SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS MANUAL

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION

MATERIAL MANUAL

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SD DEPARTMENT OF TRANSPORTATION

Department of Transportation
Division of Planning / Engineering
Office of Materials and Surfacing
700 E. Broadway Avenue
Pierre, SD 57501-2586
O: 605.773.3403 | F: 605.773.5867
dot.sd.gov

MEMORANDUM

TO: All SD Dept. of Transportation Materials Manual Holders

FROM: Office of Materials and Surfacing

DATE: August 14, 2024

SUBJECT: Materials Manual Revisions dated September 1, 2024

Enclosed you will find a copy of the Revisions for your respective Manual along with a "Manual Accountability Form" which must be completed and returned in accordance with the instructions provided thereon. If this form is not completed and submitted to the South Dakota Department of Transportation, it will be assumed the recipient of this mailing is no longer interested in receiving updates or is no longer the manual holder. These manual holders will be removed from our mailing list and will not receive future updates and revisions.

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Also enclosed is a tabulation of the changes to be made in the Manual. Remove and replace contents of your Manual in accordance with the instructions provided in the tabulation.

The subject revisions will apply to all projects let September 1, 2024, and thereafter. Projects currently under contract will need to fulfill the MSTR requirements which were in place when the project was let as identified on the DOT-14. It will be permissible to utilize these revised testing procedures and associated forms in Sections 100 to 500 of the Manual on projects let prior to the revisions as long as it does not adversely affect the contractor's ability to fulfill the contract requirements.

Sincerely,

Tanner G. Fitzke
Chief Materials & Surfacing Engineer

Kelly Hudecek
Program Administrator

CC: File

Enclosures

U.S. Department
of Transportation
**Federal Highway
Administration**

South Dakota Division
116 East Dakota Avenue, Suite A
Pierre, SD 57501-3110
Phone: 605-776-1007
Fax: 605-224-8307

In Reply Refer to:
HAD-SD
(File)

Mr. Tanner Fitzke
Chief Materials & Surfacing Engineer
South Dakota Department of Transportation
Division of Planning/Engineering
Office of Materials and Surfacing
700 E. Broadway Avenue
Pierre, South Dakota 57501

Subject: 2024 SDDOT Materials Manual Revisions Approval

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Dear Mr. Fitzke:

In accordance with Title 23, Part 637 of the Code of Federal Regulations, the 2024 revisions to the South Dakota Department of Transportation's Materials Manual that were transmitted to me via Mr. Ben Brown's June 28, 2024 email are hereby approved by the Federal Highway Administration.

Sincerely,

Kirk Van Roekel, PE
Engineering and Operations Supervisor
FHWA - SD Division Office

SD DEPARTMENT OF TRANSPORTATION

Department of Transportation
Division of Planning / Engineering
Office of Materials and Surfacing
700 E. Broadway Avenue
Pierre, SD 57501-2586
O: 605.773.3403 | F: 605.773.5867
dot.sd.gov

June 28, 2024

Kirk Van Roekel
Division Administrator
Federal Highway Administration – SD Division
116 E. Dakota Avenue
Pierre, SD 57501-3110

Dear Kirk:

Enclosed for your review and approval are the proposed revisions to the Department's Materials Manual for this year.

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The submittal includes a significant volume of paper but for the benefit of your review and ease of our user's to be able to discern where changes were made, we have provided a vertical line followed by "24" in the right margin of each sheet where a change was made. Please review the contents of the submittal and advise accordingly on approval status.

Your prompt review and response would be greatly appreciated, and if you have any questions or comments in regard to this submittal, please feel free to contact our office.

Sincerely,

Tanner G. Fitzke
Chief Materials & Surfacing Engineer Enclosures

CC: Joel Jundt
Craig Smith
Kelly Hudecek
Region Material Engineers

2024 - SOUTH DAKOTA MATERIALS MANUAL ACCOUNTABILITY FORM – 2024

MATERIALS MANUAL **NUMBER (*)** ____________________

( ) has been revised in accordance with the instructions provided.

