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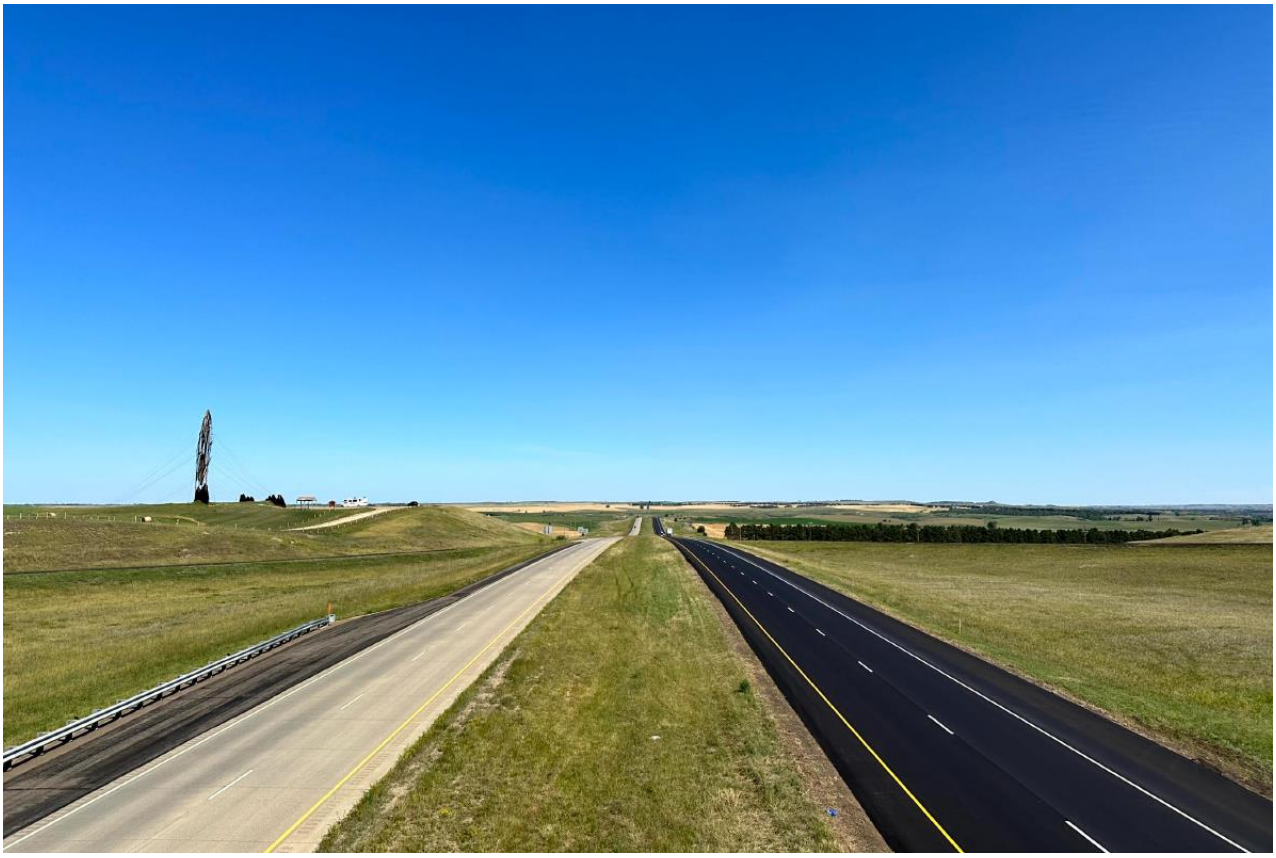
2024 FIELD SAMPLING AND TESTING MANUAL



Field Sampling and Testing Manual

Prepared by

MATERIALS AND RESEARCH DIVISION

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
BISMARCK, NORTH DAKOTA

www.dot.nd.gov

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June 20, 2024

Mr. Lee Potter
Division Administrator
Federal Highway Administration
4503 Coleman Street, Suite 205
Bismarck, ND 58503-0567

Subject: Approval of NDDOT Field Sampling and Testing Manual

Dear Mr. Potter,

We are requesting approval of our proposed changes made to the Materials and Research Division's "Field Sampling and Testing Manual." The changes include revisions to sampling and testing requirements along with test procedures to clarify sampling and testing and bring us up to date with specification and AASHTO changes.

These revisions and additions will update the "Field Sampling and Testing Manual" to be consistent with the current version of the NDDOT "Standard Specifications for Road and Bridge Construction." These changes will be available to field personnel for the 2024 construction season.

Upon approval from FHWA, the updated version of the manual will be uploaded to the NDDOT website.

Sincerely,

Tyler Wollmuth
06/20/24

Tyler Wollmuth
Assistant Materials & Research Engineer
NDDOT – Materials & Research Division

Joseph Callaway
07/01/24

Joseph Callaway
Safety and Operations Program Manager
FHWA, North Dakota Division

2024 FSTM REVISIONS

1. All font in this manual was changed to Segoe UI to follow NDDOT Manual Standards.
2. Table of Contents was formatted to follow NDDOT Manual Standards.
3. Forms were removed and replaced with links to forms.
4. Intentional blank pages were removed as this manual is online now instead of paper.
5. The definitions section removed the word abbreviations.
6. Table 258-4: Changed No. 30 Sieve to No. 8 to No. 50 sieves.
7. 302.04 Moved program oversight testing methods and frequency to section 106.
8. 430.06 Moved program oversight testing methods and frequency to section 106.
9. Table 430-6: Removed asterisk that said not to average sand equivalent.
10. Table 430-6: Added asterisk to ND T 113 and ND T 176 to reduce testing by Spec.
11. Removed ND D 4791 from tables 430-6, 430-10, 430-11, 430-13, 430-15 to match Spec.
12. Table 430-10: Added asterisk to ND T 113 and ND T 176 to reduce testing by Spec.
13. Table 550-3: Changed label from AASHTO T 23 to ND T 23.
14. Table 550-5: Changed Test Frequency.
15. Table 550-9: Changed No. 30 Sieve to No. 8 to No. 50 sieves.
16. Added section 550 Program Oversight section to section 106.
17. Table 570-2: Changed 3 labels from AASHTO designation to ND.
18. Table 570-3: Changed label from AASHTO T 23 to ND T 23.
19. Table 570-6: Changed No. 30 Sieve to No. 8 to No. 50 sieves.
20. Table 570-7 & 570-8: Changed 3 Tests from AASHTO designation to ND.
21. Table 575-1: Changed label from AASHTO T 23 to ND T 23.
22. Table 602-2: Changed 3 Tests from AASHTO designation to ND.
23. Table 602-3: Changed label from AASHTO T 23 to ND T 23.
24. Table 602-4: Changed Test Frequency.
25. Table 602-7: Changed No. 30 Sieve to No. 8 to No. 50 sieves.
26. Added Tables 602-8 and 602-9 to conduct Independent Assurance testing.
27. 602.02 Added Table 602-4 and 602-5 for Aggregate physical properties tests.
28. 650.02.B Removed M&R testing and placed in Section 106.
29. Table 650-5: Changed No. 30 Sieve to No. 8 to No. 50 sieves.
30. Table 748-4: Changed No. 30 Sieve to No. 8 to No. 50 sieves.
31. Table 748-5: Changed 3 labels from AASHTO designation to ND.
32. Table 748-6: Changed 3 labels from AASHTO designation to ND.
33. Table 750-4: Changed No. 30 Sieve to No. 8 to No. 50 sieves.
34. Table 750-5: Changed 3 labels from AASHTO designation to ND.
35. Table 750-6: Changed 3 labels from AASHTO designation to ND.
36. Revision to test procedure ND T 23 to remove field curing and change referenced test from AASHTO T 23 to AASHTO R 100.

TABLE OF CONTENTS

SECTION 100
OUTLINE

100.01 INTRODUCTION

This manual defines the procedures for field sampling, testing, inspecting, and controlling materials used on construction projects. Follow the methods outlined in this manual to assure uniformity in the use and control of materials on all construction projects. All materials covered in the contract, whether a bid item or incidental to other items, must be approved before being incorporated in the work. The Department either tests these materials or accepts them by "Certificate of Compliance." Change procedures only when authorized by the Materials and Research Engineer.

The contents of this manual follow the numbering sequence outlined in the Standard Specifications. As an example, test requirements for Section 430 of the Standard Specifications can be found in Section 430 of this manual. This section gives the required specific instructions for methods used in sampling, testing, and acceptance of Section 430 materials. Use this manual with the Standard Specifications.

This manual is updated annually by the NDDOT and is reviewed and approved by FHWA before publishing. Notify the Materials and Research Division of any errors or changes in this manual.

100.02 DUTIES AND RESPONSIBILITIES

A. Materials and Research Division.

The Materials and Research Division operates under the supervision of the Materials and Research Engineer and participates in the AASHTO Accreditation Program (AAP), and the Cement and Concrete Reference Laboratory (CCRL) inspection programs.

Each State Highway Agency (SHA) is required by 23 (CFR) Code of Federal Regulations Part 637 to maintain an accredited Central Laboratory and to assure that all materials used for highway and bridge construction conform to contract requirements. Procedures to accomplish this are detailed in this manual.

The Materials and Research Division is a material and testing resource. If a materials conflict occurs during project construction, notify Materials and Research. Materials and Research will make a recommendation to the Engineer.

B. District Materials Coordinator.

The District Materials Coordinator is the construction materials specialist within the district and is responsible for proper materials sampling, testing and specification compliance. The District Materials coordinator is accountable to the District Engineer but must coordinate activities with the Materials and Research Division.

Responsibilities include but are not limited to the following:

1. Instruct district personnel in proper sampling and testing procedures.
2. Assure that the required field tests are performed in accordance with proper test procedures (independent assurance testing).
3. Inspect and approve all field laboratories.
4. Issue, maintain, and calibrate field laboratory equipment.
5. Conduct progress and final sampling, testing, and measurements.
6. For all federal aid projects, prepare the FHWA's required certification of quality and quantity of each type of material and submit it to the District Engineer for his signature.
7. Assure that the "Materials Safety Data Sheet" for hazardous materials is posted in the field laboratory where they are used.

C. Field Laboratory Personnel.

Obtain samples, either independently or from the Contractor, of all material requiring testing for quality control or acceptance. Perform tests, document test results, complete paperwork, and inform the Project Engineer/Manager of test results. Test as many of the sampled materials in the field laboratory as possible. Perform all work in accordance with procedures set forth in this manual.

D. Consultants.

Follow the procedures outlined in this manual and directives of the District Engineer. Advice and/or direction is available from the same sources that are open to Department personnel.

E. Independent Laboratories.

Perform material testing for the Department using the Department's specifications and testing procedures. Provide certifications of all test results and, on request, allow inspection of the laboratory by representatives of the Department.

100.03 PROCUREMENT OF EQUIPMENT AND SUPPLIES

Each district office has testing equipment, sample containers, forms, and other supplies relating to material quality control. Request supplies from the District Materials Coordinator. To keep district inventory levels at a minimum and yet have ample supply

when needed, each Project Engineer/Manager needs to anticipate well in advance and keep the District Materials Coordinator fully informed.

100.04 SAMPLES AND SAMPLING

A. General.

The Project Engineer/Manager approves all sampling and testing methods used at the project level. Contract documents indicate the test method used.

Use field numbers to identify samples submitted to the District and Materials and Research Division. Accompany all samples submitted to the District or Materials and Research Division with field sample test results. When required, the District Materials Coordinator will compare the field test results with the results from the district laboratory and the Materials and Research Division.

B. Sample Information:

- Complete and submit SFN 10084 "Emulsion/Cutback/Sample Information" for emulsions and cutback oils.
- Complete and submit SFN 5650 "PG Sample Information" for PG binders.
- Complete and submit SFN 16258 "Aggregate Sample Information" for all aggregate samples.
- Complete and submit SFN 5431 "Sample Information Card" for other materials.
- Submit emulsions in plastic jugs.
- Submit PG binders and cutback oils in metal cans.
- Submit aggregates & soils in plastic pails.
- Submit cement in moisture proof pails.
- Submit core samples in sturdy boxes.
- Contact Materials & Research for other materials.

SECTION 101
DEFINITIONS

A. Acceptance

Definition: Testing conducted to verify that the specification requirements are met.

B. Quality Control (QC)

Definition: Contractor acceptance testing.

C. Quality Assurance (QA)

Definition: Agency testing to verify QC test results.

D. Independent Assurance (IA)

Definition: Evaluation of the sampling and testing procedures used in the acceptance program. IA test results are not used for material acceptance.

E. Verification

Definition: Testing conducted to verify contractor submitted mix designs or testing.

F. AASHTO Product Evaluation and Audit Solutions

Definition: This is the National Transportation Product Evaluation Program. The program combines the professional and physical resources of the AASHTO member departments to evaluate materials, products, and devices of common interest for use in highway and bridge construction. AASHTO Product Evaluation and Audit Solutions has 3 levels: product evaluation, product testing and Audit program.

SECTION 105
CONTROL OF WORK

The Standard Specification Sections 105.07, 105.09, and 105.12 give direction on control of work as it pertains to materials. Additional information as follows:

105.01 INSPECTION OF WORK

Carefully inspect all materials in the field to be accepted by certification prior to incorporation into the work. Inspect as soon as possible after the material arrives on the project. Reject any material found to be defective, regardless of previous certification, inspection, or testing.

If not used immediately, give approved materials another careful visual examination. Before use, decide acceptability of previously approved materials (based on a certification) that have deteriorated in condition or quality.

SECTION 106
CONTROL OF MATERIAL

106.01 DESCRIPTION

Section 106 of the NDDOT Standard Specifications for Road and Bridge Construction gives directions on Control of Material. The following contains additional information related to materials.

106.02 GENERAL METHODS

- Use the Materials Dropbox in the Construction Automated Records System (CARS) to store project materials testing reports. Use certification manager in CARS to store material certifications.

- All sampling and testing are conducted at the frequencies outlined throughout this manual. The specified frequencies are the minimum required for the project. The Engineer may increase sampling and testing at any time to verify the quality of the material.

- To ensure bias is eliminated from the sample selection process, sampling must be from random sample locations. The Engineer may utilize the random number table found in this manual or any other common method they find acceptable.

- Use SFN 10072 "Aggregate Quality Tests Summary" to record the results of all tests performed at an authorized laboratory. At the completion of the project, submit it to the District Materials Coordinator.

- Use SFN 10110 "Project Engineer's Report on Material Acceptance" to record the method of materials acceptance. At the completion of the project, submit it to the District Materials Coordinator.

- Some ND test procedures have the same designation as previous versions of the manual even if the AASHTO designation has changed. For example, test procedure ND T 23 now has an AASHTO designation of AASHTO R 100.

106.03 INDEPENDENT ASSURANCE SAMPLING AND TESTING PROGRAM

The Independent Assurance (IA) Program is a major element of NDDOT's Materials Quality Control Program. It is intended to ensure that test data derived from project acceptance testing is reliable by providing an independent check of test results and equipment. The program

includes observations of project sampling and testing, split sample testing, equipment checking, and documentation. Split samples are tested using equipment and testing personnel different from those used for acceptance testing. The test results are then compared to the acceptance test results. If these test results do not correlate, follow-up actions are taken to discover and correct the deficiencies document the actions taken. The testing equipment will be evaluated by calibration checks, split samples, or proficiency samples.

An IA program is required of all states by the FHWA for all federal aid projects. The states develop their own program content using FHWA prescribed guidelines. FHWA concurrence with the IA is necessary before implementation by the state. It is NDDOT policy to apply the program to all federal aid projects, including Local Public Agency (LPA) projects.

The IA program is intended to cover every lab technician that works on Federal Aid projects each construction season. If multiple technicians work on a single project, conduct multiple IA split samples and observations to ensure full coverage.

The District Materials Coordinator and the Materials & Research Division are responsible for managing the IA program. IA is independent of project acceptance testing, however close cooperation between the two is essential. All areas requiring IA are designated in this manual.

106.04 MATERIALS AND RESEARCH DIVISION PROGRAM OVERSIGHT

Program Oversight is an element of the Department's Materials Quality program. It is intended to ensure that test data derived from District Materials labs is reliable by providing checks on materials and equipment. This check is completed by the Materials and Research lab.

A. Aggregate Base – Section 302

The District Materials Coordinator will obtain and equally split these samples. The first half of the sample is retained and tested by the District Materials Coordinator. The second half of the sample along with test results will be submitted to Materials and Research.

Section 302 Program Oversight Tests	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates" ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing" NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate" ND T 113, "Lightweight Pieces in Aggregate"	2 Test results per District in each construction season.

If the test results are not within the acceptable tolerances found in the table below, the District Materials Coordinator and Materials and Research will conduct equipment checks and review test procedures until the differences are resolved.

Section 302 Tolerance	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing": • No. 4 sieve and larger • No. 30 sieve • No. 200 sieve	 ±5 ±3 ±2
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	±5
ND T 113, "Lightweight Pieces in Aggregate"	±2

B. Hot Mix Asphalt – Section 430

The District Materials Coordinator will obtain and equally split this sample. The first half of the sample will be retained and tested by the District Materials Coordinator. The second half of the sample along with test results will be submitted to Materials and Research.

The table below shows each test method required and frequency of samples when compared to any other test.

Section 430 Program Oversight Tests	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates, And ND T 11, Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing": • No. 4 sieve and larger • No. 30 sieve • No. 200 sieve	2 Test results per District in each construction season.
NDDOT T 4, "Percentage of Fracture Particles in Coarse Aggregate"	
ND T 113, "Lightweight Pieces in Aggregate"	
ND T 304, "Fine Aggregate Angularity"	
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	

If the test results are not within the acceptable tolerances found below, the District Materials Coordinator and Materials and Research will conduct equipment checks and review test procedures until the differences are resolved. The table below shows the allowable tolerance range for each test.

Section 430 Tolerance	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates" and ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing": • No. 4 sieve and larger	±7
• No. 30 sieve	±5
• No. 200 sieve	±2.5
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	±5
ND T 113, "Lightweight Pieces in Aggregate"	±3.0
ND T 304, "Fine Aggregate Angularity"	±1
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	±7

C. Concrete – Sections 550, 602, 570, 748, & 750

The District Materials Coordinator will obtain and equally split this sample. The first half of the sample will be retained and tested by the District Materials Coordinator. The second half of the sample along with test results will be submitted to Materials and Research.

Obtain and split samples according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size." The table below shows the test methods and frequency for program oversight testing.

Concrete Program Oversight Testing	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	2 Test results per District in each construction season.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces"	
ND T 113, Lightweight Pieces in Aggregate"	

If the test results are not within the acceptable tolerances found below, the District Materials Coordinator and Materials and Research will conduct equipment checks and review test procedures until the differences are resolved. The table below shows the allowable tolerance range for each test.

Concrete Tolerances	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing." • No. 4 sieve and larger • No. 8 to No. 50 sieves • No. 200 Sieve	 ±5 ±3 ±2
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces"	±1.0 ±2.5
ND T 113, Lightweight Pieces in Aggregate"	±2

SECTION 203
EXCAVATION AND EMBANKMENT

203.01 DESCRIPTION

This work consists of excavation, haul, placement, disposal, and compaction of embankment material.

203.02 EXCAVATION

No testing required.

203.03 EMBANKMENT – ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility.

The Engineer will collect material and conduct testing to verify the material meets the requirements 203.04 E, "Embankment Construction of the NDDOT *Standard Specifications for Road and Bridge Construction*. On projects that include a Linear Soil Survey, reference the report for soils information. Moisture-Density Relations of Soils in the report can be used for acceptance.

1. Compaction Control, Type A.

Table 203-1 shows test method and frequency for embankment compaction control.

Table 203-1	
Test	Frequency
ND T 180 or ND T 99, "Moisture-Density Relations of Soils (Multi-Point)"	1 moisture-density curve for each change in soil
ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber Balloon Method," or ND T 191, "Density of Soil In-Place by the Sand Cone Method"	1 test per 1,500 feet of compacted roadway per 12" lift.
ND T 265, "Laboratory Determination of Moisture Content of Soils;" or ND T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy);" or ND D 4643, "Microwave Method of Drying Soils"	1 test per 1,500 feet of compacted roadway per 12" lift.

Sample locations will be randomly selected by the Engineer.

The results of the in-place density and moisture tests are compared to the appropriate moisture density curve derived from the ND T 180 or ND T 99 testing.

Compute the ND T 180 or ND T 99 on SFN 10063, "Moisture-Density Relationship Tests" worksheet. The in-place density and moisture tests are recorded on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet – Sand Cone Method."

2. Compaction Control, Type B.

No testing required.

3. Compaction Control, Type C.

No testing required.

B. District Materials Coordinator Responsibility.

Reserved.

C. Materials and Research Responsibility.

Reserved.

203.04 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS

A. Engineer Responsibility.

Conduct IA tests on split samples taken by the District Materials Coordinator. Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility.

The District Materials Coordinator will obtain these samples and conduct these tests. Soils or soil-aggregates tested for moisture-density relations will be an equal split sample from the Engineer. In-field IA testing will be conducted next to the field test using the

same method.

Table 203-2 shows test method and frequency for embankment compaction control, Type A, for IA.

Table 203-2	
Test	Frequency
ND T 180 or ND T 99, "Moisture-Density Relations of Soils (Multi-Point)"	Minimum 1 test result per project.
ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber Balloon Method," or ND T 191, "Density of Soil In-Place by the Sand Cone Method"	Minimum 1 test result per project.
ND T 265, "Laboratory Determination of Moisture Content of Soils," or ND T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy)," or ND D 4643, "Microwave Method of Drying Soils"	Minimum 1 test result per project.

Compute the ND T 180 or ND T 99 on SFN 10063, "Moisture-Density Relationship Tests" worksheet. The in-place density and moisture tests are recorded on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet – Sand Cone Method."

The Engineer and District Materials Coordinator will compare the test results for IA tolerance in Table 203-3.

Table 203-3	
Test	Tolerance
ND T 180 or ND T 99, "Moisture-Density Relations of Soils (Multi-Point)"	± 4 lbs. cu. ft. (MDD) ± 1.5 (OM)
ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber Balloon Method," or ND T 191, "Density of Soil In-Place by the Sand Cone Method"	± 5 lbs. cu. ft.
ND T 265, "Laboratory Determination of Moisture Content of Soils," or ND T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy)," or ND D 4643, "Microwave Method of Drying Soils"	± 2.0

If the initial IA testing is not within specified tolerances, the Engineer shall obtain an additional sample for testing under the observation of the District Materials Coordinator.

The Engineer and District Materials Coordinator shall conduct equipment checks and review testing procedures. This will continue until the differences are resolved.

C. Materials and Research Responsibility.

Reserved

SECTION 210
STRUCTURAL & CHANNEL EXCAVATION, FOUNDATION FILL & PREPARATION

210.01 DESCRIPTION

A. Structural Excavation

1. Class 1: Class 1 excavation will be defined in the plans.

2. Class 2: Class 2 excavation will be defined in the plans.

3. Box Culvert Excavation: Excavation and ordinary backfill required for installation of box culverts.

B. Channel Excavation

Channel excavation will be designated on the plans and includes excavation necessary to place riprap or aggregate cushions and to flatten and shape slopes around abutment locations.

C. Foundation Preparation

Foundation preparation will be designated for installation of a box culvert or bridge.

210.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify material meets the requirements of Section 210.03.B, "Backfill" of the NDDOT Standard Specifications for Road and Bridge Construction.

Table 210-1 shows test methods and frequency for compaction control.

Table 210-1	
Tests	Frequency
ND T 180 or ND T 99, "Moisture-Density Relations of Soils (Multi-Point)"	1 compaction curve for each change in material.

ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber Balloon Method," or ND T 191, "Density of Soil In-Place by the Sand Cone Method"	1 test per 1 foot in elevation.
ND T 265, "Laboratory Determination of Moisture Content of Soils," or ND T 217, "Determination of Moisture in Soil by Mean of Calcium Carbide Gas Pressure Tester (Speedy)," or ND D 4643, "Microwave Method of Drying Soils"	1 test per 1 foot in elevation.

Sample locations will be randomly selected by the Engineer.

The results of the in-place density and moisture tests are compared to the appropriate moisture density curve derived from the ND T 180 or ND T 99 testing.

Compute the ND T 180 or ND T 99 on SFN 10063, "Moisture-Density Relationship Tests" worksheet. The in-place density and moisture tests are recorded on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet – Sand Cone Method."

Table 210-2 shows test method and frequency for aggregate placed.

Table 210-2	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	1 test result per 2,500 C.Y.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per 2,500 C.Y.
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	1 test result per 2,500 C.Y.
ND T 113, "Lightweight Pieces in Aggregate"	1 test result per 2,500 C.Y.

Compute the sieve analysis results on SFN 9987, "Aggregate Sample Worksheet." Results are recorded on SFN 10072, "Aggregate Quality Test Summary."

B. District Materials Coordinator Responsibility

Reserved.

C. Materials and Research Responsibility

Reserved.

210.03 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS

A. Engineer Responsibility

Conduct IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility

The District Materials Coordinator will obtain these samples and conduct these tests. These samples will be an equal split sample from the Engineer.

Samples will be obtained and split according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Soils or soil-aggregates tested for moisture-density relations will be an equal split sample from the Engineer. In-field IA testing will be conducted next to the field test, using the same method.

Table 210-3 shows test method and frequency for IA.

Compute the ND T 180 or ND T 99 on SFN 10063, "Moisture-Density Relationship Tests" worksheet. The in-place density and moisture tests are recorded on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet – Sand Cone Method."

Table 210-3	
Test	Frequency
ND T 180 or ND T 99, "Moisture-Density Relations of Soils (Multi-Point)"	Minimum of 1 test result per project.
ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber Balloon Method," or ND T 191, "Density of Soil In-Place by the Sand Cone Method"	Minimum of 1 test result per project.
ND T 265, "Laboratory Determination of Moisture Content of Soils," or ND T 217, "Determination of Moisture in Soil by Mean of Calcium Carbide Gas Pressure Tester (Speedy)," or ND D 4643, "Microwave Method of Drying Soils"	Minimum of 1 test result per project.
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	Minimum of 1 test result per project.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum of 1 test result per project.
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	Minimum of 1 test result per project.
ND T 113, "Lightweight Pieces in Aggregate"	Minimum of 1 test result per project.

The Engineer and District Materials Coordinator will compare the test results for IA tolerance in Table 210-4.

Table 210-4	
Test	Tolerance
ND T 180 or ND T 99, "Moisture-Density Relations of Soils (Multi-Point)"	± 4 lbs. cu. ft. (MDD) ± 1.5 (OM)
ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber Balloon Method," or ND T 191, "Density of Soil In-Place by the Sand Cone Method"	± 5 lbs. cu. ft.

ND T 265, "Laboratory Determination of Moisture Content of Soils," or ND T 217, "Determination of Moisture in Soil by Mean of Calcium Carbide Gas Pressure Tester (Speedy)," or ND D 4643, "Microwave Method of Drying Soils"	± 2.0
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing": No. 4 sieve and larger No. 30 sieve No. 200 sieve	 ±5 ±3 ±2
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	±5
ND T 113, "Lightweight Pieces in Aggregate"	±2

If the initial IA testing is not within specified tolerances, the Engineer shall obtain an additional sample for testing under the observation of the District Materials Coordinator.

The Engineer and District Materials Coordinator shall conduct equipment checks and review testing procedures. This will continue until the differences are resolved.

C. Materials and Research Responsibility.

Reserved.

SECTION 216
WATER

216.01 DESCRIPTION

This work consists of using water for dust control and to obtain proper moisture content for compaction.

216.02 ACCEPTANCE SAMPLES AND TESTS

No sampling or testing is required.

SECTION 220
STOCKPILE SITE

220.01 DESCRIPTION

This work consists of preparing or restoring a stockpile site for materials other than topsoil.

220.02 ACCEPTANCE SAMPLES AND TESTS

No sampling or testing is required.

SECTION 230
RESHAPING ROADWAY AND SUBGRADE PREPARATION

230.01 DESCRIPTION

This work consists of scarifying, shaping, compacting, and maintaining the subgrade, or reshaping an existing roadway before constructing a base, or surface course.

