and Research Laboratory will inform the District when sample submittal is required due to failing tests.

• The Materials and Research Laboratory will then test samples around the one that does not pass to determine a failing lot size. For example, there are four loads of emulsion delivered during the first half of a project and five loads for the second half of the project. The District submits Sample 3 from both halves of the project. Sample 3 from the first half passes and all material from the first half is accepted with no further testing. Sample 3 from the second half fails so the Materials and Research Laboratory will test Samples 2 and 4. If Sample 2 passes, Sample 1 is accepted with no further testing. If sample 4 fails, sample 5 is tested. If Sample 5 passes, the failing lot size is made up of loads 3 and 4. See table below.
PERFORMANCE GRADED ASPHALT CEMENT:

The following is a description of the NDDOT’s procedure for sampling and testing performance-graded (PG) asphalt cement in the Districts and Materials and Research Laboratory.

A sample is defined as two one-liter metal, screw top containers filled with the material to be tested. One liter is tested as the original sample and the second liter is used as a check if the original fails.

District Sampling and Testing:

- NDDOT project personnel will observe the Contractor obtain samples from material delivered to the job site.
- The sampling rate will be a minimum of one sample for every 250 tons for each supplier and grade of asphalt cement, or fraction thereof.
- The sample shall be taken randomly within each 250 tons of material.
- A sample will consist of taking two one-liter samples from the designated transport.
- Both samples will be sent to the NDDOT Materials and Research Laboratory.
- Label each sample can with the following information.
  - Project number
  - PCN number
  - Date sampled
  - Field sample number
  - Manifest number
  - Manufacturer
  - Grade of asphalt
  - Original or check
- Extra samples are also obtained as directed by the Engineer when necessary.

Materials and Research Laboratory Testing:

- The Materials and Research Laboratory will randomly test one sample from each lot of four delivered.
- The testing will be the full battery of tests required by AASHTO M 320.

<table>
<thead>
<tr>
<th>First Half of Project</th>
<th>Second Half of Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>Sample 1</td>
</tr>
<tr>
<td>Sample 2</td>
<td>Sample 2</td>
</tr>
<tr>
<td>Sample 3</td>
<td>Sample 3</td>
</tr>
<tr>
<td>Sample 4</td>
<td>Sample 4</td>
</tr>
<tr>
<td>Sample 1</td>
<td>Sample 1</td>
</tr>
<tr>
<td>Sample 2</td>
<td>Sample 2</td>
</tr>
<tr>
<td>Sample 3</td>
<td>Sample 3</td>
</tr>
<tr>
<td>Sample 4</td>
<td>Sample 4</td>
</tr>
<tr>
<td>Sample 5</td>
<td></td>
</tr>
</tbody>
</table>
ASPHALT CUTBACKS:

The following is a description of the NDDOT’s procedure for sampling and testing cutback asphalt in the Districts and Materials and Research Laboratory.

A sample is defined as two one-liter metal, screw top containers filled with the material to be tested. One liter is tested as the original sample and the second liter is used as a check if the original fails.

- NDDOT project personnel will observe the Contractor obtain samples from material delivered to the job site.
- Obtain two one-liter samples of cutback from each load delivered to the project.
- Submit one sample to the Materials and Research Laboratory and keep one in the field for a check sample.
- Label each sample can with the following information.
  - Project number
  - PCN number
  - Date sampled
  - Field sample number
  - Manifest number
  - Manufacturer
  - Type of cutback asphalt
  - Original or check
- Extra samples are also obtained as directed by the Engineer when necessary.

Materials and Research Laboratory Testing:

- The Materials and Research Laboratory will test each sample delivered from the project.
- The testing will be the full battery of tests required by AASHTO M 81 and AASHTO M 82 for the type of cutback delivered.

CRACK AND JOINT SEALANT:

The following is a description of the NDDOT’s procedure for sampling and testing crack and joint sealant material in the Districts and Materials and Research Laboratory.

District Sampling and Testing:

- The District will sample each lot of crack and joint sealer delivered to the project.
• The sample will consist of two boxes if the material is delivered in 30-lb single sample boxes.
• The sample will consist of one box if the material is delivered in 55-lb double sample boxes.
• All crack and joint sealers shall be submitted in the manufacturer’s original unopened container.
• Completely fill out crack and joint sealer sample card and submit it with the sample.

Materials and Research Laboratory Testing:

• The Materials and Research Laboratory will test one sample brick from material delivered from the project.
• The testing will be the full battery of tests required by AASHTO M 324 for the type of material delivered.
NDDOT 2 - CONTRACTOR CORING

Conduct this procedure according to NDDOT defined standards.