( ) has not been revised, because:

NOTE: In an effort to cut down on costs and unnecessary mailing of Materials Manual updates and revisions, it has been decided that if this form is not completed and submitted to the South Dakota Department of Transportation, it will be assumed the recipient of this mailing is no longer interested in receiving updates or is no longer the manual holder. Therefore, the recipient will be removed from our mailing list, and will no longer receive future updates and revisions.

____
Name of Company

____
Holder Name **(please print)**

____
Holder Signature

____
Title

If you are no longer in possession of this Manual, check and/or complete below:

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( ) it has been lost or destroyed,

( ) it has been transferred to: ____________________________________
Name **(please print)**

____
Address **(please print)**

Remarks: ____

____

DOT Field Personnel: Please complete this form and return it to your respective Region Materials Engineer **by <u>December 1, 2024.</u>**

All Other Manual Holders: Please complete this form and return it to Kelly Hudecek at the address shown below **by <u>December 1, 2024.</u>**

NOTE: If this document is not completed and returned, it will be assumed that you no longer have this manual and/or do not wish to receive future revisions.

Materials Manual updates and revisions can be found at the following website:
http://www.sddot.com/business/certification/forms/Default.aspx

Kelly Hudecek
South Dakota Department of Transportation
Office of Materials and Surfacing
700 East Broadway Avenue
Pierre, SD 57501

*** (This number is used by DOT Field Offices <u>ONLY</u> and is assigned by the Reg. Matl's. Engr.)**

The South Dakota Department of Transportation gives public notice of its policy to uphold and assure full compliance with the non-discrimination requirements of Title VI of the Civil Rights Act of 1964 and related Nondiscrimination authorities. Title VI and related Nondiscrimination authorities stipulate that no person in the United States of America shall on the grounds of race, color, national origin, religion, sex, age, disability, income level or Limited English Proficiency be excluded from the participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving Federal financial assistance.

Any person who has questions concerning this policy or wishes to file a discrimination complaint should contact the Department's Civil Rights Office at 605-773-3540.

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Materials Manual, Sampling, and Testing Procedures

Preface

PURPOSE:

This Materials Manual has been prepared for the purpose of standardizing the Department's sampling and testing procedures and to provide assurance that the materials and workmanship incorporated in each construction project are in reasonably close conformity with the requirements of the plans and specifications.

The Chief Materials and Surfacing Engineer will be responsible for final interpretation of the contents of this manual and will be consulted if clarification is necessary. 24

The following sampling and testing procedures are used by the Department.

1. Tests that follow the national standard without modification.
2. Tests which have been modified by the Department laboratory which contain portions of a national standard.
3. Tests developed by the Department Laboratory without reference to a national standard.

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The use & distribution of Materials & Surfacing Forms list, along with the most recent forms being used, is kept electronically by the office of Materials & Surfacing. The Approved Products List & certified plants list are maintained on the internet. A list for various approved concrete mix designs is kept electronically by the office of Materials & Surfacing. The mix design approved for a specific project is also kept in the project files. The asphalt mix designs are kept by the Bituminous Mix Design Office and in the project file. All of these lists are updated as changes occur.

LABORATORY INSPECTING PROGRAM:

The Department participates in a regular laboratory inspection and comparative sample testing program with the AMRL and CCRL.

Annual inspections and a comparative sample testing program has been established by the Central Laboratory with the Region Materials Laboratories.

A continuous inspection and comparative sample testing program is maintained between the Region Materials and the Area Engineer's project laboratories.

SAMPLING AND TESTING PROGRAM:

Minimum Sample and Test Requirements:

1. The schedules represent the minimum requirements for sampling and testing for each project. Good engineering practice may necessitate more frequent testing to assure adequate control. For example:
    (a) At the beginning of a project.
    (b) When a low volume of work is performed over a long period of time.
    (c) Whenever borderline or questionable material is encountered.
2. When project quantities are too small to justify sampling and testing costs, or when small quantities of material used will not have a significant influence on performance, strength or durability of major items on construction, or when large quantities of material of known satisfactory history are used, a request may be made to the Chief Materials and Surfacing Engineer, through the Region Materials Engineer, for permission to reduce or eliminate the Minimum Sample and Test Requirements (MSTR).