230.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility.

The Engineer will collect material and conduct testing to verify material meets the requirements of the NDDOT *Standard Specifications for Road and Bridge Construction.*

Table 230-1 shows test methods and frequency for compaction control.

Table 230-1	
Test	Frequency
ND T 180 or ND T 99, "Moisture-Density Relations of Soils (Multi-Point)"	1 moisture-density curve for each change in soil not represented in the Linear Soil Survey report.
ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber Balloon Method," or ND T 191, "Density of Soil In-Place by the Sand Cone Method"	1 test per 1,500 feet of compacted roadway per 12" lift.
ND T 265, "Laboratory Determination of Moisture Content of Soils," or ND T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy)," or ND D 4643, "Microwave Method of Drying Soils"	1 test per 1,500 feet of compacted roadway per 12" lift.

Sample locations will be randomly selected by the Engineer.

The results of the in-place density and moisture tests are compared to the appropriate moisture density curve derived from the ND T 180 or ND T 99 testing.

Compute the ND T 180 or ND T 99 on SFN 10063, "Moisture-Density Relationship Tests" worksheet. The in-place density and moisture tests are recorded on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet. – Sand Cone Method."

B. Field Laboratory Testing

The Engineer or Representative conducts a minimum of one moisture and density test for each compacted lift per 1500 feet of roadway.

Table 230-2	
Test	Frequency
AASHTO T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy)."	Minimum 1 test result per project.
ASTM D 2167, "Density and Unit Weight of Soil in Place by the Rubber-Balloon Method," or AASHTO T 191, "Density of Soil In-Place by Sand-Cone Method."	Minimum 1 test result per project.

Record information on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet – Sand Cone Method." Conduct additional tests at locations as directed by the Engineer or Representative.

If work consists of embankment widening, then testing shall be conducted on each side of roadway or embankment that is widened. Each widened portion shall be considered a separate roadway.

230.03 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS

Acceptance testing, and Independent Assurance (IA) testing must be completed using the same soils moisture determination method.

A. District Materials Laboratory Testing

The District Materials Coordinator or Representative conducts a minimum of one moisture and density test, including a proctor test, for each three miles of roadway.

Table 230-3	
Test	Frequency
AASHTO T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy),"	Minimum 1 test result per project.
ASTM D 2167, "Density and Unit Weight of Soil in Place by the Rubber-Balloon Method," or AASHTO T 191, "Density of Soil In-Place by Sand-Cone Method,"	Minimum 1 test result per project.

AASHTO T 99 or T 180, "Moisture-Density Relations of Soils."	Minimum 1 test result per project.

Record information on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet – Sand Cone Method," and SFN 10063, "Moisture-Density Relationship Test."

Frequency of testing shall not differ when conducting embankment widening.

B. Materials and Research Responsibility.

Reserved.

SECTION 251
SEEDING

251.01 DESCRIPTION

This work consists of seeding disturbed areas.

251.02 ACCEPTANCE

Accept material by certification.

SECTION 252
SODDING

252.01 DESCRIPTION

This work consists of placing sod in designated areas.

252.02 ACCEPTANCE

Accept material by certification.

SECTION 253
MULCHING

253.01 DESCRIPTION

This work consists of grass hay or straw mulching, and hydraulic mulching.

253.02 ACCEPTANCE

Accept material by certification.

SECTION 255
EROSION CONTROL BLANKET AND TURF REINFORCEMENT MAT

255.01 DESCRIPTION

This work consists of placing an Erosion Control Blanket (ECB) or Turf Reinforcement Mat (TRM) on a prepared slope or channel.

255.02 ACCEPTANCE

Accept material by certification.

SECTION 256
RIPRAP

256.01 DESCRIPTION

This work consists of furnishing or salvaging, and placing stones on slopes, channel ways, or other areas.

256.02 ACCEPTANCE

Inspect and accept material gradation in the field.

SECTION 258
CONCRETE SLOPE PROTECTION

258.01 DESCRIPTION

This work consists of placing cast-in-place concrete slope protection.

258.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify that the material meets the requirements in Sections 802, 804 and 812 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

Aggregate:

Aggregate samples will be obtained randomly and split according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 258-1 shows test method and frequency.

Table 258-1	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	One test per 500 S.Y.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	One test per 500 S.Y.
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces**"**	Minimum of 1 per project
ND T 113, Lightweight Pieces in Aggregate"	Minimum of 1 per project

Report results to the District Materials Coordinator on SFN 2455, "Concrete, Sand, and Gravel Worksheet."

One composite aggregate sample will be submitted to Materials and Research. The sample will be tested for L.A. abrasion and soundness during the beginning of aggregate stockpiling.

Cement:

Accept by certification.

Mix Water:

Test non-potable water according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge* Construction. Retesting is required if the source changes.

Concrete:

The Engineer will randomly select locations to conduct testing.

Table 258-2 shows test method and frequency.

Table 258-2	
Test	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	*1 test result per 500 S.Y. of concrete pavement.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	*1 test result per 500 S.Y. of concrete pavement.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	*1 test result per 500 S.Y. of concrete pavement.

**Perform this testing a minimum of one test per day.*

Other materials:

Joint sealant, reinforcing steel, preformed expansion joint material is accepted by certification.

258.03 INDEPENDENT ASSURANCE (IA) TESTING

A. Engineer Responsibility

Conduct IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility

The District Materials Coordinator will obtain these samples and conduct these tests. These samples will be an equal split sample with the Engineer.

Obtain and split samples according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 258-3 shows test methods and frequency for IA testing.

Table 258-3	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	1 test result per project
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per project

In Table 258-4 the District Materials Coordinator and the Engineer will compare the test results for IA tolerances.

Table 258-4	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing:"	
• No. 4 sieve and larger	±5
• No. 8 to No. 50 sieves	±3
• No. 200 sieve	±2

If the IA testing is not within specified tolerances, the Engineer will obtain an additional sample for testing under the observation of the District Materials Coordinator.

The Engineer and District Materials Coordinator will examine equipment used and review testing procedures until the differences are resolved.

The District Materials Coordinator will obtain these samples and conduct these tests.

Table 258-5 shows test methods and frequency for testing concrete.

Table 258-5	
Tests	Frequency
AASHTO T 119, "Slump of Hydraulic Cement Concrete"	1 test result per project.
AASHTO T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test result per project
AASHTO T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test result per project

In Table 258-6 the District Materials Coordinator and the Engineer will compare the test results for IA tolerances.

Table 258-6	
Tests	Tolerance
AASHTO T 119, "Slump of Hydraulic Cement Concrete"	±1
AASHTO T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	±2
AASHTO T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	±3

C. Materials and Research Division Responsibility

If necessary, conduct IA tests on split samples taken by the District Materials Coordinator.

Obtain and split samples according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 258-7 shows test methods and frequency for IA testing.

Table 258-7	
Tests	Frequency
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces"	Minimum of 1 test result per project
ND T 113, Lightweight Pieces in Aggregate"	Minimum of 1 test result per project

The District Materials Coordinator and Materials and Research will compare the test results for IA tolerances in Table 258-8.

Table 258-8	
Tests	Tolerance
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces"	±1.0 ±2.5
ND T 113, Lightweight Pieces in Aggregate"	±2

SECTION 260
SILT FENCE

260.01 DESCRIPTION

This work consists of furnishing, installing, maintaining, and removing silt fence.

260.02 ACCEPTANCE

Accept material by certification.

SECTION 261
FIBER ROLLS

261.01 DESCRIPTION

This work consists of furnishing, installing, maintaining, and removing fiber rolls.

261.02 ACCEPTANCE

Accept material by certification.

SECTION 262
FLOTATION SILT CURTAIN

262.01 DESCRIPTION

This work consists of furnishing, installing, maintaining, and removing flotation silt curtains.

262.02 ACCEPTANCE

Accept material by certification.

SECTION 265
STABILIZED CONSTRUCTION ACCESS

265.01 DESCRIPTION

This work consists of installing, maintaining, and removing a stabilized construction access where equipment enters a public roadway.

265.02 ACCEPTANCE

Accept geosynthetic material by certification. Inspect and accept material gradation in the field.

APPENDIX 200-A
CONSULTANT USE OF NUCLEAR GAUGES FOR COMPACTION CONTROL

1. GENERAL REQUIREMENTS

Consulting firms may use nuclear gauges under the following conditions:

- The use of the gauges shall be limited to soil and aggregate density and moisture testing. Testing must be conducted according to AASHTO T 310, "In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)."

- The firm providing the testing maintains accreditation under the AASHTO Accreditation Program (AAP).

    - Included in the scope must be AASHTO Standard R18, "Establishing and Implementing a Quality System for Construction Materials Laboratories," and AASHTO Test Method T 310, "In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)."

    - The firm providing the testing shall provide calibration data for the nuclear gauges they are using. The nuclear gauges are to be calibrated according to Annex A1, A2, and A3 of AASHTO T 310.

- Nuclear gauges contain radioactive materials. Users must follow all applicable safety regulations and protocol required by the North Dakota State Health Department.

2. CORRELATION REQUIREMENTS

- A series of five (5) side-by-side comparisons shall be conducted at the beginning of each project on a location determined by the Engineer.

- The data acquired from each gauge will be correlated to conventional methods of determining dry density on the same materials tested on the project. The conventional density tests are the following:

    In-Place Density Tests:

    ND D 2167, "Density and Unit Weight of Soil In-Place by the Rubber Balloon Method"
    ND T 191, "Density of Soil In-Place by the Sand Cone Method"

In-Place Moisture Tests:

ND T 265, "Laboratory Determination of Moisture Content of Soils"
ND T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy)"
ND D 4643, "Microwave Method of Drying Soils"

- Personnel conducting the nuclear density testing must also conduct the comparison testing in the field. These personnel must also be certified to provide conventional density and moisture testing according to NDDOT *Standard Specification for Road and Bridge Construction* Section 106.10.

- All correlation results are provided to the Engineer within 24 hours of the completion of the testing.

- The average of the moisture content tests shall be compared to the nuclear gauge results. If the average differentiates by less than 1.0% or 1.0 lbs./cu.ft., the nuclear gauge is used without correction.

- If the gauge results differ by more than 1.0%, a correction factor will be applied. If the in-place wet density results differ by more than 1.0 lbs./cu.ft., a correction will be applied.

3. VALIDATION OF RESULTS

- This correlation will be verified in the field with a single test for every ten (10) nuclear gauge tests for the first 30 tests. Testing can be reduced to a single validation test per 50 nuclear gauge tests thereafter.

- If a correction factor has been applied and the verification differentiates by over 0.5% or 0.5 lbs./cu.ft., a new correction factor shall be established as previously described in Section 2. Correlation testing would also revert to a single test for every ten (10) nuclear gauge tests for the first 30 tests.

4. INDEPENDENT ASSURANCE (IA)

- Independent assurance is required and conducted using the conventional in-place density methods used for the comparison testing.

- The District Materials Coordinator directs frequency and testing of the IA.

SECTION 200 FORMS

Conversion Chart for Speedy Tester SFN 13942

Density Test Work Sheet - Volume Measure SFN 2454

Aggregate Sample Worksheet SFN 9987

Moisture-Density Relationship Tests SFN 10063

Sand Cone Correction Factor SFN 59724

Density Test Worksheet-Sand Cone Method SFN 59725

SECTION 302
AGGREGATE BASE AND SURFACE COURSE

302.01 DESCRIPTION

This work consists of furnishing and placing aggregate or salvaged material on a prepared foundation.

302.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify the material meets the requirements in Section 816 or 817 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

Obtain and split aggregate samples according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 302-1 shows test methods and test frequency.

Table 302-1	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	*1 test result per lot
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	*1 test result per lot

**Definition of a lot:*

- *One day's production, if that day's production is greater than 1,000 tons.*
- *As many days' production as necessary to reach 1,000 tons (a day's production will not be split into multiple lots); or*
- *The plan quantity if plan quantity is less than 1,000 tons.*

Table 302-2 shows test methods and test frequency for fractured particles and lightweight pieces of aggregate.

Table 302-2	
Tests	Frequency
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	*1 test result per 10,000-ton lot
ND T 113, Lightweight Pieces in Aggregate"	*1 test result per 10,000-ton lot

**Definition of a lot:*

- *If a fractional lot is less than 2,500 tons, it will be included in the previous lot.*
- *If fractional lot is greater than 2,500 tons, but less than 10,000 tons, it will be considered a new lot.*

For Tables 302-1 and 302-2 obtain three random samples for each lot of material placed at a location determined by the Engineer. Test each sample and determine acceptance based on the average of the three tests.

If the results of each sample are within the specified range, collect three samples from the next lot produced and test one of the samples. If the test result is within the specified range, the Engineer will accept the material.

If the test result is outside of the specified range, test the remaining two samples and determine acceptance based on the average of the three test results. When the average of three test results is needed to determine acceptance, continue to test three samples for each lot produced. Return to testing a single sample only after all three sample test results are within the specified range.

Compute the sieve analysis results on SFN 9987, "Aggregate Sample Worksheet" and record on SFN 10072, "Aggregate Quality Test Summary."

B. District Materials Coordinator Responsibility

The District Materials Coordinator will obtain a sample. Table 302-3 shows test methods and test frequency. **This test is required for Class 5 only**.

Table 302-3	
Tests	Frequency
ND T 90, "Determining the Plasticity Limit and Plasticity Index of Soils" (Acceptance Test)	Minimum 1 test result per project.

C. Materials and Research Division Responsibility

During the beginning of aggregate stockpiling, the Engineer obtains one composite aggregate sample and submits it to Materials and Research for L.A. Abrasion testing.

Table 302-4 shows test methods and test frequency.

Table 302-4	
Tests	Frequency
AASHTO T 96, "Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	*1 test result per project.

**If the aggregate source has been tested previously by the Department and the material is within the allowable limits, the test for L.A. Abrasion will not be required.*

302.03 INDEPENDENT ASSURANCE (IA) TESTING

A. Engineer Responsibility

Perform IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility

The District Materials Coordinator will obtain these samples and perform these tests. These samples will be an equal split sample with the Engineer.

Obtain and split samples according to ND T 2, "Sampling of Aggregates," and ND T 248 "Reducing Samples of Aggregate to Testing Size."

Table 302-5 shows test methods and test frequency.

Table 302-5	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	Minimum 1 test result per project.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum 1 test result per project.
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	Minimum 1 test result per project.
ND T 113, "Lightweight Pieces in Aggregate"	Minimum 1 test result per project.

The District Materials Coordinator and the Engineer will compare the test results for IA tolerances in Table 302-6.

Table 302-6	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing": • No. 4 sieve and larger • No. 30 sieve • No. 200 sieve	 ±5 ±3 ±2
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	±5
ND T 113, "Lightweight Pieces in Aggregate"	±2

SECTION 300 FORMS

Aggregate Sample Worksheet SFN 9987

Aggregate Quality Tests Summary SFN 10072

Price Adjustment Worksheet SFN 14388

SECTION 401
PRIME, TACK, OR FOG COAT

401.01 DESCRIPTION

This work consists of preparing and treating a surface with bitumen.

401.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

Bitumen:

Under the observation of the Engineer, the Contractor will obtain a sample, which is two containers of bitumen from each load delivered to the project following NDDOT 1, "Sampling of Bituminous Materials."

For tack or fog coat, the Engineer will submit all samples to the District Materials Coordinator. Testing of Emulsions used for Tack and Fog Coat are only required if a consistency or performance issue is observed in the field. Hold samples until the material is accepted in the field. If testing is required, the testing needs to be completed within 30 days of sampling.

For prime coat, the Engineer will submit one container sample to the Materials and Research Division and retain one container as a check. Testing needs to be completed within 30 days of sampling.

Aggregate for blotter:

The Engineer will obtain and split aggregate samples according to ND T 2, "Sampling of Aggregate," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

The Engineer will obtain these samples from material placed in a stockpile or material delivered directly to the project.

Table 401-1 shows test method and frequency for aggregate testing.

Table 401-1	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	1 test result per 5 miles or fraction thereof.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per 5 miles or fraction thereof.

Compute the sieve analysis results on SFN 9987, "Aggregate Sample Worksheet." Results are recorded on SFN 10072, "Aggregate Quality Test Summary."

Water:

If water is potable, no sampling or testing is required. If water quality is unknown, obtain one sample per water source according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge Construction* and submit to the Materials and Research Division.

B. District Materials Coordinator Responsibility

For emulsified asphalt samples, the District Materials Coordinator will test for sieve and viscosity only, according to tests listed in ND T 59 "Standard Method of Test for Emulsified Asphalts" and ND T 72 "Standard Method of Test for Saybolt Viscosity." The sieve and viscosity tests may be waived if the Engineer determines there is not a consistency problem with the emulsion.

Testing frequency for emulsion testing is the first truck load delivered to the project and then one random sample from the next four trucks delivered. The testing frequency then goes to two random samples from each additional five truck lot, or fraction of a five-truck lot.

C. Materials and Research Division Responsibility

Testing of Emulsions used for Tack and Fog Coat are only required if a consistency or performance issue is observed in the field.

For emulsified asphalts, Materials and Research 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 Materials and Research for testing.

Materials and Research will inform the District when sample submittal is required due to failing tests.

Materials and Research will then test samples around the one that does not pass to determine a failing lot size. For example, using Table 401-2 below there are four loads of emulsion delivered during the first half of a project and five loads for the second half of the project:

Table 401-2				
First Half of Project				
Sample 1	Sample 2	Sample 3	Sample 4	
Second Half of Project				
Sample 5	Sample 6	Sample 7	Sample 8	Sample 9

- The District submits Sample 3 and Sample 7. Sample 3 from the first half passes and all material from the first half is accepted with no further testing.

- Sample 7 from the second half fails so Materials and Research will test Samples 6 and 8. If Sample 6 passes, Sample 5 is accepted with no further testing.

- If Sample 8 fails, Sample 9 is tested. If Sample 9 passes, the failing lot size is made up of loads 7 and 8.

Perform testing on all cutback asphalt samples, submitted by the Engineer, according to Section 818 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

Test submitted water samples according to the requirements of Section 812 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

401.03 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS

A. Engineer Responsibility

Reserved.

B. District Materials Coordinator Responsibility

Bitumen:

For all emulsions, one sample is randomly selected from each of the first and second halves of the project and sent to the Materials and Research Division.

Samples should be submitted in a timely manner because there is a 30-day limit in which testing can be done.

Aggregate:

The District Materials Coordinator will obtain and split samples according to ND T 2,

"Sampling of Aggregate," and ND T 248, "Reducing Samples of Aggregate to Testing Size." The District Materials Coordinator will obtain these samples from material placed in a stockpile or material delivered directly to the project.

Table 401-3 shows the test method and frequency for aggregate produced.

Table 401-3	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	Minimum 1 test result per project.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum 1 test result per project.

Table 401-4 shows the allowable tolerances between the IA and acceptance samples.

Table 401-4	
Test	Tolerance
ND T 11, Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing, and ND T 27, "Sieve Analysis of Fine and Coarse Aggregates":	
5/8-inch sieve	±7%
No. 4 sieve	±7%
No. 200 sieve	±2.5%

C. Materials and Research Division Responsibility

Bitumen:

Tests and frequency for IA for viscosity and sieve are shown in Table 401-5.

Table 401-5	
Test	Frequency
AASHTO T 59, "Emulsified Asphalts"	Minimum 1 test result per project.

Tolerance between IA and acceptance tests are in Table 401-6.

Table 401-6	
Test	Tolerance
AASHTO T 59, "Emulsified Asphalts": Sieve	±0.08%

Viscosity	25º C ±15% 50º C ± 21%

If the IA testing is not within specified tolerances, the District Materials Coordinator obtains an additional sample for testing.

The District Materials Coordinator and Materials and Research personnel will examine equipment used and review testing procedures. This will continue until the differences are resolved.

SECTION 411
MILLING PAVEMENT SURFACE

411.01 DESCRIPTION

This work consists of milling pavement surfaces.

411.02 ACCEPTANCE SAMPLES AND TESTS

Sampling and testing not required**.**

SECTION 420
BITUMINOUS SEAL COAT

420.01 DESCRIPTION

This work consists of an application of bitumen followed by an application of cover coat material on a prepared surface.

420.02 ACCEPTANCE SAMPLES AND TESTS WITH A FIELD LABORATORY

A. Engineer Responsibility

Bitumen:

Under the observation of the Engineer, the Contractor will obtain a sample, which is two containers of bitumen from each load delivered to the project following NDDOT 1, "Sampling of Bituminous Materials."

For emulsion samples received from the Contractor, the Engineer will submit all samples to the District Materials Coordinator. Samples need to be tested within 30 days of sampling.

Aggregate:

The Engineer shall obtain three random samples from each lot of cover coat material for testing. Obtain and split aggregate samples according to ND T 2, "Sampling of Aggregate" and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 420-1 shows test method and frequency.

Table 420-1	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	*1 test result per lot.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	*1 test result per lot.

**Definition of a lot:*

- *1,200 tons of material.*
- *Plan quantity, if plan quantity is less than 1,200 tons.*
- *If the final lot is less than 600 tons include it in the previous lot.*
- *If the final lot is greater than 600 tons, it is a separate lot.*
- *Lots continue from day to day. Each day does not start a new lot.*

Test all samples from the lot and determine acceptance of the lot based on the average of the tests.

Obtain one sample of blotter material for every five miles or fraction thereof. Obtain these

samples from material placed in a stockpile or material delivered directly to the project. Table 420-1 above lists the tests to be conducted.

Compute the sieve analysis on SFN 9987, "Aggregate Sample Worksheet." Results are recorded on SFN 10072, "Aggregate Quality Test Summary."

Submit an aggregate sample to the Materials and Research Division for L.A. Abrasion according to AASHTO T 96.

B. District Materials Coordinator Responsibility

Bitumen:

The District Materials Coordinator will test the emulsified asphalt samples for sieve and viscosity according to ND T 59 and ND T 72.

The sieve and viscosity tests may be waived if the Engineer determines there is not 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 Division for testing. Samples need to be tested with 30 days of sampling.

Aggregate:

Table 420-2 shows test method and frequency.

Table 420-2	
Test	Frequency
ND T 113, "Lightweight Pieces of Aggregate"	*1 test result per lot.

**Definition of a lot:*

- *Lot is every 10 miles or fraction thereof.*

C. Materials and Research Division Responsibility

Bitumen:

Materials and Research 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 Materials and Research for testing.

Materials and Research will inform the District when sample submittal is required due to

failing tests.

Materials and Research will then test samples around the one that does not pass to determine a failing lot size. For example, using Table 420-3 there are four loads of emulsion delivered during the first half of a project and five loads for the second half of the project.

Table 420-3				
First Half of Project				
Sample 1	Sample 2	Sample 3	Sample 4	
Second Half of Project				
Sample 5	Sample 6	Sample 7	Sample 8	Sample 9

- The District submits Sample 3 and Sample 7. Sample 3 from the first half passes and all material from the first half is accepted with no further testing.
- Sample 7 from the second half fails so Materials and Research will test Samples 6 and 8. If Sample 6 passes, Sample 5 is accepted with no further testing.
- If Sample 8 fails, Sample 9 is tested. If Sample 9 passes, the failing lot size is made up of loads 7 and 8.

Aggregate:

Perform L.A. Abrasion, AASHTO T 96, on a sample obtained during aggregate production.

Table 420-4 shows test method and frequency.

Table 420-4	
Test	Frequency
AASHTO T 96, "Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine"	*1 test result per project.

**If the aggregate source has been tested previously by the Department and the material is within allowable limits, the test for L.A. Abrasion will not be required.*

420.03 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS WITH A FIELD LABORATORY

A. Engineer Responsibility

Conduct IA tests on split samples taken by the District Materials Coordinator. Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility

Bitumen:

If the District Materials Coordinator conducts a test for sieve and viscosity according to tests listed in AASHTO T 59, "Emulsified Asphalts," then for IA another sample is tested and the remaining sample is submitted to the Materials and Research Division. Samples need to be tested within 30 days of sampling.

Aggregate:

The District Materials Coordinator will obtain aggregate samples. These samples will be an equal split sample with the Engineer.

The District Materials Coordinator shall obtain and split aggregate samples according to ND T 2, "Sampling of Aggregate," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 420-5 shows test method and frequency.

Table 420-5	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	1 test result per project.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per project.

Compute the sieve analysis on SFN 9987, "Aggregate Sample Worksheet." Results are recorded on SFN 10072, "Aggregate Quality Test Summary."

Table 420-6 shows the tolerance between IA and acceptance tests.

Table 420-6	
Test	Tolerance
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing, and ND T 27, "Sieve Analysis of Fine and Coarse Aggregates":	
3/8-inch sieve	±7%
No. 4 sieve	±7%
No. 8 sieve	±7%
No. 200 sieve	±2.5%

If the IA testing is not within specified tolerances, the District Materials Coordinator will obtain an additional sample for testing.

The Engineer and District Materials Coordinator will examine equipment used and review testing procedures. This will continue until the differences are resolved.

A sample of blotter material is not required.

C. Materials and Research Division Responsibility

If the District Materials Coordinator has conducted a test for sieve and viscosity according to tests listed in AASHTO T 59, "Emulsified Asphalts," then an IA must be completed.

Table 420-7 shows test method and frequency for IA.

Table 420-7	
Test	Frequency
AASHTO T 59, "Emulsified Asphalts"	1 test result per project.
ND T 113, "Lightweight Pieces of Aggregate"	1 test result per project.

Table 420-8 shows the tolerance between IA and acceptance tests.

Table 420-8	
Test	Tolerance
AASHTO T 59, "Emulsified Asphalts": Sieve Viscosity	±0.08%
	25º C ±15% 50º C ± 21%
ND T 113, Lightweight Pieces in Aggregate	±3%

If the IA testing is not within specified tolerances, the District Materials Coordinator will obtain an additional sample for testing.

The District Materials Coordinator and Materials and Research personnel will examine equipment used and review testing procedures. This will continue until the differences are resolved.

420.04 ACCEPTANCE SAMPLES AND TESTS WITHOUT A FIELD LABORATORY

A. Engineer Responsibility

Under the observation of the Engineer, the Contractor will obtain a sample, which is two containers of bitumen from each load delivered to the project following NDDOT 1, "Sampling of Bituminous Materials."

For emulsion samples received from the Contractor, the Engineer will submit all samples to the District Materials Coordinator. Samples need to be tested within 30 days of sampling.

B. District Materials Coordinator Responsibility

Bitumen:

The District Materials Coordinator will test the emulsified asphalt samples for sieve and viscosity only according to tests listed in AASHTO T 59, "Emulsified Asphalts."

The sieve and viscosity tests may be waived if the Engineer determines there is not 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 Division for testing.

Aggregate:

Obtain three random samples from each lot of cover coat material. Obtain and split aggregate samples according to ND T 2, "Sampling of Aggregate," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Test all samples from the lot and determine acceptance of the lot based on the average of the tests.

Table 420-9 shows test method and frequency.

Table 420-9	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	*1 test result per lot.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	*1 test result per lot.
ND T 113, "Lightweight Pieces of Aggregate"	*1 test result per lot.

**Definition of a lot:*

- *1,200 tons.*
- *If the final lot is less than 600 tons, include it in the previous lot.*
- *If the final lot is greater than 600 tons, it is a separate lot.*
- *For ND T 113 a lot is every 10 miles or fraction thereof.*
- *Lots continue from day to day. Each day does not start a new lot.*

Compute the sieve analysis on SFN 9987, "Aggregate Sample Worksheet." Results are recorded on SFN 10072, "Aggregate Quality Test Summary."

Obtain one sample of blotter material for every five miles or fraction thereof. Obtain these samples from material placed in a stockpile or material delivered directly to the project. Table 420-9 above lists the tests to be conducted excluding ND T 113.

C. Materials and Research Division Responsibility

Bitumen:

Test samples according to Section 818 of the NDDOT *Standard Specifications for Road and Bridge Construction* for the appropriate material.

Aggregate:

Perform L.A. Abrasion, AASHTO T 96, on a sample obtained during aggregate production.

Table 420-10 shows test method and frequency.