SCOPE

The following sampling procedure is for obtaining asphalt roadway cores.

REFERENCED DOCUMENTS

ND T 166 and AASHTO T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens

APPARATUS

Coring machine
Masonry saw

PROCEDURE

The diameter of the asphalt cores can be either 4" or 6". The cores are obtained by the Contractor, under the observation of the Engineer. The Engineer will compute and mark the locations to be cored using random numbers to determine station and offset from the edge of the pavement. The Engineer will adjust core locations that fall within one foot of the pavement edge or select a new random location that establishes a core location within the test area. The cores are to be taken at least 6" apart but no more than one foot apart and on a longitudinal plane.

Take asphalt cores through the full depth of the asphalt pavement. The core bit must be at right angles to the pavement surface to ensure that the resultant core is reasonably straight. Do not force the core bit through the pavement as this results in rough, uneven cores which precludes certain testing. Exercise care when removing the core from the pavement to prevent distorting or cracking.

After removing the core, fill the hole in the pavement with mix and tamp to a density close to that of the surrounding pavement.

Remove the pavement lift of interest from the core by wet sawing with a masonry saw. Transport the cores to the laboratory for mat density testing. Conduct testing according to ND T 166.
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NDDOT 3 – SHALE, IRON OXIDE PARTICLES, LIGNITE AND OTHER COAL, SOFT PARTICLES, THIN OR ELONGATED PIECES

Conduct this procedure according to NDDOT defined standards.

SCOPE

This test method determines the amount of deleterious material retained on the No. 4 sieve.

Deleterious material may be shale, hard iron oxide particles, lignite and other coal, and thin or elongated pieces.

REFERENCED PROCEDURES

ND T 2 and AASHTO T 2, Sampling Aggregates
ND T 248 and AASHTO T 248, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying

APPARATUS

Balance
Sieves: 3/8"(9.5 mm) and No. 4 (4.75 mm)
Pans
Ball pin hammer
Plate
Oven

TEST SPECIMEN

Obtain sample according to ND T 2. Split sample according to ND T 248.

Test specimen shall be a representative sample of approximately 2500 g.

PROCEDURE

Record the information on SFN 2455. All weights are recorded to the nearest 0.1 g.

Wash and dry the sample according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Material obtained in conjunction with other test procedures that has already been washed and dried may be used.

Stack the 3/8" and No. 4 sieves on a pan.
Place the sample in the stack of sieves and shake with the mechanical shaker until not more than 0.5% by weight of the total sample passes any sieve during one minute. Approximately 10 minutes will be sufficient for most materials.

Remove material retained on the 3/8" and No. 4 sieves and combine into one pan. Weigh and record as weight of Plus No. 4 fraction. Material passing the No. 4 sieve can be discarded.

Hand pick the shale, hard iron oxide particles, lignite and other coal, and thin or elongated pieces and place in separate pans. Weigh each pan and record.

Check the remainder of the sample for soft particles. To determine if particles are soft, use a small 4 oz. ball pin hammer and a flat, non-deflecting plate. Take the hammer and strike each particle with a minimum amount of effort to see if it cracks on impact. A drop of 4" to 5" is sufficient. Place cracked material in container and weigh and record.

**CALCULATIONS**

Calculate the percentages of handpicked deleterious material by dividing that weight by the weight of the Plus No. 4 fraction and multiplying by 100. The equation is as follows:

\[
A = \frac{B}{C} \times 100
\]

\[
A = \text{Percent deleterious material}
\]
\[
B = \text{Combined handpicked portions}
\]
\[
C = \text{Weight of Plus No. 4 fraction}
\]

**REPORT**

Report the results to the nearest 0.1%.

**NOTES**

The 3/8" sieve is used to prevent overloading on the No. 4 sieve.

Thin or elongated pieces are defined as having a maximum thickness less than 1/4 the maximum width, or maximum length more than three times the maximum width.

**CALIBRATION**

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
NDDOT 4 - PERCENTAGE OF FRACTURED PARTICLES IN COARSE AGGREGATE

Conduct this procedure according to NDDOT defined standards.

SCOPE

This procedure determines the percentage of particles, which by visual inspection have a fractured face.

A fractured face is an area that is at least 25% of the largest cross section of the particle.

REFERENCED PROCEDURES

ND T 2 and AASHTO T 2, Sampling Aggregates
ND T 248 and AASHTO T 248, Reduce Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying

APPARATUS

Balance
No. 4 sieve
Spatula
Pan
Oven

TEST SPECIMEN

Obtain a sample according to ND T 2. Reduce the sample according to ND T 248. Final sample size needed is approximately 500 g.