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3. The sample and test requirements are stated in quantitative units and shall be considered to be followed by the words "Or a portion thereof".
4. Acceptance of some small quantities of miscellaneous materials may be made based on the manufacturer's material certification or by visual inspection as outlined in the schedule of Minimum Sample and Test Requirements (MSTR) or as directed by the Chief Materials and Surfacing Engineer.

LOCATION FOR OBTAINING SAMPLES AND TESTS:

Samples and tests for acceptance and independent assurance (IA) shall be taken from the completed work, if practicable; or from the point nearest the finished product, prior to or following blending, that representative specimens of the specified material can be obtained or as stated on the plans. 24

The use of the random numbers table shall be used, where applicable, for any random sampling and testing.

TERMINOLOGY AND ABBREVIATIONS:

Whenever the following abbreviations are used, they are to be construed the same as the respective expressions.

π = 3.1416
AASHTO = American Association of State Highway and Transportation Officials
APL = Approved Products List
ASTM = American Society for Testing and Materials
AWPA = American Wood Preserver's Association
°C = Degrees Celsius
CCGP = Calcium Carbide Gas Pressure
CCRL = Cement and Concrete Reference Laboratory
cm = Centimeter
CM&P = Construction, Measurement, & Payment system (Software)
cu.ft. = Cubic Foot
cu.yd. = Cubic Yard
cwt. = Hundred Weight
Dia. = Diameter
DTI = Direct Tension Indicator
DOT-# = South Dakota Department of Transportation form number
°F = Degrees Fahrenheit
F&E = Flat & Elongated
FAA = Fine Aggregate Angularity
FHWA = Federal Highway Administration
ft^2 = Square Foot
ft^3 = Cubic Foot
F.M. = Fineness Modulus
g = Gram
Gmb = Bulk Specific Gravity
Gmm = Theoretical Maximum Specific Gravity
Gsb = - #4 Bulk Specific Gravity
Gse = Effective Specific Gravity of the Mineral Aggregate
Hg = Measurement on a vacuum of residual pressure in mercury
IA = Independent Assurance
IPCEA = Insulated Power Cable Engineers Association
JMF = Job Mix Formula
k = Kilo
kg = Kilogram
kg/m^2 = Kilogram Per Square Meter
kg/m^3 = Kilogram Per Cubic Meter
km = Kilometer
kPa = Kilopascals
L = Liter
lbs. = Pounds
$lbs./ft^2$ = Pounds Per Square Foot
lbs./ft3 = Pounds Per Cubic Foot
Lin. = Lineal
L.L. = Liquid Limit
m = Meter
m2 = Square Meter

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m3 = Cubic Meter
Max. = Maximum
mL = Milliliter
mm = Millimeter
MPa = Megapascals
MS&T = Materials, Sampling, & Testing system (software)
MSTR = Minimum Sample & Test Requirements
mton = Metric Ton
NEMA = National Electrical Manufacturers Association
NLT = Not Less Than
# / No. = Number
N.P. = Non-Plastic
oz. = Ounces
Pa = Pascals
Pba = Percent Asphalt Absorption
Pbe = Percent Effecting Asphalt Content
PCC = Portland Cement Concrete
PCF = Pounds Per Cubic Foot
pH = The hydrogen ion concentration expressed in units
P.I. = Plasticity Index
P.L. = Plastic Limit
ppm = Parts Per Million
psi = Pounds Per Square Inch
RAP = Recycled Asphalt Pavement
QA = Quality Assurance
QC = Quality Control
qt. = Quart
RPM = Revolutions Per Minute
RSTC = Required Samples, Tests, & Certificates
SDDOT = South Dakota Dept. of Transportation
SD # = South Dakota test number
UL = Underwriters Laboratory
Us = Uncompacted Voids
Va = Percent Air Voids
WAP = Water Asphalt Preferential
Wt. (wt.) = Weight
yd = Yard
yd2 = Square yard
yd3 = Cubic yard

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Materials and Surfacing - Organization and Functions

Materials and Surfacing.