Table 420-10	
Test	Frequency
AASHTO T 96, "Resistance to Degradation of Small- Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine"	*1 test result per project.

**If the aggregate source has been tested previously by the Department and the material is within allowable limits, the test for L.A. Abrasion will not be required.*

420.05 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS WITHOUT A FIELD LABORATORY

A. Engineer Responsibility

Reserved.

B. District Materials Coordinator Responsibility

Conduct IA tests on split samples. Obtain and split the sample. Submit a split sample to Materials and Research.

C. Materials and Research Division Responsibility.

1. Bitumen:

If the District Materials Coordinator has conducted a test for sieve and viscosity according to tests listed in AASHTO T 59, "Emulsified Asphalts," then the following must be completed. Tests and frequency for IA for viscosity and sieve are shown in Table 420-11.

Table 420-11	
Test	Frequency
AASHTO T 59, "Emulsified Asphalts"	1 test result per project.

Tolerances between IA and acceptance tests are in Table 420-12.

Table 420-12	
Test	Tolerance
AASHTO T 59, "Emulsified Asphalts"	±0.08%
	25º C ±15% 50º C ± 21%

If the IA testing is not within specified tolerances, the District Materials Coordinator will obtain an additional sample for testing.

The District Materials Coordinator and Materials and Research personnel will examine equipment used and review testing procedures. This will continue until the differences are resolved.

2. Aggregate:

Obtain and split aggregate samples according to ND T 2, Sampling of Aggregate and ND T 248, Reducing Samples of Aggregate to Testing Size.

Table 420-13 shows test method and frequency.

Table 420-13	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	1 test per 10 miles or fraction thereof.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test per 10 miles or fraction thereof.
ND T 113, "Lightweight Pieces of Aggregate"	1 test per 10 miles or fraction thereof.

Compute the sieve analysis on SFN 9987, "Aggregate Sample Worksheet." Results are recorded on SFN 10072, "Aggregate Quality Test Summary."

Table 420-14 shows tolerance between IA and acceptance tests.

Table 420-14	
Test	Tolerance
ND T 11, Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing, and ND T 27, "Sieve Analysis of Fine and Coarse Aggregates":	
3/8-inch sieve	±7%
No. 4 sieve	±7%
No. 8 sieve	±7%
No. 200 sieve	±2.5%
ND T 113, Lightweight Pieces in Aggregate	±3%

If the IA testing is not within specified tolerances, the District Materials Coordinator obtains an additional sample for testing.

The District Materials Coordinator and Materials and Research personnel will examine equipment used and review testing procedures. This will continue until the differences are resolved.

A sample of blotter material is not required.

SECTION 421
MICROSURFACING

421.01 DESCRIPTION

This work consists of applying a thin overlay material of modified emulsified asphalt, aggregate, water, and additives over a prepared surface.

421.02 ACCEPTANCE SAMPLING AND TESTING DURING STOCKPILING

A. Engineer Responsibility

Obtain and split aggregate samples according to ND T 2, "Sampling of Aggregate," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Obtain five independent samples from the stockpile. Each sample is tested separately.

Table 421-1 shows test methods to be conducted and frequency of testing.

Table 421-1	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	Minimum of one per project
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum of one per project
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test"	Minimum of one per project

Compute the sieve analysis results on SFN 9987, "Aggregate Sample Worksheet" and sand equivalent on SFN 51730, "Sand Equivalent of Fine Aggregate."

421.03 ACCEPTANCE SAMPLING AND TESTING DURING MIX PRODUCTION

A. Engineer Responsibility

Obtain material for determining moisture content.

Table 421-2 shows test methods to be conducted and frequency of testing.

Table 421-2	
Test	Frequency
ND T 255, "Total Evaporable Moisture Content of Aggregate by Drying"	3 test results per day.

Bitumen shall be sampled by the Contractor under the observation of the Engineer. Two samples of bitumen shall be obtained from each load delivered to the project. The Engineer shall take possession of both samples.

Ensure material is sampled according to NDDOT 1, "Sampling of Bituminous Materials."
Table 421-3 shows test methods to be conducted and frequency of testing.
Submit samples to Materials and Research for testing. Emulsions need to be tested within 30 days of sampling.

B. Materials and Research Division Responsibility

Bitumen:

Materials and Research 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 Materials and Research for testing.

Materials and Research will inform the District when sample submittal is required due to failing tests.

Materials and Research will then test samples around the one that does not pass to determine a failing lot size. For example, using Table 421-3 there are four loads of emulsion delivered during the first half of a project and five loads for the second half of the project.

Table 421-3				
First Half of Project				
Sample 1	Sample 2	Sample 3	Sample 4	
Second Half of Project				
Sample 5	Sample 6	Sample 7	Sample 8	Sample 9

The District submits Sample 3 and Sample 7. If Sample 3 from the first half passes, all material from the first half is accepted with no further testing.

If Sample 7 from the second half fails, Materials and Research will test Samples 6 and 8. If Sample 6 passes, Sample 5 is accepted with no further testing. If Sample 8 fails, Sample 9 is tested. If Sample 9 passes, the failing lot size is made up of loads 7 and 8.

421.04 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS

A. District Materials Coordinators Responsibility

Obtain and split aggregate samples according to ND T 2, "Sampling of Aggregate," and ND T 248, "Reducing Samples of Aggregate to Testing Size." This sample shall be an equal split from the engineer's five stockpile acceptance samples.

Table 421-4 shows test methods to be conducted and frequency of testing.

Table 421-4	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	Minimum of one per project
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum of one per project
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test"	Minimum of one per project

Compute the sieve analysis results on SFN 9987, "Aggregate Sample Worksheet" and sand equivalent on SFN 51730, "Sand Equivalent of Fine Aggregate."

Table 421-5 shows the tolerance requirements between IA and acceptance tests.

Table 421-5	
Tests	Tolerance
ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing," ND T 27, "Sieve Analysis of Fine and Coarse Aggregates": • 3/8" sieve • #4 sieve • #8 - #100 sieves • #200 sieve	 ±7% ±7% ±7% ±2.5%
ND T 176, "Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test"	±5%

If the IA testing is not within specified tolerances, the District Materials Coordinator will obtain an additional sample for testing.

The District Materials Coordinator and Materials and Research will examine equipment used and review testing procedures until the differences are resolved.

SECTION 422
SLURRY SEAL

422.01 DESCRIPTION

This work consists of applying a material composed of emulsified asphalt, aggregate, water, and additives over a prepared surface.

422.02 ACCEPTANCE SAMPLING AND TESTING DURING STOCKPILING

A. Engineer Responsibility

Obtain and split aggregate samples according to ND T 2, "Sampling of Aggregate," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Obtain five independent samples from the stockpile. Each sample is tested separately.

Table 422-1 shows test methods to be conducted and frequency of testing.

Table 422-1	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	Minimum of one per project
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum of one per project
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test"	Minimum of one per project

Compute the sieve analysis results on SFN 9987, "Aggregate Sample Worksheet" and sand equivalent on SFN 51730, "Sand Equivalent of Fine Aggregate."

422.03 ACCEPTANCE SAMPLING AND TESTING DURING MIX PRODUCTION

A. Engineer Responsibility

Obtain material for determining moisture content.

Table 422-2 shows test methods to be conducted and frequency of testing.

Table 422-2	
Tests	Frequency
ND T 255, "Total Evaporable Moisture Content of Aggregate by Drying"	3 test results per day

Bitumen shall be sampled by the Contractor under the observation of the Engineer. Two samples of bitumen shall be obtained from each load delivered to the project. The Engineer shall take possession of both samples.

Ensure material is sampled according to NDDOT 1, "Sampling of Bituminous Materials."

Table 422-3 shows test methods to be conducted and frequency of testing.

Submit samples to Materials and Research for testing. Samples need to be tested within 30 days of sampling.

B. Materials and Research Division Responsibility

Bitumen:

Materials and Research 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 Materials and Research for testing.

Materials and Research will inform the District when sample submittal is required due to failing tests.

Materials and Research will then test samples around the one that does not pass to determine a failing lot size. For example, using Table 422-3 there are four loads of emulsion delivered during the first half of a project and five loads for the second half of the project.

Table 422-3				
First Half of Project				
Sample 1	Sample 2	Sample 3	Sample 4	
Second Half of Project				
Sample 5	Sample 6	Sample 7	Sample 8	Sample 9

The District submits Sample 3 and Sample 7. If Sample 3 from the first half passes, all material from the first half is accepted with no further testing.

If Sample 7 from the second half fails, Materials and Research will test Samples 6 and 8. If Sample 6 passes, Sample 5 is accepted with no further testing.

If Sample 8 fails, Sample 9 is tested. If Sample 9 passes, the failing lot size is made up of loads 7 and 8.

422.04 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS

A. District Materials Coordinators Responsibility

Obtain and split aggregate samples according to ND T 2, "Sampling of Aggregate," and ND T 248, "Reducing Samples of Aggregate to Testing Size." This sample shall be an equal split from the Engineer's five stockpile acceptance samples.

Table 422-4 shows test methods to be conducted and frequency of testing.

Table 422-4	
Tests	Worksheet
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	Minimum of one per project
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum of one per project
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test"	Minimum of one per project

Compute the sieve analysis results on SFN 9987, "Aggregate Sample Worksheet" and sand equivalent on SFN 51730, "Sand Equivalent of Fine Aggregate."

Table 422-5 shows tolerance requirements between IA and acceptance tests.

Table 422-5	
Tests	Tolerance
ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing," and ND T 27, "Sieve Analysis of Fine and Coarse Aggregates": • 3/8" sieve • #4 sieve • #8 - #100 sieves • #200 sieve	 ±7% ±7% ±7% ±2.5%
ND T 176, "Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test"	±5%

If the IA testing is not within specified tolerances, the District Materials Coordinator will obtain an additional sample for testing.

The District Materials Coordinator and Materials and Research will examine equipment used and review testing procedures until the differences are resolved.

SECTION 430
HOT MIX ASPHALT (HMA) SAMPLING AND TESTING REQUIREMENTS

430.01 DESCRIPTION

This work consists of constructing bituminous pavement.

430.02 QUALITY CONTROL TESTING

The Contractor's QC program will be conducted by certified personnel as outlined in the NDDOT Technical Certification Program. QC samples will be split under the observation of the Engineer.

A. Testing During Aggregate Production

1. Engineer Responsibility

Reserved.

2. Contractor Responsibility

The Contractor will obtain and reduce aggregate samples according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

a. The Contractor will perform one test per 1,000 tons of material produced for each aggregate stockpile.

Table 430-1 lists the tests to be conducted.

Table 430-1	
Tests	Worksheet
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	SFN 9987, Aggregate Sample Worksheet
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	SFN 9987, Aggregate Sample Worksheet

b. The Contractor will test one sample from the first 5,000 tons of material produced from each stockpile. After the initial testing, the testing frequency will change to one sample tested for each 10,000 tons of material produced per stockpile.

Table 430-2 lists the tests to be conducted.

Table 430-2	
Tests	Worksheet
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	SFN 9987, Aggregate Sample Worksheet
ND T 113, "Lightweight Pieces in Aggregate"	SFN 9987, Aggregate Sample Worksheet
ND T 304, "Fine Aggregate Angularity"	SFN 51701, Uncompacted Void Content of Fine Aggregate
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	SFN 51730, Sand Equivalent of Fine Aggregate
ND D 4791, "Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate"	SFN 51700, Flat or Elongated Particles in Coarse Aggregate

c. When a stockpile is less than 10,000 tons for the project, a minimum of two samples per stockpile will be obtained and tests performed.

Table 430-3 lists the tests to be conducted.

Table 430-3	
Tests	Worksheet
ND T 84, "Specific Gravity and Absorption of Fine Aggregate"	SFN 2199, Fine Aggregate Specific Gravity Worksheet
ND T 85, "Specific Gravity and Absorption of Coarse Aggregate"	SFN 10081, Coarse Aggregate Specific Gravity Worksheet

3. District Materials Coordinator Responsibility

This section is to determine the specific gravity of the material according to Section 430.04 C.2, "Determination of Specific Gravity" in the *NDDOT Standard Specifications for Road and Bridge Construction*.

The District Materials Coordinator or a designee will obtain a split of the sample from the Contractor and determine the bulk (dry), apparent specific gravity, and the percent water absorption of each stockpile according to Table 430-3.

The District Materials Coordinator will conduct the tests on the initial sample received. The District Materials Coordinator has the option to run tests of any additional samples received.

B. Mix Design Requirements

1. Engineer Responsibility

Reserved.

2. Contractor Responsibility

a. Once the specific gravity has been determined and verified, develop the mix design.
b. Use NDDOT 2 "Gyratory Mix Design Procedure" and follow the requirements in Section 430 of the Standard Specifications for Road and Bridge Construction.
c. Submit the mix design, including all test data to the Engineer.

3. District Materials Coordinator Responsibility

The District Materials Coordinator will verify the Contractor mix design by using one or more of the following procedures:

a. A full mix design using the materials and mix proportions supplied by the Contractor.
b. A one-point mix design using the Contractor's optimum asphalt content, the materials, and mix proportions supplied by the Contractor.
c. NDDOT produced specimen developed from loose asphaltic concrete mix prepared at the optimum asphalt content recommended by the Contractor mix design.
d. Historic data from past projects utilizing the same aggregate source.

The mix design will be approved if the testing is within the tolerances shown in Table 430-4.

Table 430-4

Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing":	
• No. 4 sieve and larger	±5
• No. 30 sieve	±3
• No. 200 sieve	±1.5
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	±5
ND T 113, "Lightweight Pieces in Aggregate"	±1.0
ND T 304, "Fine Aggregate Angularity"	±1

ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	±5
ND D 4791, "Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate"	±1
Aggregate Bulk Specific Gravity (dry), each fraction.	±0.040
Aggregate Apparent Specific Gravity, each fraction.	±0.040
NDDOT 7 RAP Aggregate Bulk Specific Gravity	±0.040
Air Voids - ND T 209, "Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt," and ND T 166, "Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface Dry Specimens"	±1.0
ND T 209, "Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt"	±0.030

If the Contractor's mix design is not approved, the Contractor will submit another mix design. An approved mix design is required before beginning production of bituminous pavement.

4. Materials and Research Division Responsibility

Reserved.

C. Testing During Mix Production

1. Engineer Responsibility

During mix production, one half of the aggregate and hot mix asphalt QC samples will be retained by the QA. These samples will be retained until QA testing confirms the validity of the QC testing.

2. Contractor Responsibility

a. The Contractor will perform ND T 255, "Total Evaporable Moisture Content of Aggregate by Drying," twice on the first day of mix production and once per day before plant startup of mix production thereafter.

   The Contractor will perform additional testing after a rain event until the test results are consistent.

b. The Contractor will generate random numbers for determining when to obtain aggregate samples from the cold feed belt according to ND T 2, "Sampling of Aggregates". The Contractor will obtain one sample for each 1,500 tons of material produced, with a minimum of one sample obtained per day.

The Contractor will split the sample, under the observation of the Engineer, according to ND T 248, "Reducing Samples of Aggregate to Testing Size," and will bag and number the samples.

The Contractor will perform testing on one half of the sample and will submit the remaining half to the Engineer. The Engineer will retain the sample for 24 hours after

QA testing verifies the QC.

Table 430-5 lists the tests to be conducted.

Table 430-5	
Tests	Worksheet
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	SFN 9987, Aggregate Sample Worksheet
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	SFN 9987, Aggregate Sample Worksheet
*ND T 304, "Fine Aggregate Angularity"	SFN 51701, Uncompacted Void Content of Fine Aggregate

**One sample for each 3000 tons of material produced with a minimum of one sample per day.*

c. The Contractor will obtain three random aggregate samples from the cold feed belt for each lot of 10,000 tons of mix produced. The Contractor will test each sample and the Engineer will determine acceptance of the lot based on the average of the three samples.

If the results of each sample from a lot are within the designated range, the Contractor will collect three samples from the next lot and test one of the samples. If the results of the test are within the designated range, the Engineer will accept the lot.

If the results of the test are outside of the designated range, the Contractor will test the remaining two samples and the Engineer will determine acceptance of the lot based on the average of the three test results.

When the average of three results is needed to determine acceptance of a lot, the

Contractor will continue to test three samples for each lot of 10,000 tons of material. The Contractor may return to testing a single sample only after all three samples are within the designated range.

Table 430-6 lists the tests to be conducted.

Table 430-6	
Tests	Worksheet
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	SFN 9987, Aggregate Sample Worksheet
*ND T 113, "Lightweight Pieces in Aggregate"	SFN 9987, Aggregate Sample Worksheet
*ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	SFN 51730, Sand Equivalent of Fine Aggregate

** Test frequency may be reduced according to NDDOT Standard Specifications for Road and Bridge Construction.*

d. The Contractor will obtain a mix sample each time a random aggregate sample is taken for sieve analysis. The sample is obtained according to NDDOT 5, "Sampling and Splitting Field Verification Hot Mix Asphalt (HMA) Samples."

   Table 430-7 lists the tests to be conducted.

Table 430-7	
Tests	Worksheet
ND T 312, "Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of Superpave Gyratory Compactor"	SFN 50289, Maximum Density Worksheet
ND T 166, "Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens"	SFN 50289, Maximum Density Worksheet
ND T 209, "Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt"	SFN 50289, Maximum Density Worksheet

e. Contractor will collect bituminous samples, under the observation of the Engineer, according to NDDOT 1, "Sampling of Bituminous Materials."

   Obtain one sample for every 250 tons of material for each supplier and grade of asphalt cement, or fraction thereof, randomly selected and observed by the Engineer.

3. District Materials Coordinator Responsibility

If the project is on the NHS system the District Materials Coordinator will complete SFN 13889, Project Records Samples/Tests Report, and send a copy to the engineer at project completion.

The Contractor will be required to obtain one core per mile of roadway paved at random locations selected by the District Materials Coordinator after the final HMA lift is placed. The Engineer will take width measurements at the same location that the cores are obtained.

4. Materials and Research Division Responsibility

Tests will be run for acceptance or IA according to AASHTO M 332, "Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test."

430.03 QUALITY ASSURANCE TESTING

A. General

Quality assurance testing will be performed during mix production.

B. Contractor Responsibility

The Contractor will collect samples under the observation of the Engineer for bitumen and coring as required.

C. Engineer Responsibility

The Contractor will collect samples under the observation of the Engineer for bitumen and coring as required.

1. Aggregate and Mix Testing

The Engineer will conduct QA tests on random samples collected separately from the Contractor's sample. Aggregate samples collected at the plant, and asphalt mix samples collected at the paver will be obtained by the Contractor under the observation of the Engineer.

Aggregate samples from the cold feed belt are obtained according to ND T 2, "Sampling

of Aggregates." Asphalt mix samples are obtained according to NDDOT 5, "Procedure for Sampling and Splitting Field Verification HBP Samples."

a. The Engineer will conduct tests a minimum of four times during the Contractor's first 15,000 tons of mix production and will conduct a minimum of one set of tests per production day. After the first 15,000 tons of mix has been produced, the Engineer will perform these tests at least once per day of mix production.

Table 430-8 lists the tests to be conducted.

Table 430-8	
Tests	Worksheet
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	SFN 9987, Aggregate Sample Worksheet
ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing"	SFN 9987, Aggregate Sample Worksheet
ND T 304, "Fine Aggregate Angularity"	SFN 51701, Uncompacted Void Content of Fine Aggregate
ND T 312, "Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of Superpave Gyratory Compactor"	SFN 50289, Maximum Density Worksheet
ND T 209, "Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt"	SFN 50289, Maximum Density Worksheet
ND T 166, "Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens"	SFN 50289, Maximum Density Worksheet

b. The Contractor and Engineer will compare the results from one QC test to the QA test using SFN 61095 "Section 430 QC QA and IA Comparison Report."

Table 430-9 shows the allowable tolerance range for each test.

Table 430-9	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates" and ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing": • No. 4 sieve and larger • No. 30 sieve • No. 200 sieve	 ±7 ±5 ±2.5
ND T 304, "Fine Aggregate Angularity"	±1
Air Voids - ND T 209, "Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt"; and ND T 166, "Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface Dry Specimens"	±1.0

If the comparison for a test listed in Table 430-9 leads to a result outside the ranges specified, the Engineer will request an additional test. A three-way split sample will be tested between the QC, QA, and District Materials Coordinator. An evaluation of the procedures and equipment will be conducted to determine the cause of the discrepancy. If the discrepancy cannot be rectified, the dispute resolution procedure in Section 430.04 of this document will be followed.

The Engineer will conduct one test for the first 10,000 tons of mix production and one test every 30,000 tons thereafter.

Table 430-10 lists the tests to be conducted.

Table 430-10	
Tests	Worksheet
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	SFN 9987, Aggregate Sample Worksheet
*ND T 113, "Lightweight Pieces in Aggregate"	SFN 9987, Aggregate Sample Worksheet
*ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	SFN 51730, Sand Equivalent of Fine Aggregate

** Test frequency may be reduced according to NDDOT Standard Specifications for Road and Bridge Construction.*

c. The Contractor and Engineer will compare the results of the QC and QA tests.

Table 430-11 shows the allowable tolerance range for each test.

Table 430-11	
Tests	Tolerance
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	±5
ND T 113, "Lightweight Pieces in Aggregate"	±3.0
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	±7

If the test result comparisons are within the tolerances of Table 430-11 and the QC results are within specifications, then the samples in the Engineer's possession for that lot are to be discarded.

If the comparison for a test listed in Table 430-11 leads to a result outside the ranges specified, the Engineer will request an additional test. A three-way split sample will be tested between the QC, QA, and District Materials Coordinator. An evaluation of the procedures and equipment will be conducted to determine the cause of the discrepancy. If the discrepancy cannot be rectified, the dispute resolution procedure in Section 430.04 of this document will be followed.

If the retest also leads to a result outside the specified range, the Contractor will cease production and take corrective action. If the discrepancy cannot be rectified, the dispute resolution procedure in Section 430.04 of this document will be followed.

Tests performed by the District Materials Coordinator will not be used for material acceptance.

2. In-Place Density Testing

The Engineer will determine the density of pavement based on lots. A lot is equal to the amount of material, in tons, placed each production day.

A sublot is defined as a single lift, one paver width wide, and 1,000 feet long. If a partial sublot is less than 500 feet, it will be included in the previous sublot. A partial sublot greater than 500 feet will be considered a separate sublot.

The Engineer will direct the Contractor to obtain one core from each sublot. The station and offset location of each core will be determined using random numbers. If the location of the core falls within one foot of the edge of the pavement, the Engineer will adjust the location or

generate new random numbers to select a different area.

The Engineer will record the information on SFN 10071, "Compaction Control" and will observe the coring procedure. The Engineer will take immediate possession of the cores.

The Engineer will determine the density of the cores in accordance with ND T 166, "Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens," and ND T 209, "Maximum Theoretical Density." The Engineer will determine the acceptance of the sublot based on the density of the core. The density of the core is recorded on SFN 59132, Density Pay Factor.

The density of a lot will be determined using the recorded density of the sublots contained within the lot. The recorded density of the sublots will be totaled and divided by the number of sublots within the lot to obtain the average density of the pavement.

3. Bitumen Testing

Bituminous samples are obtained for testing according to NDDOT 1.

D. District Materials Coordinator Responsibility

Reserved.

E. Materials and Research Responsibility

Materials and Research will perform one test on a composite aggregate sample obtained during the beginning of aggregate stockpiling according to Table 430-12.

Table 430-12	
Test	Worksheet
AASHTO T 96, "Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine"	SFN 9987, Aggregate Sample Worksheet

If the aggregate source has been tested previously by the Department and the material is within allowable limits, the L.A. Abrasion test may be waived at the discretion of the District Materials Coordinator.

Bituminous samples are obtained and tested according to NDDOT 1.

430.04 DISPUTE RESOLUTION

If the cause of disagreement between the QC and QA results cannot be determined, a dispute resolution process will be implemented.

The material remaining from retained samples will be sent to the Materials and Research Division.

Materials and Research will test the material.

The test results from Materials and Research will be considered final.

430.05 INDEPENDENT ASSURANCE (IA) TESTING

A. General

IA testing will occur during mix production.

IA samples are a split sample tested by the Contractor, the Engineer, and the District Materials Coordinator.

Table 430-13 lists the tests to be conducted.

Table 430-13	
Tests	Worksheet
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	SFN 9987, Aggregate Sample Worksheet
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	SFN 9987, Aggregate Sample Worksheet
NDDOT 4, "Percentage of Fracture Particles in Coarse Aggregate"	SFN 9987, Aggregate Sample Worksheet
ND T 113, "Lightweight Pieces in Aggregate"	SFN 9987, Aggregate Sample Worksheet
ND T 304, "Fine Aggregate Angularity"	SFN 51701, Uncompacted Void Content of Fine Aggregate
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	SFN 51730, Sand Equivalent of Fine Aggregate

ND T 312, "Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of Superpave Gyratory Compactor"	SFN 50289, Maximum Density Worksheet
ND T 209, "Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt"	SFN 50289, Maximum Density Worksheet
ND T 166, "Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens"	SFN 50289, Maximum Density Worksheet

1. Engineer Responsibility

IA tests run by the Engineer are additional to required QA samples.

2. Contractor Responsibility

The Contractor will collect IA samples of aggregate and HMA under the observation of the District Materials Coordinator.

IA tests run by the Contractor can be used for acceptance in lieu of additional QC samples.

3. District Materials Coordinator Responsibility

The District Materials Coordinator will periodically observe tests performed by the Contractor and the QA tester and ensure that testing personnel are qualified as outlined in the NDDOT Technical Certification Program document the observation of testing.

B. Frequency Testing

Frequency for IA testing is listed in Table 430-14.

Table 430-14

Project Tonnage	Number of Tests/Project	Frequency
<10,000 tons	One IA test	IA sample will be obtained during the first four tests run by the Contractor.
10,000 - 20,000 tons	One IA test	IA sample will be obtained at the approximate mid-point of the project.

20,000 - 30,000 tons	Two IA tests	One IA sample will be obtained during the first half of the project and again, during the second half of the project.
>30,000 tons	Three IA tests	IA samples will be obtained during the first half, the approximate midpoint, and the second half of the project.

C. Comparison Testing

The results of the Contractor, Engineer, and District Materials Coordinator tests will be compared.

The results of any test must be within the ranges specified in Table 430-15 when compared to any other test.

Table 430-15	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates, and ND T 11, Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing":	
• No. 4 sieve and larger	±5
• No. 30 sieve	±3
• No. 200 sieve	±1.5
NDDOT T 4, "Percentage of Fracture Particles in Coarse Aggregate"	±5
ND T 113, "Lightweight Pieces in Aggregate"	±1.0
ND T 304, "Fine Aggregate Angularity"	±1
ND T 176, "Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test"	±5
Air Voids - ND T 209, "Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt"; and ND T 166, "Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface Dry Specimens."	±1.0

If the IA testing is not within specified tolerances, the Contractor will obtain an additional sample for testing under the observations of the District Materials Coordinator.

The Contractor, Engineer, and District Materials Coordinator will conduct equipment checks and review testing procedures. This will continue until the differences are resolved.

The IA tester and either the QC or QA tester, whichever is not within the specified tolerances, will perform the additional IA tests.

D. Gyratory Compliance Tests

For gyratory compliance, the IA will be required to obtain one sample during the first four tests run by the Contractor (QC). This sample will be used to ensure the accuracy of the shared gyratory compactor used by the QC and QA testers.

The Contractor will obtain a sample of hot mix for testing. This sample will be taken from any available location except behind the paver. The Contractor will split the sample and give half to the District Materials Coordinator.

The IA and QC labs will make gyratory plugs and compare the bulk specific gravity (G_{mb}) of their specimens. The acceptable tolerance between tests will be:

Bulk Specific Gravity of the Mix (G_{mb}): ± 0.040

The number and frequency of Gyratory Compliance samples will be based on project tonnage as shown in Table 430-16.

Table 430-16	
Project Tonnage	Frequency
<10,000	No Gyratory Compliance
≥10,000	One Gyratory Compliance

If the initial testing is not within specified tolerances, the Contractor will obtain an additional sample for testing, under the observations of the District Materials Coordinator.

The Contractor and District Materials Coordinator will conduct equipment checks, and review testing procedures.