Wash and dry according to ND T 255 at a temperature of 230 ± 9°F (110 ± 5°C). Sieve the sample over a No. 4 sieve. Test only material retained on the No. 4 sieve. This is considered the weight of the total sample. Discard the material that passes the No. 4 sieve.
PROCEDURE

Record all information on SFN 9987. All weights are recorded to the nearest 0.1 g.

Spread the sample on a clean flat surface large enough to permit the material to be spread thinly for careful inspection. Use the spatula or similar tool to separate the material into three separate portions:

1. Fractured particles.
2. Questionable fractured particles.
3. Particles with no fractured faces.

The requirement of the fracture is dependent on the class of aggregate and the particles will have either one or two fractured faces.

Place each portion into individual pans. Weigh and record each portion.

CALCULATIONS

Percentage of particles with fractured faces is calculated according to the following formula:

\[
Fractured \text{ Faces} = \frac{WF + (WQ/2)}{WA} \times 100
\]

\[
WF = Weight \text{ of fractured particles}
\]
\[
WQ = Weight \text{ of questionable fractured particles}
\]
\[
WA = Weight \text{ of total sample}
\]

REPORT

Report the percentage of particles with fractured faces to the nearest 1%.

NOTES

A fractured face may be natural or caused by a mechanical process.

CALIBRATION

A calibration check of the equipment should be performed annually as a minimum, or whenever damage or repair occurs.
NDDOT 5 - SAMPLING AND SPLITTING FIELD VERIFICATION
HOT MIX ASPHALT (HMA) SAMPLES

Conduct this procedure according to NDDOT defined standards.

SCOPE

This procedure is used to obtain samples of hot mix asphalt from behind the paver. The material is then used to run ND T 245 for Marshall plugs, ND T 209 for the Rice test, or ND T 312 for Superpave gyratory compaction.

REFERENCED DOCUMENTS

ND T 209 and AASHTO T 209, Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt
ND T 245 and AASHTO T 245, Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ND T 312 and AASHTO T 312, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

APPARATUS

Shovel - flat bottom, square-edge
Pails
Insulated container
Scoop - flat bottom, square-edge
Trowel

PROCEDURE

SAMPLING:

Obtain a hot mix asphalt sample of approximately 72 lbs (33 kg) from behind the paver. If the sample is for a Marshall project you will only need approximately 50 lbs (23 kg) of hot mix for the gyratory compactor specimens.

The location where the sample is collected is determined randomly by a DOT employee. The sample may be obtained by Contractor’s personnel under observation of DOT personnel.
Take one bucket full of material from the asphalt windrow in front of the paver. This material will be used to fill the hole created when obtaining the sample from behind the paver.

Mark out an area that is large enough to provide the required size sample. Use the shovel and take the sample a minimum of one foot from the edge of the pavement. Be careful to avoid including material from the subgrade or base.

Place the sample in the pails. Place the pails in an insulated container and cover to retain as much heat as possible for the transport to the field lab. A DOT representative will transport the sample to the field or testing lab.

SPLITTING:

At the field lab place the entire sample on a level surface or in a pan and re-mix with the scoop. Carefully flatten to a uniform thickness and divide the flattened mass into four equal quarters using a trowel.

For the Marshall specimens a portion from each of three quarters will be used. The fourth quarter will be used for running the theoretical maximum specific gravity, or Rice test.

For Superpave projects use one quarter for the Rice test and the opposite quarter for one gyratory specimen. A second gyratory specimen can be made from either one of the remaining two quarters.

Place any unused portion of the hot mix asphalt sample into a container and save it for further testing if needed.

Discard the unused portion when all testing on the original sample is complete.
NDDOT 6 - SETTLEMENT TEST FOR LIQUID MEMBRANE CURING COMPOUND

Conduct these procedures according to NDDOT defined standards.

SCOPE

This procedure determines the amount of settlement in a liquid membrane curing compound.

APPARATUS

100 mL graduated cylinder with graduation intervals of 1 mL
Disposable pipette
Rubber stopper

TEST SPECIMEN

Obtain one pint of curing compound.

PROCEDURE

Bring the sample to room temperature and mix until curing compound is homogeneous.

Pour curing compound into a 100 mL graduated cylinder. Using a disposable pipette, remove any air bubbles incorporated in the curing compound. At this time add or remove curing compound so the bottom of the meniscus reaches the 100 mL mark.

Secure a rubber stopper in the graduated cylinder to minimize evaporation and leave the sample undisturbed for 72 ± 1 hours. At the end of 72 ± 1 hours, measure the amount of settling to the nearest mL. The degree of settling is the amount of clear, colorless supernatant liquid in the graduated cylinder.

REPORT

Report the settlement to the nearest mL.
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