Supervised by: Chief Materials and Surfacing Engineer

Organization:
1. Materials
2. Pavement Design
3. Surfacing Plans
4. Concrete
5. Bituminous
6. Geotechnical
7. Region Materials

Functions of the Chief Materials and Surfacing Engineer:

Coordinates materials engineering as it relates to location, identity, mapping, options, blends, tests, specifications, construction, maintenance and structural design of pavement types.

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Establishes major policy and assignment of areas of responsibility.

Receives and monitors requests for purchase of testing equipment.

Ensures the preparation of a materials certification based on sampling, testing and certification performed in connection with each project for submittal to the FHWA and the Director of Operations.

1. Materials.

Supervised by: Materials Engineer

Functions of the Materials Engineer:

Supervises the Department of Transportation building testing laboratories dealing with bituminous, concrete, aggregate, chemistry, nuclear gauges, and maintains AASHTO Laboratory Accreditation.

Provides technical assistance for solution of field problems involving materials or surfacing design.

Responsible for the purchase, assignment, repair and annual calibration of nuclear gauges.

Responsible for conducting periodic inspection and acceptance testing at wood treatment plants, evaluating traffic paints by placing of annual field test sections and conducting other special acceptance tests, such as coating thickness, in the field.

A small volume of testing is performed for other governmental organizations and, when commercial facilities are not available, for individuals. Reimbursement at the DOT's approved rates is received for outside testing work performed.

2. Pavement Design.

Supervised by: Chief Materials and Surfacing Engineer

Functions of the Pavement Design Engineer:

Provides alternate structural designs for pavement selection.

After pavement selection, with the cooperation of Region Materials, Bituminous and Concrete Engineers, analyzes assembled data and develops recommendations for typical sections, type and thickness of pavement layers, material blends and sources and other factors affecting design and construction of the pavement.

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Provides design and bituminous recommendations for overlay projects.

Makes recommendations for preparation of specifications for equipment, methods, aggregates, and materials used for construction.

Provides technical assistance for solution of field problems involving materials, subdrainage, or surfacing design.

Makes recommendations to the designer regarding aggregate blends, asphalt type, content, application rates, and other items related to asphalt construction.

3. Surfacing Plans.

Supervised by: Surfacing Plans Engineer

Functions of the Surfacing Plans Engineer:

Responsible for preparing surfacing plans and reviewing the surfacing portion of plans prepared by others.

Provides support for work involving the preparation of surfacing plans in the Region and by others.

Obtains technical data from the Geotechnical Engineer to assure adequate support for areas needing special treatment.

4. Concrete.

Supervised by: Materials Engineer

Functions of the Concrete Engineer:

Develops Portland cement concrete (PCC) design mixes for pavement and structures and GPR (Ground Penetrating Radar) testing for steel placement in PCC. 24

Provides technical assistance for field personnel to assist in plant calibration, solving construction problems, and interpretation of specifications, policies, and construction procedures.

Performs smoothness verification testing for Portland cement concrete (PCC) paving.

Makes recommendations for preparation of specifications for equipment, methods, aggregates, and materials used in concrete construction.

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Makes annual inspections of the Region Materials Laboratories, checking their test equipment by calibration and comparative testing to establish uniformity and accuracy.

Determines the need for and assists in development of training in the areas of concrete construction.

Tests concrete pipe for acceptance.

Obtains core samples from completed Portland cement and asphalt concrete pavements for evaluation of pavement thickness.

5. Bituminous.

Supervised by: Materials Engineer

Functions of the Bituminous Engineer:

Provides mix designs for asphalt concrete to determine asphalt content for the specific mineral aggregate furnished for each project.

Provides technical assistance to field personnel on asphalt construction projects to assist in solving construction problems and clarifying specifications, policies, and construction procedures.

Performs smoothness acceptance testing on asphalt concrete construction.

Researches and evaluates existing structural surfaces and related asphalt materials.