If the second sample is not within specified tolerances, a dispute resolution procedure will be implemented in which a third gyratory will be selected and a three-way split of a sample will be tested. The third gyratory can be from another district or the Materials and Research Division.

ACCEPTANCE OF PERFORMANCE GRADED (PG) ASPHALT FOR LOCAL PUBLIC AGENCY (LPA) PROJECTS WITH FEDERAL AID

1. GENERAL REQUIREMENTS

The Performance Graded (PG) Asphalt Cement acceptance requirements will apply to all LPA projects with federal aid.

- PG asphalt can be accepted by certification from any asphalt supplier that meets the requirements of and is a participating member in the Combined States Binder Group (CSBG).

- For projects with over 20,000 tons of hot mix asphalt, one sample may be randomly selected for verification testing. PG sample will be obtained according to test procedure NDDOT 1.

- The LPA shall send the sample to a certified private lab to verify the PG asphalt cement meets AASHTO M 323.

2. ADDITIONAL REQUIREMENTS

- The North Dakota Department of Transportation may randomly select asphalt samples from LPA projects with federal aid. These samples will be tested, at no cost, to ensure supplier compliance with the CSBG requirements.

SECTION 400
FORMS

Fine Aggregate Specific Gravity Worksheet SFN 2199

Aggregate Sample Worksheet SFN 9987

Compaction Control SFN 10071

Aggregate Quality Tests Summary SFN 10072

Coarse Aggregate Specific Gravity Worksheet SFN 10081

Maximum Density Worksheet SFN 50289

Flat or Elongated Particles in Coarse Aggregate SFN 51700

Uncompacted Void Content of Fine Aggregate SFN 51701

Sand Equivalent of Fine Aggregate SFN 51730

Density Pay Factor SFN 59132

SECTION 550
CONCRETE PAVEMENT

550.01 DESCRIPTION

This work consists of constructing concrete pavement.

550.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify that the material meets the requirements in Sections 802, 804, 812, and 826 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

1. Aggregate:

Aggregate samples will be obtained randomly and split according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size." Table 550-1 shows test method and frequency.

Table 550-1	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	1 test result per 5,000 SY rural or 1,500 SY urban of concrete pavement.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per 5,000 SY rural or 1,500 SY urban of concrete pavement.

Report results to the District Materials Coordinator on SFN 2455, "Concrete, Sand, and Gravel Worksheet."

One composite aggregate sample will be submitted to the Materials and Research Division. The sample will be tested for L.A. abrasion and soundness during the beginning of aggregate stockpiling.

2. Cement:

Submit one random sample of cement per project from the silo, truck, or hopper to the Materials and Research Division. This sample shall be a minimum of 15 lbs. and placed in a moisture proof airtight container to avoid absorption of moisture and aeration of the sample.

3. Mix Water:

Obtain one sample per water source according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge* Construction and submit it to the Materials and Research Division.

4. Concrete:

The Engineer will randomly select locations to conduct testing. Table 550-2 shows test method and frequency.

Table 550-2	
Test	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	*1 test result per 2,000 SY of concrete pavement.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	*1 test result per 2,000 SY of concrete pavement.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	*1 test result per 2,000 SY of concrete pavement.

**Perform the testing a minimum of one test per day.*

Table 550-3 shows test methods and frequency for casting and testing concrete cylinders.

Table 550-3	
Test	Frequency
ND T 23, "Making and Curing Concrete Test Specimens in the Field"	Cast one set of specimens every 250 cubic yards of concrete or a minimum of one set per day.
AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens"	*See Opening to Traffic below

*Opening to Traffic:

For determining pavement strength for opening to traffic there are three options. They are as follows:

a. Maturity Curve – Verify the maturity curve from the mix design by making cylinders or beams and break near the time that the mix design criteria are met. If the results are within 50 psi flexural or 300 psi compression the curve is valid to use. If the results vary by more than 50 psi flexural or 300 psi compression then a new maturity curve must be developed.

b. Cylinders or Beams – Each day make cylinders or beams and break to determine strength.

c. Cores – Take cores from roadway and break to determine strengths are met for

opening to traffic.

Cores:

Obtain cores for thickness. Measure the pavement width at all points where cores are taken. Submit cores to the Materials and Research Division for testing, along with pertinent information on SFN 19404, "Concrete Core Specimen Worksheet."

Table 550-4 shows test method and frequency.

Table 550-4	
Test	Frequency
AASHTO T 24 "Obtaining and Testing Drilled Cores and Sawed Beams of Concrete"	*One core per lot.
ASTM E 965, Measuring Pavement Macro Texture	*One test per lot.

**Definition of a lot:*

- *4,000 square yards of concrete.*
- *If the final lot is less than 1,000 square yards include it in the previous lot.*
- *If the final lot is greater than 1,000 square yards it is a separate lot.*

B. District Materials Coordinator Responsibility

The Engineer will obtain these samples and provide them to the District Materials Coordinator.

Samples will be obtained and split according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size." Table 550-5 shows test method and frequency.

Table 550-5	
Test	Frequency
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces**"**	1 test result per 5,000 SY rural or 1,500 SY urban of concrete pavement.
ND T 113, Lightweight Pieces in Aggregate"	1 test result per 5,000 SY rural or 1,500 SY urban of concrete pavement.

An alternative testing procedure for testing shale content of coarse and fine aggregate may be used when the pit from which the aggregate samples are obtained has at least a ten-year history of no prior test results which exceed 50% of the specification limit.

If this criterion is met, perform an initial shale test at the beginning of the construction season with three more random tests performed during the remainder of the construction

season. If any shale test exceeds 50% of the specification limit or a new portion of the pit is utilized, revert testing to the frequency mentioned previously.

The NDDOT requires District Materials Coordinators to keep a file on pits utilizing this testing procedure. Document the testing performed each year in the file.

C. Materials and Research Division Responsibility

1. Aggregate:

The sample will be tested for L.A. abrasion and soundness during the beginning of aggregate stockpiling. Table 550-6 shows test method and frequency.

Table 550-6	
Test	Frequency
AASHTO T 96, "Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine"	*1 test result per project.
AASHTO T 104, "Soundness" (Sodium Sulfate)"	*1 test result per project.

**If the aggregate source has been tested previously by the Department and the material is within allowable limits testing will not be required.*

2. Cement:

Test Portland cement according to Section 804 of the NDDOT *Standard Specifications for Road and Bridge* Construction.

3. Water:

Test non-potable water according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge* Construction.

4. Cores:

Test cores submitted from the Engineer.

Table 550-7 shows test method and frequency.

Table 550-7	
Test	Frequency
AASHTO T 22, "Compressive Strength of Cylindrical Concrete Specimens"	1 core per lot.
AASHTO T 148, "Measuring Length of Drilled Concrete Cores"	1 core per lot.

550.03 INDEPENDENT ASSURANCE (IA) TESTING

A. Engineer Responsibility

Conduct IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility

The District Materials Coordinator will obtain these samples and conduct these tests. These samples will be an equal split sample with the Engineer.

Samples will be obtained and split according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size." Concrete samples shall be obtained according to ND T 141, "Sampling Freshly Mixed Concrete".

Table 550-8 shows test and frequency for IA.

Table 550-8	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	1 test result per 50,000 SY rural or 15,000 SY urban of concrete pavement.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per 50,000 SY rural or 15,000 SY urban of concrete pavement.
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test result per 3 miles rural or 15,000 SY of concrete pavement on urban projects.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test result per 3 miles rural or 15,000 SY urban of concrete pavement.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test result per 3 miles rural or 15,000 SY urban of concrete pavement.

The District Materials Coordinator and the Engineer will compare the test results for IA tolerances in Table 550-9.

Table 550-9	
Test	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing": No. 4 sieve and larger No. 8 to No. 50 sieve No. 200 sieve	 ±5 ±3 ±2
ND T 119, "Slump of Hydraulic Cement Concrete"	±1 inch
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	±1.0%
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	±2.5 lb./ft^2

C. Materials and Research Division Responsibility

Reserved. Previous testing moved to Section 106.04

SECTION 570
PORTLAND CEMENT CONCRETE PAVEMENT REPAIR

570.01 DESCRIPTION

This work consists of repairing concrete pavement.

570.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify that the material meets the requirements in Section 816 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

1. Aggregate:

Obtain and split samples according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 570-1 shows test methods and frequency of testing for aggregate produced.

Table 570-1	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	1 test result every 200 CY of concrete
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result every 200 CY of concrete
ND T 255," Total Evaporable Moisture Content of Aggregate by Drying"	1 test result on the coarse and fine aggregate daily

Report results to the District Materials Coordinator on SFN 2455, "Concrete, Sand, and Gravel Worksheet."

Submit one random sample of cement per project from the silo, truck, or hopper to the Materials and Research Division. This sample shall be a minimum of 15 lbs. and placed in a moisture proof airtight container to avoid absorption of moisture and aeration of the sample.

2. Mix Water:

Obtain one sample per water source according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge Construction* and submit to Materials and Research.

3. Concrete

Table 570-2 shows test methods and frequency for testing concrete.

Table 570-2	
Tests	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	*1 test result from the first load each day and one every 75 cubic yards of concrete thereafter
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	*1 test result from the first load each day and one every 75 cubic yards of concrete thereafter
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	*1 test result from the first load each day and one every 75 cubic yards of concrete thereafter

**Perform this testing a minimum of one test per day.*

Table 570-3 shows test methods and frequency for casting and testing concrete cylinders.

Table 570-3	
Tests	Frequency
ND T 23, "Making and Curing Concrete Specimens in the Field"	Cast one set of specimens every 75 cubic yards of concrete or a minimum of one set per day.
AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens"	See Opening to Traffic below

4. Opening to Traffic:

To determine pavement strength to open to traffic there are three options as follows:

a. Maturity Curve – Verify the maturity curve from the mix design by making cylinders or beams and break near the time that the mix design criteria are met. If the results are within 50 psi flexural or 300 psi compression, the curve is valid to use. If the results vary by more than 50 psi flexural or 300 psi compression, then a new maturity curve must be developed.

b. Cylinders or Beams – Each day make additional cylinders or beams to break to determine strength.

c. Cores – Take cores from roadway and break to determine strengths are met for opening to traffic. Record information on SFN 7623, "Concrete Cylinders."

B. District Materials Coordinator Responsibility

The Engineer will obtain these samples and provide them to the District Materials Coordinator.

Obtain and split samples according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 570-4 shows test methods and frequency of testing.

Table 570-4	
Tests	Frequency
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces"	Minimum of 1 test result per project
ND T 113, Lightweight Pieces in Aggregate"	Minimum of 1 test result per project

C. Materials and Research Division Responsibility

Cement:

Test Portland cement according to Section 804 of the NDDOT *Standard Specifications for Road and Bridge* Construction.

Test non-potable water according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

570.03 INDEPENDENT ASSURANCE (IA) TESTING

A. Engineer Responsibility

Conduct IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility

The District Materials Coordinator will obtain these samples and conduct these tests. These samples will be an equal split sample with the Engineer.

Obtain and split samples according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size.

Table 570-5 shows test methods and frequency for IA testing.

Table 570-5	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	1 test result per project
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per project

In Table 570-6 the District Materials Coordinator and the Engineer will compare the test results for IA tolerances.

Table 570-6	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing:"	
• No. 4 sieve and larger	±5
• No. 8 to No. 50 sieves	±3
• No. 200 sieve	±2

If the IA testing is not within specified tolerances, the Engineer will obtain an additional sample for testing under the observation of the District Materials Coordinator.

The Engineer and District Materials Coordinator will examine equipment used and review testing procedures until the differences are resolved.

The District Materials Coordinator will obtain these samples and conduct these tests.

Table 570-7 shows test methods and frequency for testing concrete.

Table 570-7	
Tests	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test result per project.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test result per project
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test result per project

In Table 570-8 the District Materials Coordinator and the Engineer will compare the test results for IA tolerances.

Table 570-8	
Tests	Tolerance
ND T 119, "Slump of Hydraulic Cement Concrete"	±1
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	±2
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	±3

C. Materials and Research Division Responsibility

Reserved. Previous testing moved to Section 106.04

SECTION 575
DOWEL BAR RETROFIT

575.01 DESCRIPTION

This work consists of performing a dowel bar retrofit in concrete pavement.

575.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

Table 575-1	
Tests	Frequency
ND T 23, "Making and Curing Concrete Specimens in the Field"	Cast one set of specimens every 250 CY of concrete or a minimum of one set per day.
AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens"	Cast one set of specimens every 250 CY of concrete or a minimum of one set per day.

SECTION 500
FORMS

Concrete, Sand and Gravel Worksheet SFN 2455

Concrete Core Specimen Worksheet SFN 19404

SECTION 602
CONCRETE STRUCTURES

602.01 DESCRIPTION

This work consists of the construction of bridges, cast-in-place box culverts, and retaining walls.

602.02 REQUIRED TESTS AND FREQUENCY

A. Acceptance Samples and Tests - Field Laboratory Testing

Table 602-1 shows test methods and frequency of testing for aggregate produced.

Table 602-1	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	1 test result every 200 CY of concrete
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result every 200 CY of concrete
ND T 255," Total Evaporable Moisture Content of Aggregate by Drying"	1 test result every 200 CY of concrete

Table 602-2 shows test methods and frequency for testing concrete.

Table 602-2	
Tests	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test result from the first load each day and one every 50 cubic yards of concrete thereafter
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test result from the first load each day and one every 50 cubic yards of concrete thereafter
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test result from the first load each day and one every 50 cubic yards of concrete thereafter

Table 602-3 shows test methods and frequency for casting and testing concrete cylinders.

Table 602-3	
Tests	Frequency
ND T 23, "Making and Curing Concrete Specimens in the Field"	Cast one set of specimens for every 50 cubic yards of concrete
AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens"	Cast one set of specimens for every 50 cubic yards of concrete

Submit one random sample of cement per project from the silo, truck, or hopper to the Materials and Research Division. This sample shall be a minimum of 15 lbs. and placed in a moisture proof airtight container to avoid absorption of moisture and aeration of the sample.

B. District Materials Coordinator Responsibility

The Engineer will obtain these samples and provide them to the District Materials Coordinator.

Samples will be obtained and split according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size." Table 602-4 shows test method and frequency.

Table 602-4	
Test	Frequency
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces"	1 test result every 200 CY of concrete
ND T 113, Lightweight Pieces in Aggregate"	1 test result every 200 CY of concrete

An alternative testing procedure for testing shale content of the aggregate may be used when the pit from which the aggregate samples are obtained has at least a ten-year history of no prior test results which exceeds 50% of the specification limit.

If this criterion is met, perform an initial shale test at the beginning of the construction season with three more random tests performed during the remainder of the construction season. If any shale test exceeds 50% of the specification limit or a new portion of the pit is utilized, revert testing to the frequency mentioned previously.

The NDDOT requires District Materials Coordinators to keep a file on pits utilizing this testing procedure. Document the testing performed each year in the file.

C. Materials and Research Division Responsibility

Aggregate:

The sample will be tested for L.A. abrasion and soundness during the beginning of aggregate stockpiling. Table 602-5 shows test method and frequency.

Table 602-5	
Test	Frequency
AASHTO T 96, "Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine"	*1 test result per project.
AASHTO T 104, "Soundness" (Sodium Sulfate)"	*1 test result per project.

**If the aggregate source has been tested previously by the Department and the material is within allowable limits testing will not be required.*

602.03 INDEPENDENT ASSURANCE SAMPLES AND TESTS.

A. District Laboratory Testing

Table 602-6 shows test and frequency for IA.

Table 602-6	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	Minimum 1 test result per project.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum 1 test result per project
ND T 119, "Slump of Hydraulic Cement Concrete"	Minimum 1 test result per project
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	Minimum 1 test result per project
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	Minimum 1 test result per project

The District Materials Coordinator and the Engineer will compare the test results for IA tolerances in Table 602-7.

Table 602-7	
Test	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing":	
No. 4 sieve and larger	±5
No. 8 to No. 50 sieves	±3
No. 200 sieve	±2
ND T 119, "Slump of Hydraulic Cement Concrete"	±1 inch
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	±1.0%
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	±2.5 lb./ft^2

There are several situations where small amounts of concrete are required for specification compliance, e.g., apron of a pipe. There is no requirement covering the sampling and testing in these situations. Therefore, the requirement is that the engineer/manager notify the District Laboratory to confirm that the materials used are approved materials tested in other phases of the work.

B. Materials and Research Division Testing

If necessary, conduct IA tests on split samples taken by the District Materials Coordinator.

Obtain and split samples according to ND T 2, "Sampling of Aggregates," and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 602-8 shows test methods and frequency for IA testing.

Table 602-8	
Tests	Frequency
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces"	Minimum of 1 test result per project
ND T 113, Lightweight Pieces in Aggregate"	Minimum of 1 test result per project

The District Materials Coordinator and Materials and Research will compare the test results for IA tolerances in Table 602-9.

Table 602-9	
Tests	Tolerance
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces"	±1.0 ±2.5
ND T 113, Lightweight Pieces in Aggregate"	±2

Submit one sample from every source of water used. If the water is known to be of potable quality, it may be used without testing.

SECTION 650
OVERLAY OF CONCRETE BRIDGE DECKS

650.01 DESCRIPTION

This work consists of removing and replacing unsound concrete and/or chloride contaminated concrete and resurfacing a bridge deck.

650.02 REQUIRED TESTS AND FREQUENCY

A. Acceptance Samples and Tests

Table 650-1 shows test methods and frequency of testing for aggregate produced.

Table 650-1	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	1 test result per bridge deck
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per bridge deck
ND T 255," Total Evaporable Moisture Content of Aggregate by Drying"	1 test result per bridge deck

Table 650-2 shows test methods and frequency for testing concrete.

Table 650-2	
Tests	Frequency
AASHTO T 119, "Slump of Hydraulic Cement Concrete"	1 test result from the first load each day and one every 50 cubic yards of concrete thereafter
AASHTO T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test result from the first load each day and one every 50 cubic yards of concrete thereafter
AASHTO T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test result from the first load each day and one every 50 cubic yards of concrete thereafter

Table 650-3 shows test methods and frequency for casting and testing concrete cylinders.

Table 650-3	
Tests	Frequency
AASHTO T 23, "Making and Curing Concrete Specimens in the Field"	Cast one set of specimens for every 50 CY of concrete.
AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens"	Cast one set of specimens for every 50 CY of concrete.

Submit one random sample of cement per project from the silo, truck, or hopper to the Materials and Research Division. This sample shall be a minimum of 15 lbs. and placed in a moisture proof airtight container to avoid absorption of moisture and aeration of the sample.

For latex modified concrete, the latex modifier is accepted by certification.

650.03 Independent Assurance Samples and Tests

A. District Laboratory Testing

The District Materials Coordinator or a designated representative must obtain these samples and conduct these tests.

Table 650-4 shows test and frequency for IA.

Table 650-4	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	Minimum 1 test result per project.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum 1 test result per project.
ND T 119, "Slump of Hydraulic Cement Concrete"	Minimum 1 test result per project.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	Minimum 1 test result per project.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	Minimum 1 test result per project.

The District Materials Coordinator and the Engineer will compare the test results for IA tolerances in Table 650-5.

Table 650-5	
Test	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing":	
No. 4 sieve and larger	±5
No. 8 to No. 50 sieves	±3
No. 200 sieve	±2
ND T 119, "Slump of Hydraulic Cement Concrete"	±1 inch
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	±1.0%
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	±2.5 lb./ft^2

B. Materials and Research Division Testing

Reserved

SECTION 702
MOBILIZATION

702.01 DESCRIPTION

Mobilization consists of costs incurred for preparatory work and operation that must be performed before beginning work on the project site.

702.02 ACCEPTANCE.

Sampling and testing not required.

SECTION 704
TEMPORARY TRAFFIC CONTROL

704.01 DESCRIPTION

This work consists of furnishing, installing, and maintaining all required traffic control devices, personnel, and necessary precautions for protecting the public and workers.

704.02 ACCEPTANCE

Accept material by certification.

SECTION 706
LABORATORIES

706.01 DESCRIPTION

This work consists of furnishing and placing a field laboratory.

706.02 ACCEPTANCE

All testing equipment shall be calibrated and standardized. The Engineer will complete the "Field Lab Equipment Checklist" on SFN 61067.

SECTION 709
GEOSYNTHETICS MATERIALS

709.01 DESCRIPTION

This section consists of furnishing and installing geosynthetics.

709.02 ACCEPTANCE

A. GEOSYNTHETIC DRAINAGE MATERIAL (TYPE D)

Accept Material by Certification.

B. GEOSYNTHETIC GEOGRID (TYPE G)

Accept Material by Certification.

C. GEOSYNTHETIC REINFORCEMENT (TYPE R)

Accept Material by Certification and verify that the AASHTO Product Evaluation and Audit Solutions test results meet Section 858 requirements.

D. GEOSYNTHETIC REINFORCEMENT (TYPE RG)

Accept Material by Certification and verify that the AASHTO Product Evaluation and Audit Solutions test results meet Section 858 requirements.

E. GEOSYNTHETIC FOR RIPRAP (TYPE RR)

Accept Material by Certification and verify that the AASHTO Product Evaluation and Audit Solutions test results meet Section 858 requirements.

F. GEOSYNTHETIC SEPARATION MATERIAL (TYPE S)

Accept Material by Certification and verify that the AASHTO Product Evaluation and Audit Solutions test results meet Section 858 requirements.

SECTION 714
CULVERTS, STORM DRAINS, EDGE DRAINS, AND UNDERDRAINS

714.01 DESCRIPTION

This work consists of constructing culverts, storm drains, edge drains, and underdrains.

714.02 ACCEPTANCE SAMPLES AND TESTS

A. UNDERDRAIN GRANULAR FILL MATERIAL

Field Laboratory Testing:

Table 714-1	
Test	Frequency
ND T 2, "Sampling of Aggregate"	Minimum of two samples per project
ND T 248, "Reducing Samples of Aggregate to Testing Size"	Minimum of two samples per project
ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregate by Washing," and ND T 27, "Sieve Analysis of Fine and Coarse Aggregates."	Minimum of two samples per project

B. FOR COMPACTION CONTROL OF PIPE BACKFILL

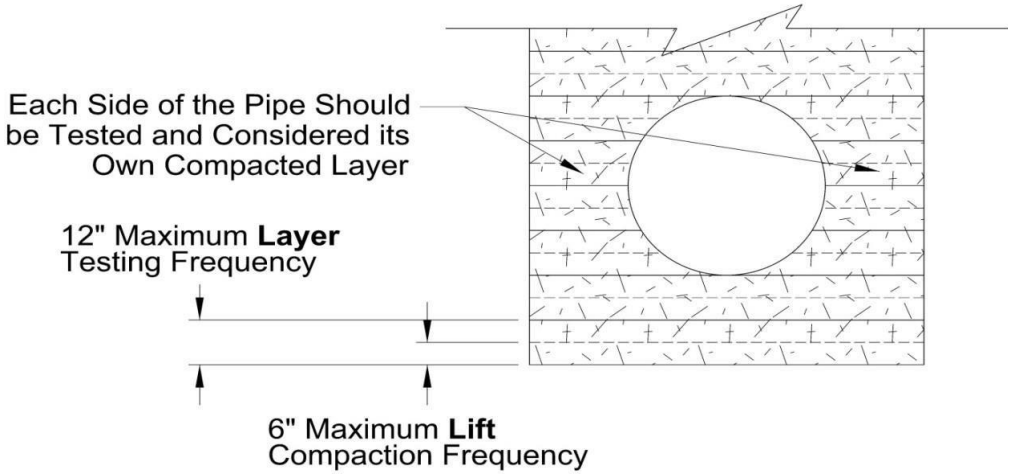
If aggregate is used for backfilling, the Engineer must obtain one aggregate sample for sieve analysis of select backfill or foundation fill for every source used.

Table 714-2	
Test	Frequency
ND T 2, "Sampling of Aggregate"	Minimum of two samples per project
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates."	Minimum of two samples per project

The Engineer must conduct a minimum of one moisture and density test for each layer of compacted aggregate or native material. A layer of compacted material is defined by a

thickness of 12 inches and a maximum length of 200 lineal feet. The width shall be defined by the trench width except each side of the pipe shall be considered as separate layers.

The sketch below illustrates the testing and compaction intervals.



Conduct tests according to ND 4643, "Determination of Water Content of Soil by Microwave Oven Method"; ND T 255, "Total Evaporable Moisture of Aggregate by Drying"; ND T 265, "Laboratory Determination of Moisture Content of Soils"; ND T 191, "Density of Soil In-Place by Sand-Cone Method"; or ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber-Balloon Method."

Compare the results derived from these tests to the compaction curve developed from a multi-point Proctor test derived from ND T 180, "Moisture-Density Relations of Soils." Establish a new compaction curve for each type of material encountered**.**

All other materials accepted by certification.

714.03 INDEPENDENT ASSURANCE SAMPLES AND TESTS

A. COMPACTION CONTROL FOR PIPE BACKFILL

The District Materials Coordinator must conduct a moisture and density test at a minimum rate of one test for every 1,000 lineal feet of pipe or fraction thereof. Independent assurance testing must be completed using the same tests conducted for acceptance.

Table 714-3	
Test	Frequency
ND T 180, "Moisture-Density Relations of Soils"	Minimum of one sample per project

SECTION 720
MONUMENTS AND RIGHT OF WAY MARKERS

720.01 DESCRIPTION

This work consists of furnishing and installing Alignment Monuments, Iron Pin Right of Way Monuments, Iron Pin Reference Monuments, and Right of Way Markers.

720.02 ACCEPTANCE

A. Concrete

No specific test frequency for acceptance is required.

B. Epoxy Resin Adhesives

Accept material by certification.

C. Deformed and Plain Steel bars for Concrete Placement

Accept material by certification.

SECTION 722
MANHOLES, CATCH BASINS, AND INLETS

722.01 DESCRIPTION

This work consists of constructing and adjusting manholes, catch basins, and inlets, including the furnishing or resetting of necessary metal frames, covers or gratings, valve boxes, or other accessories to new line grades.

722.02 ACCEPTANCE

Accept material by certification.

SECTION 724
WATER MAINS, WATER LINES, AND SEWER LINES

724.01 DESCRIPTION

This work consists of furnishing and installing water lines, sewer lines and appurtenances.

724.02 ACCEPTANCE

Accept Material by Certification.

SECTION 744
POLYSTYRENE INSULATION BOARD

744.01 DESCRIPTION

This work consists of furnishing and installing extruded expanded polystyrene insulation board.

744.02 ACCEPTANCE

Accept Material by Certification.

SECTION 748
CURB AND GUTTER

748.01 DESCRIPTION

This work consists of constructing curb, gutter, or combination curb and gutter.

748.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify that the material meets the requirements in Sections 802, 804, 812, and 826 of the NDDOT *Standard Specifications for Road and Bridge Construction.*

1. Aggregate:

Aggregate samples will be obtained randomly and split according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size." Table 748-1 shows test method and frequency.

Table 748-1	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	One test per 2,000 LF
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	One test per 2,000 LF
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces**"**	Minimum of 1 per project.
ND T 113, Lightweight Pieces in Aggregate"	Minimum of 1 per project.

Report results to the District Materials Coordinator on SFN 2455, "Concrete, Sand, and Gravel Worksheet."

One composite aggregate sample will be submitted to Materials and Research. The sample will be tested for L.A. abrasion and soundness during the beginning of aggregate stockpiling.

2. Cement:

Accept by certification.

3. Mix Water:

Test non-potable water according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge* Construction. Retesting is required if the source changes.

4. Concrete:

The Engineer will randomly select locations to conduct testing.

Table 748-2 shows test method and frequency.

Table 748-2	
Test	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	*1 test result per 2,000 Linear Feet.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	*1 test result per 2,000 Linear Feet.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	*1 test result per 2,000 Linear Feet.

**Perform this testing a minimum of one test per day.*

Cast cylinders or beams to determine when opening strength is met, according to ND T 23, "Making and Curing Concrete Specimens in the Field". The Engineer will determine frequency based on time frame for opening to traffic. Cylinders shall be tested according to AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens." Record sample information on SFN 7623, "Concrete Cylinders."

748.03 INDEPENDENT ASSURANCE (IA) TESTING

A. Engineer Responsibility

Conduct IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility

The District Materials Coordinator will obtain these samples and conduct these tests. These samples will be an equal split sample with the Engineer.

Obtain and split samples according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size.

Table 748-3 shows test methods and frequency for IA testing.

Table 748-3	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates"	1 test result per project
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per project

In Table 748-4 the District Materials Coordinator and the Engineer will compare the test results for IA tolerances.

Table 748-4	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing:"	
• No. 4 sieve and larger	±5
• No. 8 to No. 50 sieves	±3
• No. 200 sieve	±2

If the IA testing is not within specified tolerances, the Engineer will obtain an additional sample for testing under the observation of the District Materials Coordinator.

The Engineer and District Materials Coordinator will examine equipment used and review testing procedures until the differences are resolved.

The District Materials Coordinator will obtain these samples and conduct these tests.

Table 748-5 shows test methods and frequency for testing concrete.

Table 748-5	
Tests	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test result per project.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test result per project

ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test result per project

In Table 748-6 the District Materials Coordinator and the Engineer will compare the test results for IA tolerances.

Table 748-6	
Tests	Tolerance
ND T 119, "Slump of Hydraulic Cement Concrete"	±1
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	±2
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	±3

C. Materials and Research Division Responsibility

Reserved. Previous testing moved to Section 106.04.

SECTION 750
DETECTABLE WARNING PANELS, SIDEWALKS, DRIVEWAYS, AND MEDIANS

750.01 DESCRIPTION

This work consists of constructing detectable warning panels, sidewalks, driveways, and medians.

750.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify that the material meets the requirements in Sections 802, 804 and 812 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

1. Aggregate:

Aggregate samples will be obtained randomly and split according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 750-1 shows test method and frequency.

Table 750-1	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	One test per 500 SY
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	One test per 500 SY
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces**"**	Minimum of 1 per project
ND T 113, Lightweight Pieces in Aggregate"	Minimum of 1 per project

Report results to the District Materials Coordinator on SFN 2455, "Concrete, Sand, and Gravel Worksheet."

One composite aggregate sample will be submitted to Materials and Research. The sample will be tested for L.A. abrasion and soundness during the beginning of aggregate stockpiling.

2. Cement:

Accept by certification.

3. Mix Water:

Test non-potable water according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge* Construction. Retesting is required if the source changes.

4. Concrete:

The Engineer will randomly select locations to conduct testing.

Table 750-2 shows test method and frequency.

Table 750-2	
Test	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	*1 test result per 500 S.Y. of concrete pavement.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	*1 test result per 500 S.Y. of concrete pavement.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	*1 test result per 500 S.Y. of concrete pavement.

*Perform this testing a minimum of one test per day.

Cast cylinders or beams to determine when opening strength is met, according to ND T 23, "Making and Curing Concrete Specimens in the Field." The Engineer will determine the frequency based on the time frame for opening to traffic. Cylinders shall be tested according to AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens." Record sample information on SFN 7623, "Concrete Cylinders."

5. Other materials:

Detectable warning panels, reinforcing steel, and preformed expansion joint material are accepted by certification.

750.03 INDEPENDENT ASSURANCE (IA) TESTING

A. Engineer Responsibility

Conduct IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility

1. Aggregate:

The District Materials Coordinator will obtain these samples and conduct these tests. These samples will be an equal split sample with the Engineer.

Obtain and split samples according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size.

Table 750-3 shows test methods and frequency for IA testing.

Table 750-3	
Tests	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	1 test result per project
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	1 test result per project

In Table 750-4 the District Materials Coordinator and the Engineer will compare the test results for IA tolerances.

Table 750-4	
Tests	Tolerance
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates," and ND T 11, "Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing:"	
• No. 4 sieve and larger	±5
• No. 8 to No. 50 sieves	±3
• No. 200 sieve	±2

If the IA testing is not within specified tolerances, the Engineer will obtain an additional sample for testing under the observation of the District Materials Coordinator.

2. Concrete:

The Engineer and District Materials Coordinator will examine equipment used and review testing procedures until the differences are resolved.

The District Materials Coordinator will obtain these samples and conduct these tests.

Table 750-5 shows test methods and frequency for testing concrete.

Table 750-5	
Tests	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test result per project
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test result per project
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test result per project

In Table 750-6 the District Materials Coordinator and the Engineer will compare the test results for IA tolerances.

Table 750-6	
Tests	Tolerance
ND T 119, "Slump of Hydraulic Cement Concrete"	±1
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	±2
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	±3

C. Materials and Research Division Responsibility

Reserved. Previous testing moved to Section 106.04

SECTION 752
FENCING - INSTALLATION AND RESETTING

752.01 DESCRIPTION

This work consists of constructing fences, removal of fences, and resetting fences.

752.02 ACCEPTANCE

Accept material by certification.

SECTION 754
HIGHWAY SIGNS

754.01 DESCRIPTION

This work consists of constructing furnishing, fabricating, and installing highway signs, delineators, and supporting structures.

754.02 ACCEPTANCE

A. Highway Signs

Accept material by certification.

B. Concrete

The Engineer will randomly select locations to conduct testing. Table 754-1 shows test method and frequency.

Table 754-1	
Test	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test per 30 C.Y. of concrete.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test per 30 C.Y. of concrete.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test per 30 C.Y. of concrete.

Cast one set each of 7-day test cylinders, according to ND T 23, "Making and Curing Concrete Specimens in the Field", per project. Cylinders shall be tested according to AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens." Record sample information on SFN 7623, "Concrete Cylinders."

All other materials accepted by certification.

C. Reinforcing Steel

Accept material by certification.

SECTION 760
RUMBLE STRIPS

760.01 DESCRIPTION

This work consists of installing centerline, shoulder, and intersection rumble strips.

760.02 ACCEPTANCE

Sampling and testing not required.

SECTION 762
PAVEMENT MARKING

762.01 DESCRIPTION

This work consists of furnishing and installing pavement markings.

762.02 ACCEPTANCE

A. Water based pavement marking paint, Epoxy pavement marking paint, short term pavement marking paint - Type NR (non-removable), and Glass beads for water based and epoxy pavement marking are tested annually by Materials & Research and every approved lot is listed on the NDDOT website at this web address: https://www.dot.nd.gov/divisions/materials/waterbasedmarking.htm

1. Any materials not listed on the website need to be sampled by the Engineer and tested by Materials & Research. Contact Materials and Research for sampling procedure.

B. Preformed patterned pavement marking film, short term pavement marking - Type R (removable) and raised pavement markers are accepted by certification.

SECTION 764
GUARDRAIL AND ATTENUATION DEVICES

764.01 DESCRIPTION

This work consists of installing, removing, and resetting guardrail and attenuation devices.

764.02 ACCEPTANCE

A. Guardrail and Posts

Accept material by certification.

B. Concrete

The Engineer will randomly select locations to conduct testing. Table 754-1 shows test method and frequency.

Table 754-1	
Test	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test per 30 CY of concrete.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test per 30 CY of concrete.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test per 30 CY of concrete.

Cast one set each of 7-day test cylinders, according to ND T 23, "Making and Curing Concrete Specimens in the Field", per project. Cylinders shall be tested according to AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens." Record sample information on SFN 7623, "Concrete Cylinders."

All other materials accepted by certification.

C. Reinforcing Steel

Accept material by certification.

SECTION 766
MAILBOX ASSEMBLIES

766.01 DESCRIPTION

This work consists of removing mailbox assemblies, furnishing, and installing new support systems, and fastening the removed mailboxes or new mailboxes to the new support systems.

766.02 ACCEPTANCE

Accept material by certification.

SECTION 770
HIGHWAY LIGHTING

770.01 DESCRIPTION

This work consists of furnishing and installing highway lighting.

770.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify that the material meets the requirements in Sections 802, 804, 812, and 826 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

1. Aggregate:

Aggregate samples will be obtained randomly and split according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size."

Table 770-1 shows test method and frequency.

Table 770-1	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	Minimum of 1 per project.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum of 1 per project.
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces**"**	Minimum of 1 per project.
ND T 113, Lightweight Pieces in Aggregate"	Minimum of 1 per project.

Report results to the District Materials Coordinator on SFN 2455, "Concrete, Sand, and Gravel Worksheet."

One composite aggregate sample will be submitted to Materials and Research. The sample will be tested for L.A. abrasion and soundness during the beginning of aggregate stockpiling.

2. Cement:

Accept by certification.

3. Mix Water:

Test non-potable water according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge* Construction. Retesting is required if the source changes.

4. Concrete:

The Engineer will randomly select locations to conduct testing.

Table 770-2 shows test method and frequency.

Table 770-2	
Test	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test per 30 CY of concrete.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test per 30 CY of concrete.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test per 30 CY of concrete.

Cast one set each of 7-day test cylinders, according to ND T 23, "Making and Curing Concrete Specimens in the Field", per project. Cylinders shall be tested according to AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens." Record sample information on SFN 7623, "Concrete Cylinders."

All other materials accepted by certification.

SECTION 772
HIGHWAY TRAFFIC SIGNALS

772.01 DESCRIPTION

This work consists of furnishing and installing flashing beacons and traffic signals.

772.02 ACCEPTANCE SAMPLES AND TESTS

A. Engineer Responsibility

The Engineer will collect material and conduct testing to verify that the material meets the requirements in Sections 802, 804, 812, and 826 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

1. Aggregate:

Aggregate samples will be obtained randomly and split according to ND T 2, "Sampling of Aggregates" and ND T 248, "Reducing Samples of Aggregate to Testing Size." Table 772-1 shows test method and frequency.

Table 772-1	
Test	Frequency
ND T 27, "Sieve Analysis of Fine and Coarse Aggregates**"**	Minimum of 1 per project.
ND T 11, "Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing"	Minimum of 1 per project.
NDDOT 3, "Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces**"**	Minimum of 1 per project.
ND T 113, Lightweight Pieces in Aggregate"	Minimum of 1 per project.

Report results to the District Materials Coordinator on SFN 2455, "Concrete, Sand, and Gravel Worksheet."

One composite aggregate sample will be submitted to Materials and Research. The sample will be tested for L.A. abrasion and soundness during the beginning of aggregate stockpiling.

2. Cement:

Accept by certification.

3. Mix Water:

Test water according to Section 812 of the NDDOT *Standard Specifications for Road and Bridge* Construction. Retesting is required if the source changes.

4. Concrete:

The Engineer will randomly select locations to conduct testing. Table 772-2 shows test method and frequency.

Table 772-2	
Test	Frequency
ND T 119, "Slump of Hydraulic Cement Concrete"	1 test per 30 CY of concrete.
ND T 152, "Air Content of Freshly Mixed Concrete by Pressure Method"	1 test per 30 CY of concrete.
ND T 121, "Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"	1 test per 30 CY of concrete.

Cast one set each of 7-day test cylinders, according to ND T 23, "Making and Curing Concrete Specimens in the Field", per project. Cylinders shall be tested according to AASHTO T 22 "Compressive Strength of Cylindrical Concrete Specimens." Record sample information on SFN 7623, "Concrete Cylinders."

All other materials accepted by certification.

TESTING PROCEDURES FOR ALL TESTS

ND T 2	Sampling of Aggregates
ND T 11	Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing
ND T 23	Making and Curing Concrete Test Specimens in the Field
ND T 27	Sieve Analysis of Fine and Coarse Aggregates
ND T 30	Mechanical Analysis of Extracted Aggregates
ND T 59	Standard Method of Test for Saybolt Viscosity
ND T 72	Standard Method of Test for Emulsified Asphalts, Sieve Test
ND T 84	Specific Gravity and Absorption of Fine Aggregate
ND T 85	Specific Gravity and Absorption of Coarse Aggregate
ND T 87	Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
ND T 89	Determining the Liquid Limit of Soils
ND T 90	Determining the Plastic Limit and Plasticity Index of Soils
ND T 99/T 180	Moisture-Density Relations of Soils
ND T 113	Lightweight Pieces in Aggregate
ND T 119	Slump of Hydraulic Cement Concrete
ND T 121	Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ND T 141	Sampling Freshly Mixed Concrete
ND T 152	Air Content of Freshly Mixed Concrete by the Pressure Method
ND T 166	Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
ND T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
ND T 191	Density of Soil In-Place by the Sand-Cone Method
ND T 209	Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt

ND T 217	Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester (Speedy)
ND T 224	Correction for Coarse Particles in the Soil Compaction Test
ND T 245	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ND T 248	Reducing Samples of Aggregate to Testing Size
ND T 255	Total Evaporable Moisture Content of Aggregate by Drying
ND T 265	Laboratory Determination of Moisture Content of Soils
ND T 304	Uncompacted Void Content of Fine Aggregate
ND T 308	Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method
ND T 309	Temperature of Freshly Mixed Hydraulic Cement Concrete
ND T 312	Preparing and Determining Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ND T 318	Water Content of Freshly Mixed Concrete Using Microwave Oven Drying
ND D 2167	Density and Unit Weight of Soil in Place by the Rubber-Balloon Method
ND D 4643	Microwave Method of Drying Soils
ND D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
NDDOT 1	Sampling of Bituminous Materials
NDDOT 2	Hot Mix Asphalt Mix Design Procedure
NDDOT 3	Shale, Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces
NDDOT 4	Percentage of Fractured Particles in Coarse Aggregate NDDOT
NDDOT 5	Sampling and Splitting Field Verification Hot Mix Asphalt (HMA) Samples

NDDOT 6 Settlement Test for Liquid Membrane Curing Compound

NDDOT 7 Determination of Rap Aggregate Bulk Specific Gravity (G_{sb})

ND T 2 SAMPLING OF AGGREGATES

SCOPE

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

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

REFERENCED DOCUMENTS

AASHTO R 90, Sampling of Aggregates Products
ND T 248 and AASHTO R 76, Reducing Samples of Aggregate to Testing Size. ASTM D 75M, Standard Practice for Sampling Aggregates.

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, but not required 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 sealable bags
Shovel
Scoop or spoon
Brush
Sampling tubes
Belt template

PROCEDURE

Ensure sample containers and equipment are free of debris and dry prior to aggregate sampling.

The sample size is based on the type and number of tests to be performed. Field samples should meet or exceed the minimums found in Table 1. Table 1 gives the approximate sample size required for different aggregate sizes.

When practicable, samples shall be obtained from the finished product. Sampling requires three or more 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.

TABLE 1 – RECOMMENDED SAMPLE SIZES

Recommended Sample Sizes	
Nominal Maximum Size*, in (mm)	Minimum Mass of Test Sample, lb. (kg)
Fine Aggregate	
No. 8 (2.36)	25 (10)
No. 4 (4.75)	25 (10)
Coarse Aggregate	
3/8 (9.5)	25 (10)
½ (12.5)	35 (15)
¾ (19.0)	55 (25)
1 (25.0)	110 (50)
1½ (37.5)	165 (75)
2 (50)	220 (100)
2½ (63)	275 (125)
3 (75)	330 (150)
Combined Coarse and Fine Aggregates	
Base or subbase	25 (10)
*Nominal Maximum Size is defined by the aggregate type and terminology in this standard.	

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. Avoid sampling from the beginning or end of the flowing stream.

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. Avoid sampling from the beginning or end of the windrow.

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 dustpan may be used to remove the fine material. Make sure to include all the fine material. Space the three samples apart. Avoid sampling from the beginning or end of the conveyor belt.

SAMPLING FROM A STOCKPILE:

Segregation often occurs when materials are stockpiled; therefore, 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' (minimum) in length.

SAMPLING FROM A TRUCK:

Take samples from a minimum of three trenches. Dig trenches across the truck box at points on the surface that appear to be representative of the material. Make the trench bottom approximately level, at least one-foot wide and one-foot below the surface of the aggregate. Take equal portions of material by pushing the shovel downward into the material in the bottom of the trench at three equally spaced locations. Do not scrape the material horizontally. Combine the nine portions (minimum) to form the combined sample from the truck.

For sampling the fine aggregate, insert a sampling tube at a minimum of five locations. Sampling tube should be a minimum of 1¼" in diameter by 6' in length.

NOTES

It is desirable to sample any material as near as possible to, if not at, the final in-place position. Hierarchies of preferred sampling locations are in-place, windrow, conveyor belt, flowing stream, truck box, or stockpile.

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 T 11, Procedure A 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.

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 R 90, 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 R 76, 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 or other heat source
Washing container
Spoon

TEST SPECIMEN

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

Test sample shall be representative and based on the following table. If the same sample is also to be tested according to ND T 27. The minimum mass shall be as described in the applicable sections in that method.

Nominal Maximum Size	Minimum Mass
No. 4 (4.75 mm) or smaller	300 g
3/8" (9.5 mm)	1000 g
3/4" (19.0 mm)	2500 g
1½" (37.5 mm)	5000 g

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. 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. 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 are calculated on SFN 9987.

If this test has been run for the purpose of accurate determination of material finer than the No. 200 sieve for concrete aggregate, the results are calculated on SFN 2455.

The calculation for concrete aggregate is as follows: Subtract weight after washing from weight of original sample, then divide result by weight of original sample then multiply by 100. Record as material passing No. 200 sieve as percent of total sample.

The equation is as follows:

$$A = [(B-C)/B] \times 100$$

A = percent of material finer than No. 200 sieve by washing
B = weight of original sample before washing
C = weight of sample after washing

REPORT

Report the percentage 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.

Utilization of wetting agents is not within this scope.

Due to the potential breakdown of soft or friable aggregates, use of mechanical washers is not allowed.

CALIBRATION

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

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 R 100, 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:

Specimen Type and Size	Number of Layers of Approximately Equal Depth	Number of Insertions per Layer
Cylinder Diameter:		
4" (100 mm)	2	25
6" (150 mm)	3	25

Tamping Rod Requirements for Cylinder and Beam Molds:

Cylinder Mold Diameter or Beam Mold Width	Tamping Rod Diameter	Tamping Rod Length
< 6" (< 150 mm)	3/8" (10 mm)	12" (300 mm)
6" (150 mm)	5/8" (16 mm)	20" (500 mm)

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:

Specimen Type and Size	Number of Layers of Approximately Equal Depth	Number of Insertions per Layer
Cylinder Diameter:		
4" (100 mm)	2	1
6" (150 mm)	2	2

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:

Specimen Type and Size	Number of Layers of Approximately Equal Depth	Number of Insertions per Layer
Beam Width:		
6" to 8" (150 to 200 mm)	2	1 insertion per 2 sq.in.
> 8" (> 200 mm)	3	1 insertion per 2 sq.in.

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:

Specimen Type and Size	Number of Layers of Approximately Equal Depth	Number of Insertions per Layer
Beam Width:		
6" to 8" (150 to 200 mm)	1	6" intervals
> 8" (> 200 mm)	2 or more	6" intervals

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 and Flexural Test Beams:

After the initial curing, remove cylinders and beams 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.

If water storage tanks are utilized, cure test specimens 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, then 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 R 90, Sampling Aggregate Products
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 R 76, 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 or other heat source
Bronze brush
Paint brush, approximately 1" wide
Sample splitters, small and large
Mortar and rubber tipped pestle

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.

Fine Aggregate – Minimum sample size after drying is 300 grams.

Coarse Aggregate – Mass of test sample required is shown in the following table.

Coarse Aggregate Test Sample Size	
Nominal Maximum Size Square Openings, in (mm)	Minimum Mass of Test Sample, lb. (kg)
3/8 (9.5)	2 (1)
½ (12.5)	4 (2)
¾ (19.0)	11 (5)
1 (25.0)	22 (10)
1½ (37.5)	33 (15)
2 (50)	44 (20)
2½ (63)	77 (35)
3 (75)	130 (60)

Coarse and Fine Aggregate Mixtures – Mass of test sample shall be the same as the coarse aggregate minimums.

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. Weigh and record as original weight.

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.

Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve and cover. Agitate the sieves by mechanical apparatus for a maximum of 10 minutes or until meeting the criteria for adequacy of sieving.

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.

*Randomly select a sieve and handshake until not more than 0.5% by weight of the total sample passes the sieve for one minute. Use manual shaking of the material on any one sieve to check on the thoroughness of sieving by any mechanical shaker.

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.

Maximum Allowable Quantity of Material Retained*			
Sieve Size	8″ Diameter	12″ Diameter	14" Square
2" (50 mm)	7.9 lbs (3.6 kg)	18.5 lbs (8.4 kg)	33.7 lbs (15.3 kg)
1½" (37.5 mm)	6.0 lbs (2.7 kg)	13.9 lbs (6.3 kg)	25.4 lbs (11.5 kg)
1" (25.0 mm)	4.0 lbs (1.8 kg)	9.3 lbs (4.2 kg)	17.0 lbs (7.7 kg)
3/4" (19.0 mm)	3.1 lbs (1.4 kg)	7.1 lbs (3.2 kg)	12.8 lbs (5.8 kg)
1/2" (12.5 mm)	2.0 lbs (0.89 kg)	4.6 lbs (2.1 kg)	8.4 lbs (3.8 kg)
3/8" (9.5 mm)	1.5 lbs (0.67 kg)	3.5 lbs (1.6 kg)	6.4 lbs (2.9 kg)
No. 4 (4.75 mm)	0.7 lbs (0.33 kg)	1.8 lbs (0.80 kg)	3.3 lbs (1.5 kg)
-No. 4 (4.75 mm)	0.4 lbs (0.20 kg)	1.0 lbs (0.47 kg)	1.9 lbs (0.86 kg)
*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. The minimum sample size after drying is 300 grams.

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.

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%.

Calculate the percent retained on each sieve by dividing each cumulative 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:

% retained on sieve = (Cumulative weight/Original weight) x 100
% passing = 100 - % 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:

% total sample = [(% passing No.4) x (% passing smaller sieve)]/100

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

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 an appropriate brush. 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 or magnifying glass to inspect for damages.

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.

ND T 30
MECHANICAL ANALYSIS OF EXTRACTED AGGREGATES

Conduct this procedure according to ND T 30.

Consult the current edition of AASHTO T 30 for procedure in its entirety and equipment specification details.

SCOPE

This test method determines the particle size distribution of fine and coarse aggregates extracted from asphaltic mixtures.

REFERENCED DOCUMENTS

ND T 27 and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 164, Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying
ND T308 and AASHTO T 308, Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

APPARATUS

Balance
Sieves: 8" or 12’ round
Mechanical sieve shaker Oven
Wetting Agent, such as dishwashing soap
Container of sufficient size to cover entire sample with water and avoid loss during agitation.
Bronze brush
Paint brush, approximately 1" wide
Spoon

TEST SPECIMEN

The test specimen shall consist of the entire sample of aggregate obtained from AASHTO T 164 or ND T 308.

PROCEDURE

Use SFN 7005 to record all information.

Dry the sample (if necessary) according to ND T 255. Determine and record as original weight. All weights are recorded to the nearest 0.1 g.

Nest a No. 16, sieve above the No. 200 sieve.

Place the test sample in a container and cover with water. Add the wetting agent to the water to assure a thorough separation of the material finer than the No. 200 sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

Manually agitate sample to ensure complete separation of the material finer than No. 200 from coarser particles and bring the fine material into suspension above the coarser material.

Immediately decant the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill No. 200 sieve.

Add water to cover material remaining in the container, agitate, and repeat manual agitation. Continue this process until the wash water is reasonably clear.

Remove the upper sieve, return any material retained to the sample container. Then rinse the material retained on the No. 200 sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed.

Return all material retained on the No. 200 sieve to the washed sample by rinsing into the sample container.

Dry the sample according to ND T 255. Determine and record as weight after wash.

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.

Place the sample in top sieve complete sieve analysis according to ND T 27.

CALCULATIONS

Complete all calculations according to ND T 27.

REPORT

Report all percentages to the nearest 1 percent, except the percent passing the No. 200 sieve, which is the nearest 0.1 percent.

NOTES

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 number of aggregate particles stuck in the mesh must appear to remain approximately the same for accurate results.

CALIBRATION

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

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.

ND T 59
Standard Method of Test for Emulsified Asphalts, Sieve Test

Conduct this procedure according to ND T 59.

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

SCOPE

This procedure is used to determine the percentage of material retained on a #20 sieve when a given amount of asphalt emulsion is poured through it.

REFERENCED DOCUMENTS

AASHTO T 59, Standard Method of Test for Emulsified Asphalts

APPARATUS

3-inch # 20 sieve
Pan for the 3-inch, #20 sieve
Sodium Oleate Solution (2 percent distilled water) Desiccator
Balance

TEST SPECIMEN

The test temperature is related to an emulsion's viscosity.

Test Temperature for Asphalt Emulsion Sieve Test	
Viscosity	Test Temperature
< 100 seconds	Room Temperature
> 100 seconds	122 ± 5° F
Specified at 122° F	122 ± 5° F

PROCEDURE

If heating is necessary, vent and place the container containing the sample in an oven or water bath. Stir the sample to achieve homogeneity.

Record the weight of the sieve and pan on SFN 18781. Wet the wire cloth with the 2 percent Sodium Oleate Solution. For cationic emulsions, use distilled water instead of the Sodium Oleate

Weigh 1000 g of the emulsified asphalt into a suitable container and pour it through the sieve. Wash the container and the residue on the sieve with the Sodium Oleate Solution (distilled water if cationic) until the washing runs clear. Place the pan under the sieve and heat in oven at 325°F (163°C) for two hours. Cool in a desiccator and weigh the sieve, pan, and residue. Calculate the percentage of the sample retained on the sieve.

ND T 72
Standard Method of Test for Saybolt Viscosity

Conduct this procedure according to ND T 72.

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

SCOPE

This method covers the procedures for determining the Saybolt Furol viscosity of emulsified asphalt.

REFERENCED DOCUMENTS

AASHTO T 59, Standard Method of Test for Emulsified Asphalts AASHTO T 72, Standard Method of Test for Saybolt Viscosity

APPARATUS

Saybolt Furol viscometer and bath. Withdrawal tube or another suitable device. Thermometer support.
Thermometers - ASTM 17° or 19° Fahrenheit (F) or Celsius (C). Filter funnels with number 20 (850 μ m) wire-mesh insert.
Receiving flask.
Timing device capable of recording to 1/10(0. 1) second.

PREPERATION OF APPARATUS

Fill the Saybolt viscometer internal bath with mineral oil to at least 1/4" (6 mm) above the overflow rim.

Clean the viscometer tubes thoroughly with water and then with an appropriate solvent and then a final rinse with acetone. Remove all solvent from the viscometer. Wash the receiving flask with water and appropriate solvent and then a final rinse with acetone.

Set up the viscometer and bath in an area where it will not be exposed to drafts or rapid changes in air temperature. Use of an enclosing hood reduces any chances that dust, or vapors might contaminate the viscometer or sample.

Place the receiving flask beneath the viscometer so that the graduation mark on the receiving flask is from four to five inches (100 to 130 millimeters, mm) below the bottom of the viscometer tube. Position the receiving flask so that the stream from the viscometer strikes the neck of the flask.

Provide adequate stirring and thermal control for the bath so that the temperature of the test sample in the viscometer does not vary more than ± 0.1 °F (0.05°C) after reaching the test temperature. Do not make viscosity measurements at temperatures below the dew point of the room's atmosphere.

PROCEDURE

Establish and control the bath temperature at the selected test temperature. Insert a cork stopper into the air chamber at the bottom of the viscometer. A small chain or cord may be attached to the cork to simplify rapid removal. Use a cork that fits tight enough to prevent the escape of air, as evidenced by the absence of oil on the cork when it is withdrawn.

If the selected test temperature is above room temperature, the test may be hastened by preheating the sample in its original plastic or glass container. This temperature is not to exceed 3.0°F (5.4°C) above the test temperature.

Stir the sample well, then strain it through the filter funnel equipped with a number 20 screen into a beaker. Put the sample from the beaker into the viscometer until the level is above the overflow rim.