Determines the need and assists in the development of training in areas of asphalt construction.

Responsible for the acceptance testing of all asphalt cement and liquid asphalt used in construction and maintenance statewide.

6. Geotechnical:

Supervised by: Geotechnical Engineer

Functions of the Geotechnical Engineer:

Responsibilities include preliminary engineering on bridge and roadway alignments primarily, but project responsibilities also follow through construction and maintenance.

Provides engineering data including geotechnical design parameters for fill and structure foundations, stability of rock and soil slopes, geologic studies, and the effective use of naturally occurring materials.

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Activities include investigative borings, collecting undisturbed field samples, installing, monitoring and reading geotechnical instrumentation.

Conducts preliminary investigations of soils proposed for use on construction projects.

Analyzes the accumulated data and makes recommendations relating to soil selection, construction control limits of moisture and density, grade height and needed subdrainage facilities.

Obtains geophysical data and analyses samples with emphasis on soil strength determination.

Combines field, laboratory and historic data with graphic subsurface profile to make recommendations for the designer.

Coordinates project operations through the office that is responsible for the project, i.e., Bridge Engineer, Operations Engineer, State Engineer, etc.

Working with the Region Materials Engineers, the Geotechnical Engineer is responsible for locating, securing options and haul agreements for borrow sources.

Make recommendations for bridge end backfill and undercut on structure projects.

7. Region Materials.

Supervised by: Region Materials Engineer

Functions of the Region Materials Engineer:

Responsibilities on preliminary engineering work include scouting, locating, optioning, mapping, sampling, recording, and submitting samples and data for materials needed for construction projects.

With Region Engineer's approval, makes material recommendations to the Materials Engineer in Pierre. Advises project technicians in the use of correct sampling and testing procedures in accordance with the South Dakota Materials Manual, AASHTO, and ASTM.

Promotes and maintains accuracy and uniformity of sampling and testing by project personnel through a program of field laboratory and equipment inspection and a continuous comparative sampling and testing program.

Insures that minimum requirements for independent assurance sampling and testing are met and that the comparisons with acceptance tests results are promptly made, documented and reported.

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The Region Materials personnel shall not give oral or written orders to the Contractor, subcontractors or their employees.

South Dakota Department of Transportation

Required Samples, Tests, and Certificates (RSTC)

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Required Samples, Tests, and Certificates (RSTC)

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1. Introduction:

Each certificate received, sample taken, or test made shall be recorded, managed, and used as described. Sampling and testing will be in accordance with the South Dakota Materials Manual, the South Dakota Materials Testing & Inspection Certification Program Manual, AASHTO, ASTM, or as directed by the Chief Materials and Surfacing Engineer.

Only new or clean containers (Bags, bottles, cans, etc.) will be used for obtaining and transporting sample specimens. Each container shall be examined, to determine that it is clean and free from contamination. Sample containers are available through the Region Materials Office.

2. Location and Frequency:

The location and frequency at which samples are taken and tests made will be in accordance with MSTR.

Contracts that include more than one project will be considered one project for calculating the minimum number of samples and tests required.

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3. Sample Size:

Each sample will be large enough to provide a minimum of two specimens for testing, or as directed by the applicable testing procedure. Standby specimens are to be tested immediately, in event of accidental loss, or known or suspected error in the first analysis. All tests must be reported, with explanations, when standby specimens are tested. Standby specimens will not be tested solely to confirm results of tests.

4. Identification:

Every sample or test for each kind of material or construction shall be numbered consecutively, starting with the number one, for each project. Contracts, which include more than one project, shall be considered one project for the purposes of numbering the samples and tests.

Results of tests on samples, representing material used on two or more contracts, shall be reported for each contract to ensure the maintenance of proper individual project files.

Preparation of sample data information – The Sample Data Sheet (DOT-1) shall be complete and accompany each sample submitted to a laboratory not located on the project. When a sample is tested in the laboratory located on the project, the sample information may be recorded on the test worksheet or report.