Test the sample at either 77°F or 122°F (25° or 50°C} depending on the grade of emulsion. Stir the sample in the viscometer with the appropriate thermometer equipped with the thermometer support. Use a circular motion at an approximate rate of 60 revolutions per minute. When the sample temperature remains constant within 0.1 °F (0.05°C) of the test temperature, continuously stir for one minute, then remove the thermometer. Immediately place the tip of the withdrawal tube into the gallery and apply suction to remove emulsified asphalt until its level is below the overflow rim. Do not touch the overflow rim with the withdrawal tube or the effective liquid head of the sample may become reduced.

Check to see that the receiving flask is properly positioned then snap the cork from the end of the viscometer, and at the same moment start the timing device. Stop the timing device at the instant the bottom of the oil meniscus reaches the graduation mark on the receiving flask. Record the time to the nearest 0.1 second. Multiply this time by the correction factor (F) for the viscometer to arrive at the sample viscosity and record on SFN 18781. Clean the equipment for the next test.

CALIBRATION AND STANDARDIZATION

Calibrate the Saybolt once every three years. Follow standard test procedures for determining the calibration factor. If the afflux time differs by more than two percent, find a correction factor by using the following formula.

$$F = V / t$$

V = certified Saybolt viscosity of the standard t = measured afflux time at 100°F (37.8°C) F = correction factor

ND T 84
SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE

Conduct this procedure according to AASHTO T 84-13 (2021), Specific Gravity and Absorption of Fine Aggregate. This method will be followed in its entirety but with the following exceptions or modifications.

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 based on 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 R 90, Sampling of Aggregates
AASHTO T 84-13 (2021), Specific Gravity and Absorption of Fine Aggregate ND T 248 and AASHTO R 76, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying

APPARATUS

- **AASHTO 5.2** – Pycnometer - 1000 mL volumetric flask and a glass cover plate. Volumetric flasks with opening ground flat to ensure airtight seal. Glass Plate to cover opening. Fruit jar fitted with pycnometer is not allowed.
- **AASHTO 5**.3 - Masking tape around SSD (Saturated Surface Dry) mold
- Other items - Distilled water. Stainless steel pan for drying.

SAMPLING

- **AASHTO 6.1 -** Delete
- Obtain sample according to ND T 2.
- Sample taken from conveyor belt, when possible, avoid sampling from stockpiles.
- Sample size is determined by nominal maximum size of material.
- Sample shall only be transported in a clean sealed container (bucket) to prevent loss of fines.
    - Thoroughly clean sample transport containers prior to use.

PREPARATION OF TEST SPECIMEN

Prepare sample for testing according to Section 7 of AASHTO T 84, except with the

following provisions.

- Mix and reduce to testing size according to ND T 248.
- Reducing sample size should only be done on material that is in the SSD condition using Method A of ND T 248.
- Take extra care to prevent loss of fines.
- **AASHTO 7.1 -** Test specimen shall be a representative sample of approximately 1100 g of material passing the No. 4 sieve. Do not wash the material passing the No. 200 sieve.
- Record all information on SFN 2199. Weights are recorded to the nearest 0.1 g.
- **AASHTO 7.1.1** – Cover with distilled water.
- The addition of 6% moisture to an oven dried sample is not allowed.
- **AASHTO 7.1.2 -** Delete
- **AASHTO 7.2 -** After the soak period carefully remove excess water. Take care to avoid loss of any fines. Decanting the water is not recommended. Sample should be prepared according to AASHTO 7.2. The sample shall remain in a pan until test specimen reaches a free-flowing condition to not lose any material.
- **AASHTO 7.2.1 –** Cone test for surface moisture shall be run on a large, flat, smooth, nonabsorbent surface that is sufficiently thick to avoid any movement or vibration.
- All tools used to run test shall be set lightly on a soft surface next to testing area. Testing lab shall be free of high humidity and in a controlled air movement environment including temperature control.
- 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. Carefully slide cupped fingers down the mold to allow material to slough naturally at the top of cone.
- Remove the material spilled around the mold with a small brush and slowly lift the mold vertically. It is recommended to place masking tape around cone to avoid slipping with fingers.
- Test the tamped fine aggregate at frequent intervals until approximately 50% of the top diameter of the cone slumps. At this point the material has reached the saturated surface dry condition. Immediately weigh 500±10 g of the tested saturated surface dry

material for introduction into the flask.

PROCEDURE

Test sample according to Section 8 of AASHTO T 84, except with the following provisions.

- **AASHTO 8.2 -** Partially fill the pycnometer flask with distilled water. Immediately introduce the 500±10 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 circulating 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.

  At this time, it is also recommended to place additional distilled water into water bath to bring to the same temperature as the water in the sample flask.

- 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 convex 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.

- **Table 1-Precision** – Delete

- **AASHTO 8.2.1 –** Delete

- **AASHTO 8.2.2 –** Delete

- **AASHTO 8.3 –** Keep but Delete Note 5.

- **AASHTO 8.3.1 –** Delete

- **AASHTO 8.4 -** 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 convex 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. Recalibrate pycnometer flasks annually, or after damage, or replacement occurs.

- **AASHTO 8.4.1 –** Delete

BULK SPECIFIC GRAVITY

Calculate the bulk specific gravity according to Section 9 of AASHTO T 84, except with the following provision.

- **AASHTO 9.1.1 -** Delete

BULK SPECIFIC GRAVITY (SATURATED SURFACE-DRY BASIS)

Calculate the bulk specific gravity based on mass of the SSD aggregate according to Section 10 of AASHTO T 84, except with the following provision.

- **AASHTO 10.1.1 -** Delete

APPARENT SPECIFIC GRAVITY

Calculate the apparent specific gravity according to Section 11 of AASHTO T 84.

ABSORPTION

Calculate the absorption according to Section 12 of AASHTO T 84.

REPORT

Report specific gravity results and absorption according to Section 12 of AASHTO T 84, except with the following provisions.

- **AASHTO 13.1 –** Report specific gravity results to the nearest 0.001 and absorption to the nearest 0.01%.
-
- **AASHTO 13.2 –** Delete

PRECISION AND BIAS

- **AASHTO 14.1 –** Delete
- **AASHTO 14.2 –** Delete

KEYWORDS

Report specific gravity results and absorption according to Section 12 of AASHTO T 84.

APPENDIXES

- **AASHTO X.1 –** Delete
- **AASHTO X.1.1 –** Delete
- **AASHTO X.1.2 –** Delete

- **AASHTO X.2 –** Delete
- **AASHTO X.2.1 –** Delete

ND T 85
SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE

Conduct this procedure according to ND T 85.

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 R 90, 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 R 76, 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
or other heat source
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.

Nominal Maximum Size	Minimum Mass of Test Sample
1/2" (12.5 mm)	4 lbs (2 kg)
3/4" (19.0 mm)	7 lbs (3 kg)
1" (25.0 mm)	9 lbs (4 kg)
1½" (37.5 mm)	11 lbs (5 kg)
2" (50 mm)	18 lbs (8 kg)

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. Then allow the sample to cool to a comfortable handling temperature. Immerse the aggregate in water at room temperature for a period of 15 to 19 hours.

Remove the sample from the 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. Allow the sample to cool until it is 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 = A/(B - C)

A = Weight of oven dry sample in air
B = Weight of saturated surface dry sample in air
C = 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 = 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 = 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 = [(B - A)/A] x 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 AGGREGATE 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.

Diameter of Largest Particle	Approximate Minimum Mass of Portion
3/8" (9.5 mm)	1 lb (0.5 kg)
1" (25 mm)	4.25 lbs (2.0 kg)
2" (50 mm)	8.5 lbs (4.0 kg)
3" (75 mm)	11 lbs (5.0 kg)

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.

Test	Sample Size Needed
Liquid Limit ND T 89	100 g
Plastic Limit ND T 90	20 g
Shrinkage Factors	30 g
Check and Referee Tests	100 g

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.

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 = [(B - C)/C] x 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.

Number of Blows N	Factor for Liquid Limit k
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014

Liquid Limit corrected for closure at 25 blows = (k) x (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 1.5g 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:

$$A = [(B - C)/C] \times 100$$

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 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.

Plasticity Index = Liquid Limit - 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.

C. ND T 99 AND ND T 180 MOISTURE-DENSITY RELATIONS OF SOILS

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

FEATURE	ND T 99	ND T 180
Weight of Compaction Rammer	5.5 lbs	10 lbs
Distance of Drop	12"	18"
Number of Soil Layers	3	5
Diameter of Mold	4"	4"
Soil Passing Sieve Size	No. 4	No. 4
Rammer, Blows/Layer	25	25

METHOD D

FEATURE	ND T 99	ND T 180
Weight of Compaction Rammer	5.5 lbs	10 lbs
Distance of Drop	12"	18"
Number of Soil Layers	3	5
Diameter of Mold	6"	6"
Soil Passing Sieve Size	3/4"	3/4"
Rammer, Blows/Layer	56	56

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.

Wet Weight of Soil = Weight of Mold + Soil – Weight of Mold Wet

Density, pcf = Wet Weight of Soil/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:

Dry Density, pcf = (Wet Density X 100)/(100 + % 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.

GRAPH

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%.

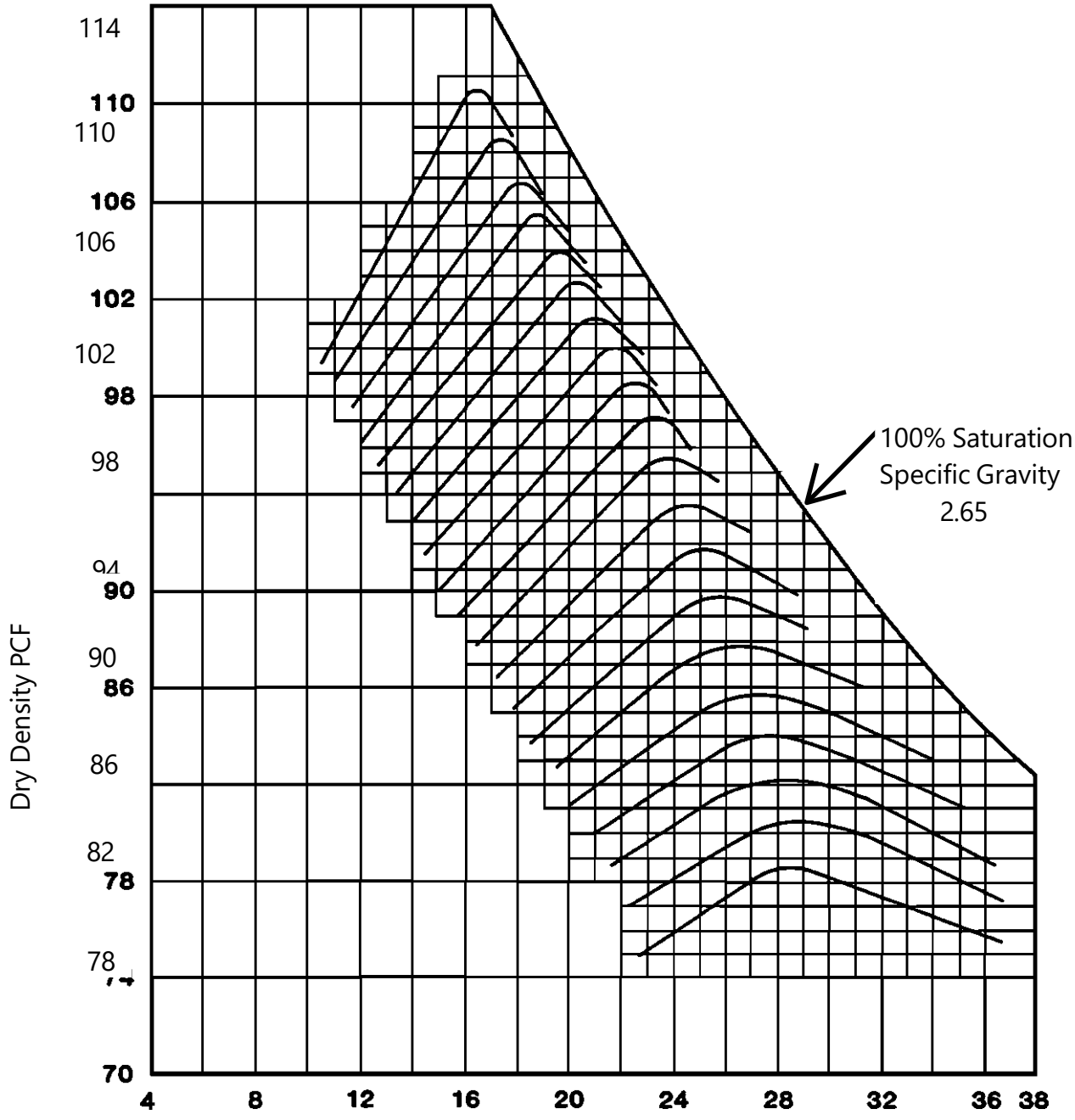
NOTES

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.

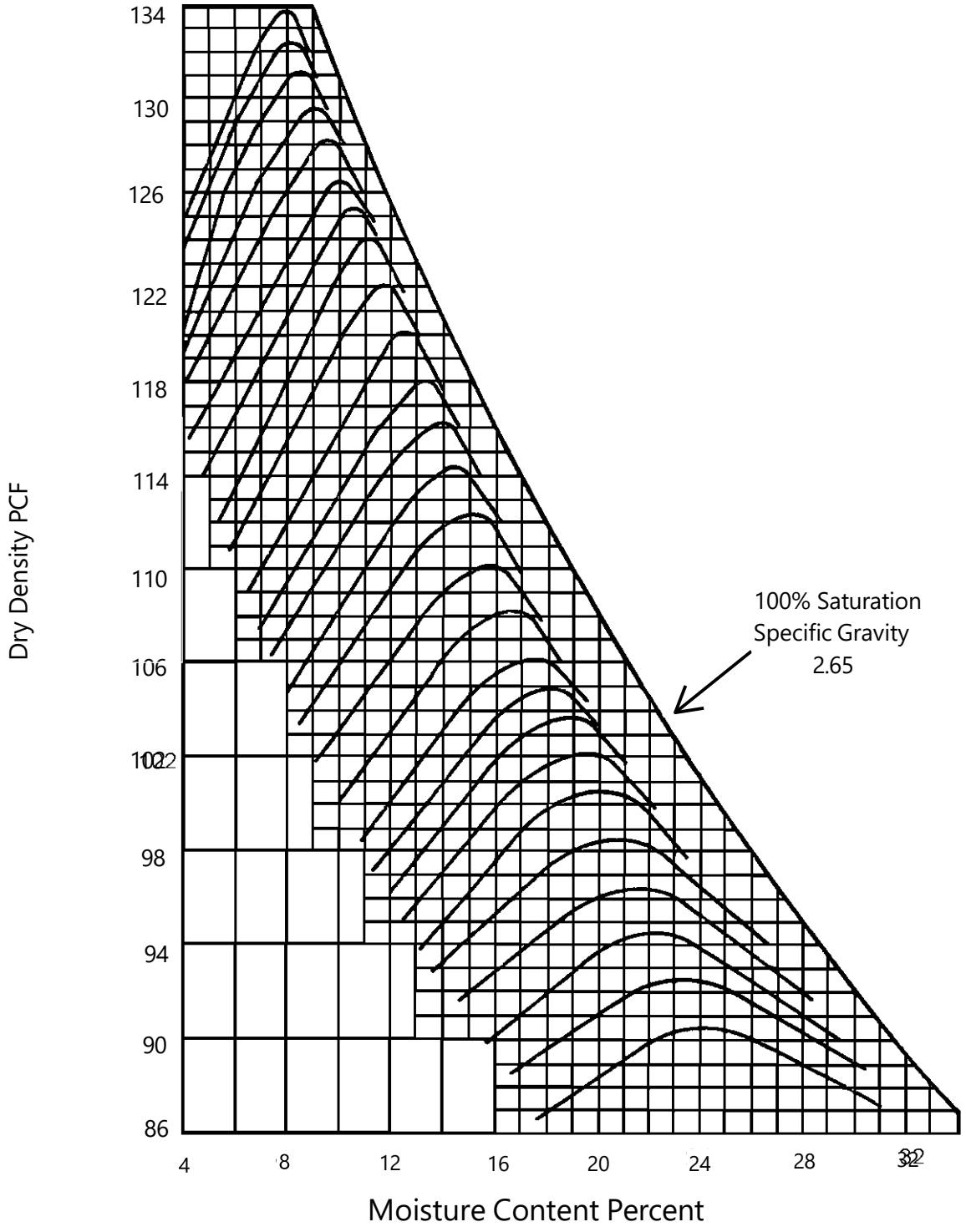
In order to perform the test in conjunction with and at the same location as the in- place density test, there are steel-capped, wooden pedestals available to support the mold base plate. During compaction, place the mold and pedestal on firm level ground.

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

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 agitates the fine aggregate sample for 15 seconds and then allows resting for 1-2 minutes before removing the lightweight pieces. 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 R 90, 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 R 76, 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 or other heat source

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:

Nominal Maximum Size of Aggregate	Minimum Mass of Sample
No. 4 (4.74 mm)	200 g
3/8" (9.5 mm)	1500 g
3/4" (19.0 mm)	3000 g
1½" (37.5 mm)	5000 g
3" (75 mm)	10,000 g

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. Cover the sample and cool to room temperature.

When performing sieve analysis according to ND T 27, sample size should be determined by the applicable sections in that test method.

PROCEDURE

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

Coarse Aggregate:

Thoroughly wash the sample to remove dust or other coatings from the surface and dry to constant mass. 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. Weigh and record as weight of lightweight pieces in Plus No. 4 material, immediately after removal from oven or other heat source.

Fine Aggregate:

Weigh the sample and record as weight of Minus No. 4 Plus No. 30 material.
Place the fine portion into the zinc chloride solution in a nonabsorbent container, preferably a glass beaker. 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. Weigh and record as weight of lightweight pieces Minus No. 4 Plus No. 30 material, immediately after removal from oven or other heat source.

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 = (B/C) x 100

  A = Percent of lightweight pieces in the coarse aggregate

B = Weight of coarse lightweight pieces

C = 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 = (A x E)/100

  D = Percent coarse lightweight pieces, total sample
  A = Percent of lightweight pieces in the coarse aggregate E
  = 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 = (G/H) x 100

  F = Percent of lightweight pieces in fine aggregate
  G = Weight of fine lightweight pieces
  H = 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 = (F x J)/100
  I = Percent fine lightweight pieces, total sample
  F = Percent of lightweight pieces in fine aggregate
  J = 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 chemical irritant of the eyes, skin, and respiratory system. 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 increments. 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 start 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 = Concrete and bucket (lbs)
B = Weight of bucket (lbs)
C = Weight of concrete (lbs)

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

D = C x Multiplication Factor D

= Unit weight (lbs/cu.ft.)
C = Weight of concrete (lbs)

Or the volume of the bucket may be used.

Weight of concrete divided by volume of bucket = unit weight

D = C/Volume of bucket
C = Weight of concrete (lbs)
D = 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:

Yield = Total weight of batch/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:

Cement Content = 27 x 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 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**:

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 to12 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 = Apparent Air Content of Sample Tested (%)
B = Aggregate Correction Factor (%)
C = Air content of sample tested (%)

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 USINGSATURATED 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 Asphalt Mixtures Using Paraffin-Coated Specimens
AASHTO T 331, Bulk Specific Gravity and Density of Compacted Asphalt Mixtures 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 asphalt 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. Each specimen shall be immersed and weighed individually.

Remove the specimen from the water and surface dry by blotting with a damp towel. Determine the mass as quickly as possible. The entire operation is not to exceed 15 seconds. Record as surface-dry specimen in air.

CALCULATIONS

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

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

A = Weight in grams of the specimen in air
B = Weight in grams, surface dry
C = 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:

Percent of water absorbed by volume = [(B - A)/(B - C)] x 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 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.

ND T 176
PLASTIC FINES IN GRADED AGGREGATES AND SOILS BY USE OF THE SAND EQUIVALENT TEST

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.

For equipment specification details, consult the current edition of AASHTO T 176, Alternate Method 2.

REFERENCED DOCUMENTS

ND T 2 and AASHTO R 90, 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 R 76, Reducing Samples of Aggregate to Testing Size
ND T 255 and AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying

APPARATUS

Pan
Trowel
Damp cloth
Plastic splitting cloth
3-oz. sample tins
Spatula or straightedge
Graduated plastic cylinder
Stock calcium chloride solution
Oven or other heat source
Funnel
Clock or stopwatch
Rubber stopper
Mechanical or Manual 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. Dry the sample according to ND T 255.

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 oven-dried 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.

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. Strike 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. A manual shaker capable of producing an oscillating motion at the rate of 100 complete cycles

in 45 ± 5 seconds, can also be used.

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 reaches 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 0.1 of an inch. If the reading falls between the 0.1 of an inch graduation, 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:

Sand Equivalent = (Sand reading/Clay reading) x 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

Hand shaking of sample is not allowed.

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.

$$D_B = (m_3 - m_4 - C_C)/V_C$$

Where:

D_B = 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 C_C = Cone correction
V_C = 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

Maximum Particle Size	Minimum Test Hole Volume	Minimum Sample Size for Moisture Content
No. 4 (4.75 mm)	0.025 ft^3	100 g
1/2" (12.5 mm)	0.050 ft^3	250 g
1" (25.0 mm)	0.075 ft^3	500 g
2" (50.0 mm)	0.100 ft^3	1000 g

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 = (Initial Mass - Final Mass - C_C)/D_B*

  Calculate the volume of test hole to the nearest 0.0001 ft^3.

- *(M_{DS}) Dry Mass of Material removed from test hole = (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/ft^3.

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 ASPHALT MIXTURES

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 Asphalt Mixtures

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

Oven

*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 according to 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 50289.

Flask Calibration

- Flask Calibration: Determine the weight of each flask full of potable 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 convex 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.

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. Samples obtained from the field do not require the 2-hour cure.

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%.

Spread the mixture 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 sample in the flask and weigh. After recording weight, add sufficient potable 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 applying gradually increasing vacuum until the gauge reads 27.5 +/- 2.5 mm Hg (3.7 +/- 0.3 kPa). Maintain the pressure while agitating the flasks 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.

Release the vacuum at a rate not to exceed 60 mm Hg (8 kPa) per second. Remove flasks from shaker and fill flasks with potable water that is at a temperature of 77 ± 2°F (25 ± 1°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, add water to slightly overfill and slide the glass cover plate over the flask. Dry the outside. Weigh and record.

CALCULATIONS

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

Theoretical Maximum Specific Gravity = A/(A + D – E) A
= mass of oven-dry sample in air
D = mass of container filled with water at 77°F (25°C)
E = 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 0.014. Use the average of the results from the two flasks of the passing test for the final maximum specific gravity.

If the difference exceeds 0.014, 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 nearest 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."

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.

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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)

$$MC_T = [(MC_F) \times (P_f) + (MC_c) \times (P_c)]/100$$

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 (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% = [(12.0 x 85) + (2.0 x 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 lbs/ft^3 = 100 x 122.0 x 165.4/ [(122.0 x 15) + (165.4 x 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
AASHTO T 245, Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus

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 = Maximum Load x 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

Volume of Specimen (cm^3)	Thickness of Specimen (in.)	mm	Correlation Ratio	Volume of Specimen (cm^3)	Thickness of Specimen (in.)	mm	Correlation Ratio
200 to 213	1	25.4	5.56	406 to 420	2	50.8	1.47
214 to 225	1 1/16	27.0	5.00	421 to 431	2 1/16	52.4	1.39
226 to 237	1 1/8	28.6	4.55	432 to 443	2 1/8	54.0	1.32
238 to 250	1 3/16	30.2	4.17	444 to 456	2 3/16	55.6	1.25
251 to 264	1 1/4	31.8	3.85	457 to 470	2 1/4	57.2	1.19
265 to 276	1 5/16	33.3	3.57	471 to 482	2 5/16	58.7	1.14
277 to 289	1 3/8	34.9	3.33	483 to 495	2 3/8	60.3	1.09
290 to 301	1 7/16	36.5	3.03	496 to 508	2 7/16	61.9	1.04
302 to 316	1 1/2	38.1	2.78	509 to 522	2 1/2	63.5	1.00
317 to 328	1 9/16	39.7	2.50	523 to 535	2 9/16	65.1	0.96
329 to 340	1 5/8	41.3	2.27	536 to 546	2 5/8	66.7	0.93
341 to 353	1 11/16	42.9	2.08	547 to 559	2 11/16	68.3	0.89
354 to 367	1 3/4	44.4	1.92	560 to 573	2 3/4	69.9	0.86
368 to 379	1 13/16	46.0	1.79	574 to 585	2 13/16	71.4	0.83
380 to 392	1 7/8	47.6	1.67	586 to 598	2 7/8	73.0	0.81
393 to 405	1 15/16	49.2	1.56	599 to 610	2 15/16	74.6	0.78
				611 to 625	3	76.2	0.76

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 OFAGGREGATE 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. The techniques used should minimize variation in measured characteristics between the test samples selected and the entire sample. The final product should be a sample representative of the source.

REFERENCED DOCUMENTS

ND T 2 and AASHTO R 90, Sampling Aggregates
ND T 248 and AASHTO R 76, 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 8 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 4 to 8 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 or ASTM 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
ND D 4643, Microwave Method of Drying Soils

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 minimum power rating of 700 watts with variable power control.)

TEST SPECIMEN

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

Sample Size for Aggregate

Nominal Max Size of Aggregate	Mass of Normal Weight Aggregate Sample
No.4 (4.75 mm)	1 lb. (0.5 kg)
3/8" (9.5 mm)	3 lbs. (1.5 kg)
1/2" (12.5 mm)	4 lbs. (2 kg)
3/4" (19.0 mm)	7 lbs. (3 kg)
1" (25.0 mm)	9 lbs. (4 kg)
1½" (37.5 mm)	13 lbs. (6 kg)
2" (50 mm)	18 lbs. (8 kg)

2½" (63 mm)	22 lbs. (10 kg)
3" (75 mm)	29 lbs. (13 kg)

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 further heating causes or would cause less than 0.1 percent additional mass loss.

CALCULATIONS

Calculate the percent moisture as follows:

$$A = [(B - C)/C] \times 100$$

A = Percent moisture
B = Mass of original sample
C = Mass of dry sample

Report percent moisture to the nearest 0.1%.

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.

Maximum Particle Size	Minimum Mass of Sample
No. 40 (0.425 mm) sieve	10 g
No. 4 (4.75 mm) sieve	100 g
1/2" (12.5 mm)	300 g
1" (25.0 mm)	500 g
2" (50 mm)	1000 g

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:

$$A = [(B - C)/(C - D)] \times 100$$

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 CONTENTOF FINE AGGREGATE

Conduct this procedure according to ND T 304.

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 T 304, Method A for procedure in its entirety and equipment specification details.

SCOPE

This method 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 R 90, 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 R 76, 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
Oven or other heat source

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. The 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 sieve analysis according to ND T 27.

Remove the individual fractions as defined by the 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:

Individual Size Fraction	Weigh
t No. 8 to No. 16	44 g
No. 16 to No. 30	57 g
No. 30 to No. 50	72 g
No. 50 to No. 100	17 g

The tolerance on each of these amounts is ±0.2 g

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 excess from the top of the cylinder by a 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. 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. Brush away any loose material from the outside and weigh the cylinder plus aggregate. Weigh and record as weight of cylinder plus aggregate.

Recombine all material for the second trial. Repeat the procedure.

CALCULATIONS

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

Uncompacted Voids in Percent = [(V – (F/G)]/V x 100

V = Volume of calibrated cylinder in mL
F = Net weight of sample in cylinder, gross weight mass of empty cylinder
G = 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

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:

$$V = 1000 \times (M/D)$$

V = Volume of cylinder, mL
M = Net mass of water, g
D = 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.

Density of Water		
°F	°C	kg/m^3
60	15.6	999.01
65	18.3	998.54
70	21.1	997.97
73.4	23.0	997.54
75	23.9	997.32
80	26.7	996.59

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 308
DETERMINING THE ASPHALT BINDER CONTENT OF ASPHALT MIXTURES BY THE IGNITION METHOD

This procedure covers the determination of asphalt binder content of asphalt mixtures by ignition of the binder in accordance with AASHTO T 308.

OVERVIEW

The sample is heated in a furnace up to 538°C (1000°F) or less. The aggregate remaining after burning can be used for sieve analysis or Fine Aggregate Angularity (FAA) and Fractured Faces calculations. Asphalt binder in the asphalt mixture is ignited in a furnace. Asphalt binder content is calculated as the percentage difference between the initial mass of the asphalt mixture and the mass of the residual aggregate, with the asphalt binder correction factor, and moisture content subtracted. The asphalt binder content is expressed as percent of moisture-free mix mass. Use method A of the procedure.

APPARATUS

The apparatus for Method A requires an internal balance.

- Ignition Furnace: A forced-air ignition furnace that can heat the specimens to 538 ± 5°C (1000 ± 9°F). For Method A, the furnace will be equipped with an internal scale thermally isolated from the furnace chamber and accurate to 0.1 g. The scale shall be capable of determining the mass of a 3500 g sample in addition to the sample baskets. A data collection system will be included so that mass can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate the change in mass of the sample baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive minutes.

- The furnace chamber dimensions shall be adequate to accommodate a 3500 g sample. The furnace door shall be equipped so that it cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided and the furnace shall be vented so that no emissions escape into the laboratory. The furnace shall have a fan to pull air through the furnace to expedite the test and to eliminate the escape of smoke into the laboratory.

- Sample Basket Assembly will be consisting of sample basket(s), catch pan, and basket guards. Sample basket(s) will be of appropriate size allowing samples to be thinly spread and allowing air to flow through and around the sample particles. Sets of two or

more baskets shall be nested. A catch pan: of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught. Basket guards will completely enclose the basket and be made of screen mesh, perforated stainless steel plate, or other suitable material.

- Thermometer, or other temperature measuring device, with a temperature range of 10 - 260°C (50-500°F).

- Oven capable of maintaining 110 ±5°C (230 ±9°F).

- Balance or scale with a capacity sufficient for the sample mass.

- Safety equipment: Safety glasses or face shield, high temperature gloves, long sleeved jacket, a heat resistant surface capable of withstanding 650°C (1202°F), a protective cage capable of surrounding the sample baskets during the cooling period, and a particle mask for use during removal of the sample from the basket assembly.

- Miscellaneous equipment: A pan larger than the sample basket(s) for transferring sample after ignition, spatulas, bowls, and wire brushes.

PROCEDURE – METHOD A

- Preheat the ignition furnace to 482 ± 5°C (900 ± 9°F).

- Dry the sample to constant mass or determine the moisture content of a companion sample.

- Determine and record the mass of the sample basket assembly to the nearest 0.1 g.

- Evenly distribute the sample in the sample basket assembly, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.

- Determine and record the total mass of the sample and sample basket assembly at room temperature to the nearest 0.1 g. Calculate and record the initial mass of the sample (total mass minus the mass of the sample basket assembly) to the nearest 0.1 g.

- Record the correction factor or input into the furnace controller for the specific asphalt mixture.

- Input the initial mass of the sample into the ignition furnace controller. Verify that the correct mass has been entered.

- Verify the furnace scale is reading zero, if not, reset to zero

- Open the chamber door and gently set the sample basket assembly in the furnace.

Carefully position the sample basket assembly so it is not in contact with the furnace wall. Close the chamber door and verify that the sample mass displayed on the furnace scale equals the total mass of the sample and sample basket assembly recorded within ±5 g.
Note: Furnace temperature will drop below the set point when the door is opened but will recover when the door is closed, and ignition begins. Sample ignition typically increases the temperature well above the set point – relative to sample size and asphalt binder content.

- Initiate the test by pressing the start button. This will lock the sample chamber and start the combustion blower.
  Safety note: Do not attempt to open the furnace door until the asphalt binder has been completely burned off.

- Allow the test to continue until the stable light and audible stable indicator indicate that the change in mass does not exceed 0.01 percent for three consecutive minutes. Press the stop button. This will unlock the sample chamber and cause the printer to print out the test results.

- Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 minutes).

- Determine and record the total after ignition mass to the nearest 0.1 g. Calculate and record the mass of the sample, after ignition (total after ignition mass minus the mass of the sample basket assembly) to the nearest 0.1 g.

- Use the asphalt binder content percentage from the printed ticket or external calculation. Subtract the moisture content and the correction factor (if not entered into the furnace controller) from the printed ticket or external calculation asphalt binder content and report the difference as the corrected asphalt binder content.

Calculation of Corrected asphalt binder content:

$$PP_{bb} = BBC - MMC - CC_{ff} *$$

* if a correction factor is not entered into the furnace controller.

where:

P_b = the corrected asphalt binder content as a percent by mass of the asphalt mixture
BC = asphalt binder content shown on printed ticket
MC = moisture content of the companion asphalt mixture sample, percent
C_f = correction factor as a percent by mass of the asphalt mixture sample

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.

The final compacted gyratory plug height requirement is 115 ± 5 mm.

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. To ensure 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.

ND T 318
WATER CONTENT OF FRESHLY MIXED CONCRETE USING MICROWAVE OVEN DRYING

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. The 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 = [(B - C)/B - D] x 100
A = Water Percentage
B = Mass of wet sample, container, and cloth
C = Mass of dry sample, container, and cloth D= Mass of container and cloth

Calculate the total water content as follows:

E = [(27) x (A) x (F)]/100
E = Total Water Content A
= Water Percentage
F = 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 test hole volume required.

Maximum Particle Size	NDDOT Minimum Test Hole Volume
1/2"	0.025 cu.ft.
1"	0.03 cu.ft
1½"	0.035 cu.ft.

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. The 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 = (Wet Density x 100) / (100 + 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 OR AGGREGATES

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
Stirring tools such as a glass rod, spatula, or knife
Oven mitts
Heat sink (see notes)
Microwave oven (It is preferable the microwave oven has a vented chamber, variable power control, and a power rating of about 700 watts or greater.

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.

Sieve Retaining Not More Than About 10% of Sample	Recommended Mass of Moist Specimen

No. 10 (2.0 mm)	100 to 200 g
No. 4 (4.75 mm)	300 to 500 g
3/4" (19 mm)	500 to 1000 g

For samples consisting entirely of rock or aggregate, the minimum mass shall be 500g.

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 to the microwave 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:

$$A = [(B - C)/(C - D)] \times 100$$

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

Heat sink is a liquid or material placed in microwave to absorb energy after moisture is driven from the test sample.

Initial power setting may be higher than defrost. The proper power setting can be determined by 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.

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 and/or elongated particles in coarse aggregate.

REFERENCED DOCUMENTS

ND T 2 and AASHTO R 90, Sampling of Aggregates
ND T 27 and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregate
ND T 248 and AASHTO R 76, 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 or other heat source
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.

Nominal Maximum Size	Sample Size
3/8" (9.5 mm)	2 lbs (1 kg)
1/2" (12.5 mm)	4 lbs (2 kg)
3/4" (19.0 mm)	11 lbs (5 kg)
1" (25.0 mm)	22 lbs (10 kg)
1½" (37.5 mm)	33 lbs (15 kg)

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. Weigh and record as original weight of total sample.

Perform a dry sieve analysis according to ND T 27. Discard material passing the 3/8" (9.5 mm) sieve. Record and calculate weight and percent retained.

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:

$$A = (B/C) \times 100$$

A = Percent flat and elongated particles
B = Weight of flat and elongated material
C = Weight of 100 particles

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 the 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

SCOPE

Conduct these procedures according to NDDOT defined standards.

The following sampling and testing procedures are for emulsified asphalt, performance graded asphalt cement, asphalt cutbacks, and hot applied crack and joint sealants.

REFERENCED DOCUMENTS

AASHTO M 81, Cutback Asphalt (Rapid-Curing Type) AASHTO
M 82, Cutback Asphalt (Medium-Curing Type) AASHTO M 140
Emulsified Asphalt
AASHTO M 208, Cationic Emulsified Asphalt
AASHTO M 316, Polymer-Modified Cationic Emulsified Asphalt
AASHTO M 332, Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test
AASHTO M 324, Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavement

APPARATUS

- One-half gallon plastic, wide-mouth jar with a plastic cap with liner for emulsions.
- Metal quart screw-top containers for performance graded asphalt cement and cutbacks.
- Manufacturer's original unopened container, either two 30-lb single sample boxes or one 55-lb double sample box for hot applied crack and joint sealants.

PROCEDURE

The sample will be taken from a sampling valve. The valve may be located on the truck or on a discharge line connected to the truck.

For emulsions, performance graded asphalt cement, and cutbacks, draw a minimum of one gallon and discard before obtaining the sample.

Engineer will label each sample with the following information:

- Project Number
- PCN Number
- Date sampled
- Field sample number
- Manifest number
- Manufacturer

- Type and grade of bituminous material
- Original or check sample
- For emulsions, mark first or second half of project.

EMULSIFIED ASPHALT:

A sample is defined as two one-half gallon plastic containers.

The emulsion containers shall be filled to near capacity, squeeze to expel all air and seal.

Sample each truck load delivered to the project.

Record the sample numbers on SFN 10084.

PERFORMANCE GRADED ASPHALT CEMENT:

A sample is defined as two one-quart metal, screw top containers.

Randomly obtain one sample for every 250 tons for each grade of asphalt cement.

Record the sample number on SFN 5650.

ASPHALT CUTBACKS:

A sample is defined as two one-quart metal, screw top containers filled with the material to be tested.

Sample each truck load delivered to the project.

Record the sample numbers on SFN 10084.

HOT APPLIED CRACK AND JOINT SEALANT:

All hot applied crack and joint sealers must be submitted in the manufacturer's original unopened container.

Obtain a sample from each lot of crack and joint sealer delivered to the project. Record

the sample numbers on SFN 19907.

NDDOT 2
HOT MIX ASPHALT MIX DESIGN PROCEDURE

A. GENERAL

This Procedures has been developed to provide the required method for developing and verifying Hot Mix Asphalt (HMA) mix designs to meet the requirements set forth in the specifications and test methods referenced in this document.

The purpose of the gyratory mix design is to determine the optimum asphalt content for a specific blend of aggregate that will provide a pavement structure which will perform for the design life under the expected traffic loads. This procedure is for HMA that may or may not contain Recycled Asphalt Pavement (RAP).

B. EQUIPMENT

1. Gyratory compactor and support equipment meeting the requirements in AASHTO T 312 Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor.

2. Ignition furnace and support equipment meeting the requirements of AASHTO T 308 Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method.

3. Solvent extractor and support equipment meeting the requirements of AASHTO T 164 Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA).

4. All related equipment to perform ND T 166 Bulk Specific Gravity (G_{mb}) of Hot Mix Asphalt Mixtures Using Saturated Surface Dry Specimens.

5. All related equipment to perform ND T 209 Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA).

C. REFERENCES

1. NDDOT Standard Specifications for Road and Bridge Construction (Specs)
2. NDDOT Field Sampling and Testing Manual (FSTM)
3. NDDOT Technical Certification Program
4. MS-2, Asphalt Mix Design Methods, The Asphalt Institute
5. AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing and AASHTO Provisional Standards

D. TESTING DURING AGGREGATE PRODUCTION

1. Test stockpiles of aggregates according to section 430 of the FSTM during aggregate production. Provide samples to the Engineer for verification of specific gravities and absorption for each aggregate component according to Section 430 of the FSTM and Specs.

2. When a Mix Contains Recycled Asphalt Pavement (RAP)

    a. Determine the RAP asphalt binder content by conducting two AASHTO T 164 solvent extractions. Use the average of the two solvent extractions for mix design calculations. Submit all supporting information for the determination of the RAP asphalt content to the Engineer, including any correction factor used for solvent extraction.

    b. Obtain RAP aggregate sample by conducting AASHTO T 164 solvent extractions or AASHTO T 308 ignition furnace tests. Several tests may be required to obtain enough material for RAP aggregate testing.

    c. Determine the RAP aggregate properties including gradation according to ND T 30, fine aggregate angularity (FAA) according to ND T 304, and aggregate bulk specific gravity according to NDDOT 7.

        (1) When 15 percent or less RAP is used in the mix design, the combined values from the virgin coarse aggregate bulk specific gravity (G_{sb}) and the combined fine aggregate bulk specific gravity (G_{sb}) from the virgin aggregates will be used for the RAP G_{sb} portion of the final blend.

        (2) When more than 15 percent RAP is used in the mix design, determine the bulk specific gravity (G_{sb}) of the RAP aggregates.

    d. The RAP gradation, FAA and aggregate bulk specific gravity (G_{sb}) are used to determine the final aggregate blend.

    e. It is not required to test RAP for the properties in the NDDOT Standard Specifications Table 430-02.

    f. Submit a split sample of RAP material to the Engineer for verification of RAP properties. The Engineer will use AASHTO T 308 ignition furnace test on the RAP materials to produce aggregates for verification.

3. Determine an appropriate blend of aggregate sources to produce a proper gradation of mineral aggregates. The average gradation of each individual aggregate source and the average gradation of the RAP, when used, will be combined to form the aggregate blend. Adjust the aggregate blend to meet mixture parameters.

4. Plot the blend gradation on the 0.45 power chart using the procedure in MS-2. This chart graphically displays any trends of the actual gradation with respect to a maximum density line.

5. After at least 10,000 tons of virgin aggregate material is produced and uniform production of each aggregate component is assured, the Contractor shall produce a mix design.

E. MIX DESIGN

Preparing samples of mixture in the laboratory for mix design analysis requires batching the aggregates, mixing in the proper amount of binder, conditioning the prepared mixture, heating the mixture to compaction temperature, compacting the specimens, and testing the specimens to determine the mix design parameters.

1. Aggregate Preparation

   a. Dry each virgin aggregate sample to a constant weight at 230° F ± 9° F. Fractionate by dry sieving on the 3/8-inch sieve and the No. 4 sieve as follows:
      (1) + 3/8 inch
      (2) - 3/8 inch to + No. 4
      (3) - No. 4

   b. For gyratory specimens, weigh out the appropriate amounts of the required aggregate size fractions and combine in a bowl to the proper batch weight. Typically, a batch weight of 4500 - 4700 grams of aggregate will provide enough material for a finished specimen height of 115 ± 5 mm. Two gyratory specimens are required per asphalt cement (AC) content used for the mix design.

   c. For ND T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA), weigh out the appropriate amounts of the required aggregate size fractions and combine them in a bowl to the proper batch weight. Typically, a batch weight of 2000 - 2500 grams of aggregate will provide enough material for the ND T 209 test.

   d. Heat the aggregate samples in an oven at approximately 325° F. Virgin aggregate may be heated overnight or for a minimum of four hours.

2. Mixture Preparation

   a. Obtain the type and grade of asphalt to be used on the project from the asphalt Supplier. Obtain the specific gravity of the asphalt from the supplier to determine mix properties. If the project requires two different grades of AC,

use only one type for producing the mix design. Supply the same grade used for the mix design to the Engineer for verification testing.

b. Heat the asphalt cement according to the supplier's recommendation or 290 ± 10° F without exceeding a maximum heating time of 4 hours. Heat the asphalt only once.

c. Charge the mixing bowl with the heated aggregate for one sample and mix thoroughly. If the sample is slightly less than originally weighed, add a small amount of hot minus No. 4 natural fine material to bring the sample to the proper weight. Form a crater in the dry blended aggregate, place the mixing bowl on a scale, tare the scale and pour the asphalt cement into the crater until the required weight is obtained. Use a mechanical mixer to mix the aggregate and asphalt cement as quickly and thoroughly as possible to yield a mixture having a uniform distribution of asphalt throughout. Repeat this process for the various asphalt percentages.

d. If RAP is used, heat the RAP for a minimum of two hours and a maximum of four hours at 230 ± 5° F. After heating, add the RAP to the aggregate and binder mixture. Care must be taken to thoroughly mix all components.

e. After mixing, spread the loose mixture in a flat, shallow pan in a 1-to-2-inch layer and cover. Place each sample of mix into an oven set at the compaction temperature shown below (Table 1) for a two-hour curing period. After one hour, thoroughly mix each sample to maintain uniform conditioning, and continue the curing process. The two-hour cure is for lab mixed material only. Do not cure bituminous mixture samples that have been produced in a hot-mix plant.

3. Compaction of Specimens

a. A minimum of two gyratory specimens is required at four different asphalt contents for the mix design. Additional specimens at a fifth asphalt content may be needed to determine the optimum asphalt content. Choose the AC contents at 0.3 to 0.5 percentage points apart. Preheat the gyratory molds, base plates, and funnel in an oven set at a temperature of 290 ± 10° F.

b. Compaction temperature will vary based on the Performance Graded (PG) Asphalt Cement used (Table 1).

Table 1

Performance Graded AC	**Compaction Temperature** ° F
58S-28	270 ± 5° F
58S-34 and 58H-28	275 ± 5° F
58H-34 and 58V-28	280 ± 5° F
58V-34 and 58E-(28 or 34)	Manufacturer's Recommendation

c. Compact the specimens in a gyratory compactor according to AASHTO T 312 at the N_{design} gyration level shown in the contract documents.

d. After compaction, allow the specimens to cool in the mold for an amount of time to prevent damage. Remove the gyratory specimen from the mold with an extrusion jack. Place the specimens on a smooth, level surface and allow them to cool to room temperature. The use of a fan will facilitate the cooling process. Identify the specimen by number using a marker or crayon.

e. If the gyratory specimen is outside the height tolerance (115 ± 5 mm), adjust the batch weight accordingly for the next specimen.

f. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with ND T 166, Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens.

g. Conduct the theoretical maximum specific gravity test for each asphalt content used during the gyratory mix design in accordance with ND T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA).

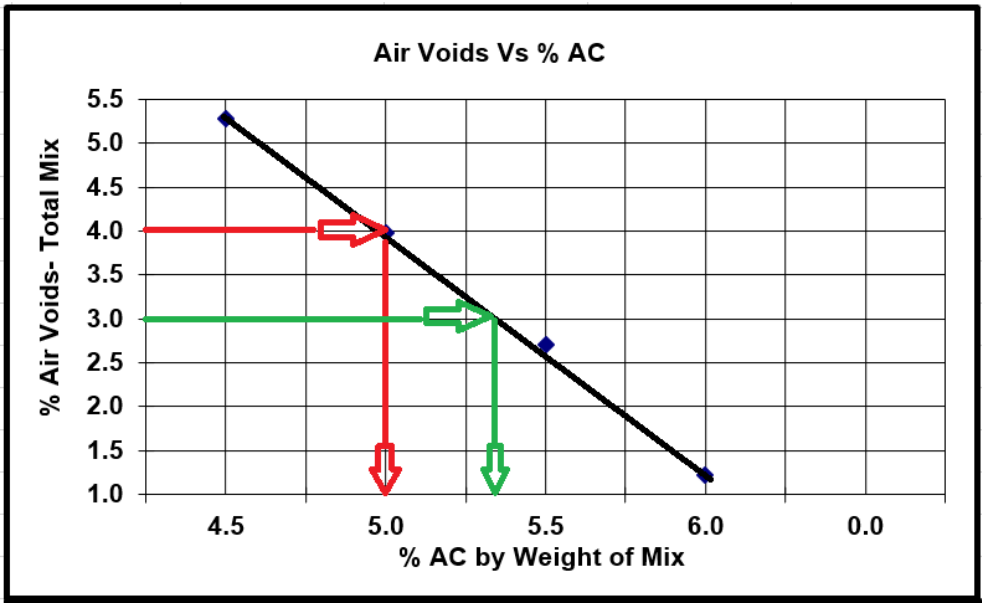
h. After all the required mix testing has been completed, plot the results for each of the four AC contents on a graph comparing the percentage air voids in the total mix to each percentage AC content point. Draw a best fit curve connecting all the points. Determine, from the graph, the point where the curve intersects at 4.0% air voids and read straight down to determine the optimum % AC content of the asphalt mixture.

    (1) Use the optimum % AC content determined at 4.0% air voids to calculate the remaining mixture properties from the graphs for: VFA vs % AC, Theoretical Maximum SpG vs % AC, % Gmm @ Ninitial vs % AC, VMA vs % AC, and Unit Weight vs. % AC. Record these properties on the mix design summary. These properties must meet the values specified in Table 430-03 and Table 430-05 in the Specs.

    (2) The specified air void target has changed from 4.0% to 3.0%. This target change will be accomplished by adding additional binder content to the mix.

    (3) From the Air Voids vs % AC graph, determine the optimum % AC at 3.0% air voids (See Example). Record this as your Optimum % AC on the summary.

Example:



From the Example graph:
AC Content at 4.0% Air Voids (red) = 5.0% (Used to determine mix properties)
AC Content at 3.0% Air Voids (green)= 5.3% (Optimum % AC for production)

i. Using the % AC at 4.0% Air Voids, batch enough mixture at the optimum % AC and compact to $N_{maximum}$ to determine % Gmm @ $N_{maximum}$. This value must meet the specified criteria in Table 430-05 of the Specs.

4. Reporting:

a. Use the NDDOT's Asphalt mix Design spreadsheet to report the mix design results located at www.dot.nd.gov/business/contractors.htm#resources. Submit the completed mix design, including all test data, to the Engineer.

b. The Contractors mix design will be approved when the verification testing correlates within the tolerances listed in the Standard Specifications and FSTM. If the mix design is not approved, the Contractor shall submit another mix design. An approved mix design is required prior to beginning production of hot mix asphalt.

5. Specific Gravity Definitions

Bulk Specific Gravity, G_{sb} is the volume measurement that includes the overall volume of the aggregate particle as well as the volume of the water permeable voids.

Effective Specific Gravity, G_{se}, includes all void spaces in the aggregate particles except those that absorb asphalt.

Apparent Specific Gravity, $G_{sa,}$ considers the volume as being the volume of the entire aggregate.

The G_{sb} should be lower than the G_{se} and the G_{se} should be lower than the G_{sa}.

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 for concrete aggregate material.

Deleterious material may be shale, hard iron oxide particles, lignite and other coal, soft particles, and thin or elongated pieces.

REFERENCED PROCEDURES

ND T 2 and AASHTO R 90, Sampling Aggregates
ND T 248 and AASHTO R 76, 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 or other heat source

TEST SPECIMEN

Obtain sample according to ND T 2. Split sample according to ND T 248. The

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. 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.

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:

$$A = (B/C) \times 100$$

A = Percent deleterious material
B = Combined handpicked portions
C = 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 FRACTUREDPARTICLES 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 considered an area that is at least 25% of the largest cross section of the particle and having a defined edge.

REFERENCED PROCEDURES

ND T 2 and AASHTO R 90, Sampling Aggregates
ND T 248 and AASHTO R 76, 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 or other heat source

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.

Sieve over a No. 4 sieve. Wash and dry according to ND T 255. 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 Faces = [WF + (WQ/2)] / WA x 100 WF

= Weight of fractured particles
WQ = Weight of questionable fractured particles
WA = Weight 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

SCOPE

Conduct this procedure according to NDDOT defined standards.

This procedure is used to obtain samples of hot mix asphalt from a windrow in front of the paver or from the mat behind the paver. The material is then used to run ND T 209 or ND T 312.

REFERENCED DOCUMENTS

ND T 209, Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt ND 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

Two methods are allowed for obtaining samples. From a windrow in front of the paver or from the mat behind the paver.

SAMPLE:

Sample size shall be large enough to conduct the required testing.

For the Contractor's Quality Control (QC) testing, the sample taken is split in half with the Engineer obtaining possession of one half of the sample.

For Quality Assurance (QA) and Independent Assurance (IA), a sample will be taken by the Contractor under the observation of the Engineer.

The Engineer will transport all QA and IA samples to the lab.

SAMPLING FROM A WINDROW:

Choose a location along the windrow that appears uniform and contains material from one transport truck. Avoid the beginning or the end of the windrow section.

A sample is a composite of three locations from the windrow.

Use a shovel to remove approximately one foot of material from the top of the windrow, discarding the material to either side. Take a sample from the flattened area of the windrow.

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 lab.

SAMPLING FROM THE MAT BEHIND THE PAVER:

Take enough material from the asphalt windrow in front of the paver to fill the space that will be created from obtaining a sample.

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 lab.

SPLITTING:

At the lab place the entire sample on a non-absorbent 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.

Use one quarter for ND T 209 and the opposite quarter for ND T 312. A second gyratory specimen can be made from the last remaining 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.

During mix production, one half of the aggregate and hot mix asphalt QC samples will be retained by the QA. These samples will be retained until QA testing confirms the validity of the QC testing.

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.

NDDOT 7
DETERMINATION OF RAP AGGREGATE BULK SPECIFIC GRAVITY (G_{sb})

A. GENERAL

This procedure is used to determine the bulk specific gravity (G_{sb}) of the aggregate in a recycled asphalt pavement (RAP) sample. After the asphalt content of the RAP is determined, either by chemical extraction or ignition oven tests, two "Rice" tests are performed to estimate an effective specific gravity (G_{se}) of the RAP. The G_{se} value is used to determine the G_{sb} of the RAP.

B. EQUIPMENT

All related equipment to perform ND T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures is required.

C. PROCEDURE

1. Reduce a large amount of RAP material to a minimum 2200-gram representative sample.

2. Before actual testing begins any moisture present within the RAP must be removed. Dry each test sample in an oven at 230 ±9° F until further drying does not alter the mass by more than 0.1%.

3. Transfer this entire sample into a large flat pan.

4. Break up the RAP sample similar to a standard Gmm sample.

5. Process the RAP sample until it is homogeneous. It's important that the clumps of fine aggregate are reduced to no larger than 3/4" in size.

6. Remix the RAP sample thoroughly to allow the old RAP binder to coat any uncoated aggregate particles.

7. Place the RAP sample in a mixing bowl and add new binder at a rate of 1-3 percent of the total sample weight. Mix the sample to ensure all particles are fully coated. The RAP and virgin AC should be heated at 230 ±9° F to ensure proper coating.

8. Once the sample reaches a homogeneous state, allow the sample to cool. As it cools continue the process of chopping and remixing. Prevent the RAP from hardening back into a solid mass. The idea is to bring the RAP to a loose condition.

9. Thoroughly blend the sample and split out a representative sample required for AASHTO T209 Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA) testing.

10. Perform AASHTO T209 to determine the RAP theoretical maximum density (G_{mm}) value of both flasks. The average value of the flasks will be used to calculate G_{se} of the RAP, if the individual results do not vary by more than 0.014. If the flasks do not meet the 0.014 tolerance, retest a new sample until the requirement is met.

D. CALCULATION

1. The $G_{mm\ (RAP)}$ is calculated by cancelling the added asphalt mass and volume from the original procedure.

$$Gmm\ (RAP) = \frac{A - J}{(A+D) - (E+K)}$$

A = Weight of sample in air, g.
D = Weight of container, solution and cover plate, g.
E = Weight of sample, container, solution and cover plate, g.
J = Weight of added AC, g.
K = Volume of added AC, cc or ml. $K = J / G_b$
G_b = Specific gravity of the AC added.

2. The average $G_{mm\ (RAP)}$ and percent AC values of the RAP are used to calculate the effective specific gravity $G_{se\ (RAP)}$. The specific gravity of the RAP value of 1.040 is used to account for RAP binder aging. The following equation is used:

$$Gse\ (RAP) = \frac{100 - \%\ AC\ (RAP)}{\frac{100}{Gmm(RAP)} - \frac{\%\ AC\ (RAP)}{1.040}}$$

3. The Gsb of the RAP is determined by the following equation.

$$Gsb\ (RAP) = \frac{Gse\ (RAP)}{\frac{Pba\ (RAP) \times Gse\ (RAP)}{100 \times 1.040} + 1}$$

$P_{ba\ (RAP)}$ = AC absorption of the RAP. Use historic data from past mix designs to determine a typical AC absorption rate.

ROUNDING PROCEDURES FOR DETERMINING SIGNIFICANT DIGITS

ROUNDING NUMBERS FOR DETERMINING SIGNIFICANT DIGITS

It is necessary to perform all mathematical calculations in the proper format. The industry references The American Society for Testing Materials (ASTM) Standard E-29, "Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications."

ROUNDING OFF RULES

A. When the figure next beyond the last place to be retained is less than 5, retain unchanged the figure in the last place retained.

Example: Round to the nearest tenth (0.1) 45.71 = 45.7
45.72 = 45.7
45.73 = 45.7
45.74 = 45.7

B. When the figure next beyond the last place to be retained is greater than 5, increase by 1 the figure in the last place retained.

Example: Round to the nearest tenth (0.1) 45.76 = 45.8
45.77 = 45.8
45.78 = 45.8
45.79 = 45.8

C. When the next figure beyond the last place to be retained is 5 and there are no figures beyond this 5, or only zeros, increase the figure to be retained by 1 if it is odd.

Example: Round to the nearest tenth (0.1) 45.7500 = 45.8

Leave the figure unchanged if it is even.

Example: Round to the nearest tenth (0.1) 45.4500 = 45.4

Increase the figure by 1 in the last place retained, if there are figures beyond this 5.

Example: Round to the nearest tenth (0.1) 45.45001 = 45.5 Round to the nearest tenth (0.1) 45.45105 = 45.5
Round to the nearest tenth (0.1) 45.45099 = 45.5

COMPUTER AND CALCULATOR ROUNDING (unofficial rounding)

Today's computers and calculators provide automatic rounding. However, in the case of part "C" above, they simply round up.

When using calculators, many people carry all of the decimals, beyond significant figures, when making several related computations. This is not the correct method to perform computations; however, it does save time. You may choose to carry the decimals through long computations. However, if the computation results in a value that is near a specification limit, the computation must be recalculated using the methods described below. The methods described below are the official round-off procedures of the NDDOT.

GENERAL PROCEDURES FOR ROUNDING

Primary calculations are carried out and rounded to one decimal place more than is needed in the final answers.

When adding:

Primary calculations are carried out - rounded to hundredths (0.01)

510.37 cu. yds.
270.12 cu. yds.
+121.89 cu. yds.
902.38 cu. yds. = Total cubic yards of riprap placed.
902.4 cu. yds. = Final answers are rounded to tenths (0.1).

When using a calculation where rounding cannot be set, expect some differences in the answers. Do not carry calculations to decimal places beyond those needed.

Calculating to tenths (0.1):

When tenths are required, primary calculations are carried out and rounded to hundredths (0.01). Final answers are rounded to tenths (0.1).

When multiplying:

Primary – Calculation A	Primary – Calculation B
25.52 x 13.14 = 335.3328	9.45 x 3.2 = 30.240
Rounded to: 335.33	Rounded to: 30.24

Final Calculation

335.33 X 30.24 = 10,140.3792
Rounded to: 10,140.4

Calculating to hundredths (0.01):

When hundredths are required, primary calculations are carried out and rounded to thousandths (0.001). Final answers are rounded to hundredths (0.01).

When dividing:

Primary – Calculation A

542.15 ÷ 28.47 =19.0428
Rounded to: 19.043

Primary – Calculation B

138.46 ÷ 12.12 = 11.4241
Rounded to: 11.424

Final Calculation

19.043 ÷ 11.424 = 1.667
Rounded to: 1.67

Calculating to thousandths (0.001):

When thousandths are required, primary calculations are carried out and rounded to ten thousandths (0.0001). Final answers are rounded to thousandths (0.001).

When adding:

Primary – Calculation A

4.46891
2.15672
1.12013
+ 0.01882
7.76458
Rounded to: 7.7646

Primary – Calculation B

3.97163
1.05872
2.18291
+ 1.50562
8.71888
Rounded to: 8.7189

Final Calculation

7.7646
+8.7189
16.4835
Rounded to: 16.484

Rounding final answers to whole units:

Always round the numbers you have to work with to one more decimal place than needed in the final answer. If the final answer is to be in tenths (0.1), round the numbers to hundredths (0.01). If the final answer is to be in hundredths (0.01), round the number

to thousandths (0.001). If the final answer is to be to the nearest whole number, round the numbers to tenths (0.1).

The following values will be added to find an answer to the nearest whole number:

460.57 cu. yds.	460.6 cu. yds.
571.59 cu. yds.	571.6 cu. yds.
+342.65 cu. yds.	+342.7 cu. yds.
1374.9 cu. yds.	1375 cu. yds.

Note how the numbers are rounded to tenths before they are added and how the final answer is rounded to a whole number.

One more rule: In calculations using Pi (3.1416), the first calculation is made without rounding. In other words, the number 3.1416 is not rounded, but the first calculation using 3.1416 is rounded.

TECHNICAL DESCRIPTION OF ROUND-OFF RULE

Discard the (k + 1)th and all subsequent decimals.

(a) If the number thus discarded is less than half a unit in the kth place, leave the kth decimal unchanged ("*rounding down*").

(b) If it is greater than half a unit in the kth place, add one to the kth decimal ("*rounding up*").

(c) If it is exactly half a unit, round off to the nearest even decimal (example: rounding off 3.45 and 3.55 to one decimal gives 3.4 and 3.6, respectively).

The last part of the rule is supposed to ensure that in discarding exactly half a decimal, rounding up and rounding down happens about equally often, on the average.

If we round off 1.2535 to 3, 2, 1 decimals, we get 1.254, 1.25, 1.3, but if 1.25 is rounded off to one decimal, without further information we get 1.2.

For further or additional determinations, refer to ASTM E-29, "Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications."

RANDOM SAMPLING AND TESTING

A random sample is a sample taken using a sampling plan in which each unit of a lot has an equal chance of being chosen. Random sampling is based on the use of a random number table to select items such as test sites, test samples, and times for selection of samples. The random number table provides how an item can be selected using the product of the random number and the dimension of the applicable item. The use of a calculator to generate random numbers is acceptable, but in the following examples the random number table will be used.

Example No. 1

Assume one day's production is a lot. The contractor begins work at 7:00 A.M. and works a 12-hour day. The sampling frequency is four samples selected at random times during the day.

Divide the 12-hour day into four equal sublots of three hours each. The following times result:

7:00 A.M.	-	10:00 A.M.
10:00 A.M.	-	1:00 P.M.
1:00 P.M.	-	4:00 P.M.
4:00 P.M.	-	7:00 P.M.

To determine the sampling times, arbitrarily select a group of digits on the random numbers table (located at the back of this appendix) by placing the point of a pencil on the page with eyes closed. In addition to the number under the pencil point, select three more numbers by going up or down, left or right, or diagonally. The pencil point landed on 0.18 in this example. Prior to the selection of the number it had been decided to go down the column. The three additional numbers are 0.90, 0.93, and 0.73 (Block "A"). Multiply each number by three hours (convert to 180 minutes) and add the result to the beginning time of each sublot to determine the sample times.

0.18 x 180 minutes =32 minutes
0.90 x 180 minutes = 162 minutes
0.93 x 180 minutes = 167 minutes
0.73 x 180 minutes = 131 minutes

Samples should be obtained at the following times:

32 minutes after 7:00 A.M. or **7:32 A.M**.
162 minutes after 10:00 A.M. or **12:42 P.M.**
167 minutes after 1:00 P.M. or **3:47 P.M.**
131 minutes after 4:00 P.M. or **6:11 P.M**.

Example No. 2

Under Section 430 of the Standard Specifications, the Contractor is to take two cores in each sublot for determining density. The cores are to be taken adjacent to each other and at a random location. A sublot is defined as one paver-width wide (excluding the shoulders), 2,000 ft long, and of the depth specified for the pavement course.

Sample numbers and sublot numbers are established for the full day's production. On SFN 10071, "Compaction Control," record the sample number and the beginning station of the lot. The beginning station of each sublot is 2,000 ft greater than the previous one. Compute the locations to be cored using random numbers to determine the station and offset from the edge of the pavement. Adjust core locations falling within one foot of the pavement edge or select a new random location within the test area.

Use the same procedure as in Example No. 1 to arbitrarily select the digits from the random number table. In this example only three numbers will be chosen (Block "B"). Assume the beginning station of the lot to be 105+00.

Sample No.		Station	
1	0.13 x 2000 = 260 ft	Sta. 105+00 + 260 =	Sta. 107+60
2	0.94 x 2000 = 1880 ft	Sta. 125+00 + 1880 =	Sta. 143+80
3	0.14 x 2000 = 280 ft	Sta. 145+00 + 280 =	Sta. 147+80

To select the transverse distance from the right edge of the roadway, three additional consecutive numbers are chosen following the procedure in Example No. 1. Each of the digits in Block "C" is multiplied by the lane width (12 ft).

Sample No.	Transverse Distance from Right Edge
1	0.68 x 12 = 8.2 ft
2	0.26 x 12 = 3.1 ft
3	0.85 x 12 = 10.2 ft

The calculations above result in the following sampling schedule for each sublot:

Sample No.	Sample Location
1	Sta. 107+60 - 8.2 ft from right edge of roadway
2	Sta. 143+80 - 3.1 ft from right edge of roadway
3	Sta. 147+80 - 10.2 ft from right edge of roadway

TABLE OF RANDOM NUMBERS WITH EXAMPLES

0.10	0.09	0.73	0.25	0.33	0.76	0.52	0.01	0.35	0.86	0.34	0.67	0.35	0.48	0.76	0.80	0.95	0.90	0.91	0.17
0.37	0.54	0.20	0.48	0.05	0.64	0.89	0.47	0.42	0.96	0.24	0.80	0.52	0.40	0.37	0.20	0.63	0.61	0.04	0.02
0.08	0.42	0.26	0.89	0.53	0.19	0.64	0.50	0.93	0.03	0.23	0.20	0.90	0.25	0.60	0.15	0.95	0.33	0.47	0.64
0.99	0.01	0.90	0.25	0.29	0.09	0.37	0.67	0.07	0.15	0.38	0.31	0.13	0.11	0.65	0.88	0.67	0.67	0.43	0.97
0.12	0.80	0.79	0.99	0.70	0.80	0.15	0.73	0.61	0.47	0.64	0.03	0.23	0.66	0.53	0.98	0.95	0.11	0.68	0.77
0.66	0.06	0.57	0.47	0.17	0.34	0.07	0.27	0.68	0.50	0.36	0.69	0.73	0.61	0.70	0.65	0.81	0.33	0.98	0.85
0.31	0.06	0.01	0.08	0.05	0.45	0.57	0.18	0.24	0.06	0.35	0.30	0.34	0.26	0.14	0.86	0.79	0.90	0.74	0.39
0.85	0.26	0.97	0.76	0.02	0.02	0.05	0.16	0.56	0.92	0.68	0.66	0.57	0.48	0.18	0.73	0.05	0.38	0.52	0.47
0.63	0.57	0.33	0.21	0.35	0.05	0.32	0.54	0.70	0.48	0.90	0.55	0.35	0.75	0.48	0.28	0.46	0.82	0.87	0.09
0.73	0.79	0.64	0.57	0.53	0.03	0.52	0.96	0.47	0.78	0.35	0.80	0.83	0.42	0.82	0.60	0.93	0.52	0.03	0.44
															A				
0.98	0.52	0.01	0.77	0.67	0.14	0.90	0.56	0.86	0.07	0.22	0.10	0.94	0.05	0.58	0.60	0.97	0.09	0.34	0.33
0.11	0.80	0.50	0.54	0.31	0.39	0.80	0.82	0.77	0.32	0.50	0.72	0.56	0.82	0.48	0.29	0.40	0.52	0.42	0.01
0.83	0.45	0.29	0.96	0.34	0.06	0.28	0.89	0.80	0.83	0.13	0.74	0.67	0.00	0.78	0.18	0.47	0.54	0.06	0.10
0.88	0.68	0.54	0.02	0.00	0.86	0.50	0.75	0.84	0.01	0.36	0.76	0.66	0.79	0.51	0.90	0.36	0.47	0.64	0.93
0.99	0.59	0.46	0.73	0.48	0.87	0.51	0.76	0.49	0.69	0.91	0.82	0.60	0.89	0.28	0.93	0.78	0.56	0.13	0.68
0.65	0.48	0.11	0.76	0.74	0.17	0.46	0.85	0.09	0.50	0.58	0.04	0.77	0.69	0.74	0.73	0.03	0.95	0.71	0.86
0.80	0.12	0.43	0.56	0.35	0.17	0.72	0.70	0.80	0.15	0.45	0.31	0.82	0.23	0.74	0.21	0.11	0.57	0.82	0.53
0.74	0.35	0.09	0.98	0.17	0.77	0.40	0.27	0.72	0.14	0.43	0.23	0.60	0.02	0.10	0.45	0.52	0.16	0.42	0.37
0.69	0.91	0.62	0.68	0.03	0.66	0.25	0.22	0.91	0.48	0.36	0.93	0.68	0.72	0.03	0.76	0.62	0.11	0.39	0.90
0.09	0.89	0.32	0.05	0.05	0.14	0.22	0.56	0.85	0.14	0.46	0.42	0.75	0.67	0.88	0.96	0.29	0.77	0.88	0.22
					C														
0.91	0.49	0.91	0.45	0.23	0.68	0.47	0.92	0.76	0.86	0.46	0.16	0.28	0.35	0.54	0.94	0.75	0.08	0.99	0.23
0.80	0.33	0.69	0.45	0.98	0.26	0.94	0.03	0.68	0.58	0.70	0.29	0.73	0.41	0.35	0.53	0.14	0.03	0.33	0.40
0.44	0.10	0.48	0.19	0.49	0.85	0.15	0.74	0.79	0.54	0.32	0.97	0.92	0.65	0.75	0.57	0.60	0.04	0.08	0.81
0.12	0.55	0.07	0.37	0.42	0.11	0.10	0.00	0.20	0.40	0.12	0.86	0.07	0.46	0.97	0.96	0.64	0.48	0.94	0.39
0.63	0.60	0.64	0.93	0.29	0.16	0.50	0.53	0.44	0.84	0.40	0.21	0.95	0.25	0.63	0.43	0.65	0.17	0.70	0.82
0.61	0.19	0.69	0.04	0.46	0.26	0.45	0.74	0.77	0.74	0.51	0.92	0.43	0.37	0.29	0.65	0.39	0.45	0.95	0.93
0.15	0.47	0.44	0.52	0.66	0.95	0.27	0.07	0.99	0.53	0.59	0.36	0.78	0.38	0.48	0.82	0.39	0.61	0.01	0.18
0.94	0.55	0.72	0.85	0.73	0.67	0.89	0.75	0.43	0.87	0.54	0.62	0.24	0.44	0.31	0.91	0.19	0.04	0.25	0.92
0.42	0.48	0.11	0.62	0.13	0.97	0.34	0.40	0.87	0.21	0.16	0.86	0.84	0.87	0.67	0.03	0.07	0.11	0.20	0.59
0.23	0.52	0.37	0.83	0.17	0.73	0.20	0.88	0.98	0.37	0.68	0.93	0.59	0.14	0.16	0.26	0.25	0.22	0.96	0.63
												B							
0.04	0.49	0.35	0.24	0.94	0.75	0.24	0.63	0.38	0.24	0.45	0.86	0.25	0.10	0.25	0.61	0.96	0.27	0.93	0.35
0.00	0.54	0.99	0.76	0.54	0.64	0.05	0.18	0.81	0.59	0.96	0.11	0.96	0.38	0.96	0.54	0.69	0.28	0.23	0.91
0.35	0.96	0.31	0.53	0.07	0.26	0.89	0.80	0.93	0.54	0.33	0.35	0.13	0.54	0.62	0.77	0.97	0.45	0.00	0.24
0.59	0.80	0.80	0.83	0.91	0.45	0.42	0.72	0.68	0.42	0.83	0.60	0.94	0.97	0.00	0.13	0.02	0.12	0.48	0.92
0.46	0.05	0.88	0.52	0.36	0.01	0.39	0.00	0.22	0.86	0.77	0.28	0.14	0.40	0.77	0.93	0.91	0.08	0.36	0.47
0.32	0.17	0.90	0.05	0.97	0.87	0.37	0.92	0.52	0.41	0.05	0.56	0.70	0.70	0.07	0.86	0.74	0.31	0.71	0.57
0.69	0.23	0.46	0.14	0.06	0.20	0.11	0.74	0.52	0.04	0.15	0.95	0.66	0.00	0.00	0.18	0.74	0.39	0.24	0.23
0.19	0.56	0.54	0.14	0.30	0.01	0.75	0.87	0.53	0.79	0.40	0.41	0.92	0.15	0.85	0.66	0.67	0.43	0.68	0.06
0.45	0.15	0.51	0.49	0.38	0.19	0.47	0.60	0.72	0.46	0.43	0.66	0.79	0.45	0.43	0.59	0.04	0.79	0.00	0.33
0.94	0.86	0.43	0.19	0.94	0.36	0.16	0.81	0.08	0.51	0.34	0.88	0.88	0.15	0.53	0.01	0.54	0.03	0.54	0.56
0.98	0.08	0.62	0.48	0.26	0.45	0.24	0.02	0.84	0.04	0.44	0.99	0.90	0.88	0.96	0.39	0.09	0.47	0.34	0.07
0.33	0.18	0.51	0.62	0.32	0.41	0.94	0.15	0.09	0.49	0.89	0.43	0.54	0.85	0.81	0.88	0.69	0.54	0.19	0.94
0.80	0.95	0.10	0.04	0.06	0.96	0.38	0.27	0.07	0.74	0.20	0.15	0.12	0.33	0.87	0.45	0.01	0.62	0.52	0.98
0.79	0.75	0.24	0.91	0.40	0.71	0.96	0.12	0.82	0.96	0.69	0.86	0.10	0.25	0.91	0.74	0.85	0.22	0.05	0.39
0.18	0.63	0.33	0.25	0.37	0.98	0.14	0.50	0.65	0.71	0.31	0.01	0.02	0.46	0.74	0.05	0.45	0.56	0.14	0.27
0.74	0.02	0.94	0.39	0.02	0.77	0.55	0.73	0.22	0.70	0.97	0.79	0.01	0.71	0.19	0.52	0.52	0.75	0.80	0.21
0.54	0.17	0.84	0.56	0.11	0.80	0.99	0.33	0.71	0.43	0.05	0.33	0.51	0.29	0.69	0.56	0.12	0.71	0.92	0.55
0.11	0.66	0.44	0.98	0.83	0.52	0.07	0.98	0.48	0.27	0.59	0.38	0.17	0.15	0.39	0.09	0.97	0.33	0.34	0.40
0.48	0.32	0.47	0.79	0.28	0.31	0.24	0.96	0.47	0.10	0.02	0.29	0.53	0.68	0.70	0.32	0.30	0.75	0.75	0.46
0.69	0.07	0.49	0.41	0.38	0.87	0.63	0.79	0.19	0.76	0.35	0.58	0.40	0.44	0.01	0.10	0.51	0.82	0.16	0.15

TABLE OF RANDOM NUMBERS CONT.

0.10	0.09	0.73	0.25	0.33	0.76	0.52	0.01	0.35	0.86	0.34	0.67	0.35	0.48	0.76	0.80	0.95	0.90	0.91	0.17
0.37	0.54	0.20	0.48	0.05	0.64	0.89	0.47	0.42	0.96	0.24	0.80	0.52	0.40	0.37	0.20	0.63	0.61	0.04	0.02
0.08	0.42	0.26	0.89	0.53	0.19	0.64	0.50	0.93	0.03	0.23	0.20	0.90	0.25	0.60	0.15	0.95	0.33	0.47	0.64
0.99	0.01	0.90	0.25	0.29	0.09	0.37	0.67	0.07	0.15	0.38	0.31	0.13	0.11	0.65	0.88	0.67	0.67	0.43	0.97
0.12	0.80	0.79	0.99	0.70	0.80	0.15	0.73	0.61	0.47	0.64	0.03	0.23	0.66	0.53	0.98	0.95	0.11	0.68	0.77
0.66	0.06	0.57	0.47	0.17	0.34	0.07	0.27	0.68	0.50	0.36	0.69	0.73	0.61	0.70	0.65	0.81	0.33	0.98	0.85
0.31	0.06	0.01	0.08	0.05	0.45	0.57	0.18	0.24	0.06	0.35	0.30	0.34	0.26	0.14	0.86	0.79	0.90	0.74	0.39
0.85	0.26	0.97	0.76	0.02	0.02	0.05	0.16	0.56	0.92	0.68	0.66	0.57	0.48	0.18	0.73	0.05	0.38	0.52	0.47
0.63	0.57	0.33	0.21	0.35	0.05	0.32	0.54	0.70	0.48	0.90	0.55	0.35	0.75	0.48	0.28	0.46	0.82	0.87	0.09
0.73	0.79	0.64	0.57	0.53	0.03	0.52	0.96	0.47	0.78	0.35	0.80	0.83	0.42	0.82	0.60	0.93	0.52	0.03	0.44
0.98	0.52	0.01	0.77	0.67	0.14	0.90	0.56	0.86	0.07	0.22	0.10	0.94	0.05	0.58	0.60	0.97	0.09	0.34	0.33
0.11	0.80	0.50	0.54	0.31	0.39	0.80	0.82	0.77	0.32	0.50	0.72	0.56	0.82	0.48	0.29	0.40	0.52	0.42	0.01
0.83	0.45	0.29	0.96	0.34	0.06	0.28	0.89	0.80	0.83	0.13	0.74	0.67	0.00	0.78	0.18	0.47	0.54	0.06	0.10
0.88	0.68	0.54	0.02	0.00	0.86	0.50	0.75	0.84	0.01	0.36	0.76	0.66	0.79	0.51	0.90	0.36	0.47	0.64	0.93
0.99	0.59	0.46	0.73	0.48	0.87	0.51	0.76	0.49	0.69	0.91	0.82	0.60	0.89	0.28	0.93	0.78	0.56	0.13	0.68
0.65	0.48	0.11	0.76	0.74	0.17	0.46	0.85	0.09	0.50	0.58	0.04	0.77	0.69	0.74	0.73	0.03	0.95	0.71	0.86
0.80	0.12	0.43	0.56	0.35	0.17	0.72	0.70	0.80	0.15	0.45	0.31	0.82	0.23	0.74	0.21	0.11	0.57	0.82	0.53
0.74	0.35	0.09	0.98	0.17	0.77	0.40	0.27	0.72	0.14	0.43	0.23	0.60	0.02	0.10	0.45	0.52	0.16	0.42	0.37
0.69	0.91	0.62	0.68	0.03	0.66	0.25	0.22	0.91	0.48	0.36	0.93	0.68	0.72	0.03	0.76	0.62	0.11	0.39	0.90
0.09	0.89	0.32	0.05	0.05	0.14	0.22	0.56	0.85	0.14	0.46	0.42	0.75	0.67	0.88	0.96	0.29	0.77	0.88	0.22
0.91	0.49	0.91	0.45	0.23	0.68	0.47	0.92	0.76	0.86	0.46	0.16	0.28	0.35	0.54	0.94	0.75	0.08	0.99	0.23
0.80	0.33	0.69	0.45	0.98	0.26	0.94	0.03	0.68	0.58	0.70	0.29	0.73	0.41	0.35	0.53	0.14	0.03	0.33	0.40
0.44	0.10	0.48	0.19	0.49	0.85	0.15	0.74	0.79	0.54	0.32	0.97	0.92	0.65	0.75	0.57	0.60	0.04	0.08	0.81
0.12	0.55	0.07	0.37	0.42	0.11	0.10	0.00	0.20	0.40	0.12	0.86	0.07	0.46	0.97	0.96	0.64	0.48	0.94	0.39
0.63	0.60	0.64	0.93	0.29	0.16	0.50	0.53	0.44	0.84	0.40	0.21	0.95	0.25	0.63	0.43	0.65	0.17	0.70	0.82
0.61	0.19	0.69	0.04	0.46	0.26	0.45	0.74	0.77	0.74	0.51	0.92	0.43	0.37	0.29	0.65	0.39	0.45	0.95	0.93
0.15	0.47	0.44	0.52	0.66	0.95	0.27	0.07	0.99	0.53	0.59	0.36	0.78	0.38	0.48	0.82	0.39	0.61	0.01	0.18
0.94	0.55	0.72	0.85	0.73	0.67	0.89	0.75	0.43	0.87	0.54	0.62	0.24	0.44	0.31	0.91	0.19	0.04	0.25	0.92
0.42	0.48	0.11	0.62	0.13	0.97	0.34	0.40	0.87	0.21	0.16	0.86	0.84	0.87	0.67	0.03	0.07	0.11	0.20	0.59
0.23	0.52	0.37	0.83	0.17	0.73	0.20	0.88	0.98	0.37	0.68	0.93	0.59	0.14	0.16	0.26	0.25	0.22	0.96	0.63
0.04	0.49	0.35	0.24	0.94	0.75	0.24	0.63	0.38	0.24	0.45	0.86	0.25	0.10	0.25	0.61	0.96	0.27	0.93	0.35
0.00	0.54	0.99	0.76	0.54	0.64	0.05	0.18	0.81	0.59	0.96	0.11	0.96	0.38	0.96	0.54	0.69	0.28	0.23	0.91
0.35	0.96	0.31	0.53	0.07	0.26	0.89	0.80	0.93	0.54	0.33	0.35	0.13	0.54	0.62	0.77	0.97	0.45	0.00	0.24
0.59	0.80	0.80	0.83	0.91	0.45	0.42	0.72	0.68	0.42	0.83	0.60	0.94	0.97	0.00	0.13	0.02	0.12	0.48	0.92
0.46	0.05	0.88	0.52	0.36	0.01	0.39	0.00	0.22	0.86	0.77	0.28	0.14	0.40	0.77	0.93	0.91	0.08	0.36	0.47
0.32	0.17	0.90	0.05	0.97	0.87	0.37	0.92	0.52	0.41	0.05	0.56	0.70	0.70	0.07	0.86	0.74	0.31	0.71	0.57
0.69	0.23	0.46	0.14	0.06	0.20	0.11	0.74	0.52	0.04	0.15	0.95	0.66	0.00	0.00	0.18	0.74	0.39	0.24	0.23
0.19	0.56	0.54	0.14	0.30	0.01	0.75	0.87	0.53	0.79	0.40	0.41	0.92	0.15	0.85	0.66	0.67	0.43	0.68	0.06
0.45	0.15	0.51	0.49	0.38	0.19	0.47	0.60	0.72	0.46	0.43	0.66	0.79	0.45	0.43	0.59	0.04	0.79	0.00	0.33
0.94	0.86	0.43	0.19	0.94	0.36	0.16	0.81	0.08	0.51	0.34	0.88	0.88	0.15	0.53	0.01	0.54	0.03	0.54	0.56
0.98	0.08	0.62	0.48	0.26	0.45	0.24	0.02	0.84	0.04	0.44	0.99	0.90	0.88	0.96	0.39	0.09	0.47	0.34	0.07
0.33	0.18	0.51	0.62	0.32	0.41	0.94	0.15	0.09	0.49	0.89	0.43	0.54	0.85	0.81	0.88	0.69	0.54	0.19	0.94
0.80	0.95	0.10	0.04	0.06	0.96	0.38	0.27	0.07	0.74	0.20	0.15	0.12	0.33	0.87	0.45	0.01	0.62	0.52	0.98
0.79	0.75	0.24	0.91	0.40	0.71	0.96	0.12	0.82	0.96	0.69	0.86	0.10	0.25	0.91	0.74	0.85	0.22	0.05	0.39
0.18	0.63	0.33	0.25	0.37	0.98	0.14	0.50	0.65	0.71	0.31	0.01	0.02	0.46	0.74	0.05	0.45	0.56	0.14	0.27
0.74	0.02	0.94	0.39	0.02	0.77	0.55	0.73	0.22	0.70	0.97	0.79	0.01	0.71	0.19	0.52	0.52	0.75	0.80	0.21
0.54	0.17	0.84	0.56	0.11	0.80	0.99	0.33	0.71	0.43	0.05	0.33	0.51	0.29	0.69	0.56	0.12	0.71	0.92	0.55
0.11	0.66	0.44	0.98	0.83	0.52	0.07	0.98	0.48	0.27	0.59	0.38	0.17	0.15	0.39	0.09	0.97	0.33	0.34	0.40
0.48	0.32	0.47	0.79	0.28	0.31	0.24	0.96	0.47	0.10	0.02	0.29	0.53	0.68	0.70	0.32	0.30	0.75	0.75	0.46
0.69	0.07	0.49	0.41	0.38	0.87	0.63	0.79	0.19	0.76	0.35	0.58	0.40	0.44	0.01	0.10	0.51	0.82	0.16	0.15

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