Data required on a Sample Data Sheet (DOT-1):

Submitted by: The name, title, and office of the individual submitting the sample.

Send results to: The name, title, and office to whom the results should be sent.

Contractor and subcontractor: Show the prime Contractor (And subcontractor when it applies to a subcontractor).

Project: Show the project number as it appears on the plans or proposal.

PCN: Show the PCN number as it appears on the plans or proposal.

County: Show all counties that the project is in, as shown on the plans or proposal.

Charge To: Self-explanatory.

This is a _____ sample: Identify the type of sample e.g., acceptance, IA, quality, mix design, information, etc.

Field number: Show the sample number as in Section 4.

Date sampled: The date the sample was taken.

This sample represents: Quantity represented in feet, cubic yards, gallons, tons, cars, sacks, cwt., miles, Sta. ________ to Sta. ________, lift, ticket number, and sufficient other information to describe the exact unit and location of material represented by the sample.

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For material placed, identify the lift, its thickness, and the total thickness. Identify the last (top) lift as “final lift”. For example, if total thickness is 12 in. placed in 3 in. lifts, indicate them as 1st: 3/12; 2nd: 6/12; 3rd: 9/12; and “final lift”: 12/12.

Type of material: Kind of material and intended use.

For material shipped in: Self-explanatory.

For local material: Self-explanatory.

Shipping ticket #: Self-explanatory.

Truck or car #: Self-explanatory.

Unloaded at: Self-explanatory.

Use the space at the bottom and the back of the form for additional data, instructions, or remarks.

List special tests required.

Request the return for project use of items or materials (Hardware, cast iron or steel, paint submitted in large containers, posts, etc.) submitted to laboratories for sampling or non-destructive tests.

Record the percentages of each component when samples of blended materials are submitted.

Sample Data Envelope (DOT-2) – The data envelope will be completed by the individual sampling or submitting the material for test. Place DOT-1 into the DOT-2 envelope and securely fasten to sample. 24

Miscellaneous – When practical, an identification card, note, or slip should be placed inside the sample bag or container. This eliminates the possibility of voiding the test due to conflicting or lost data sheets or envelopes.

4.1 Acceptance Samples and Tests.

A. Use numbers only, e.g., 01, 02, 03, etc. as opposed to letters of the alphabet as sample or test identification numbers. The numbers 1 thru 9 will be 01, 02, 03, etc. Sample numbers 10 thru 99 will not be preceded by a "0". This scenario will always be true for all materials or test types unless it is anticipated before a project begins that there will be more than 100 certificates, samples or tests for a particular material. If that is the case, test numbers 1 thru 9 will be preceded by two 00's e.g.; 001, 002, 003, etc. Test numbers 10 thru 99 will be preceded by one 0 e.g.; 010, 011, 012, etc. samples and tests from 100 to 999 will not be preceded by a 0.

The prefix "E", "P", "PP", "B", “U”, “BEE” or “EM” should be used to distinguish between embankment, pipe, pre-installation pipe, berm, undercut densities, bridge end embankment and embankment moisture.

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B. A set of 4 concrete cylinders are required as per the minimum requirements for concrete. The cylinders will be numbered 05, 05A, 05B and 05C. Cylinder 05 shall always be used for the 28 day break, 05A as the 28 day break (Back-up), 05B and 05C shall be used for early breaks. It is recommended that the early breaks be tested at 7 and 14 days respectively. These numbers shall be provided on one end of the cylinder in accordance with the example provided in SD 405.

The data provided on the DOT-23 for cylinder sets for concrete will provide all data necessary to make proper identification of the section represented. In addition to the routine information (Test #., station, date made, etc.), the data must also include detailed information for the structure such as the section of the box culvert which are numbered 1, 2, 3, 4, 5, etc. from left to right on the box when viewing the structure in the direction of ascending project stationing or one of the bridge components as provided below:

<u>Box Culverts</u>
B.S. = Bottom slab
BBL. = Side walls and top slab
W.W. = Wing wall
Apron = Apron
C/W = Cut off wall
T.S. = Top slab, if poured separate from the sides.
S.W. = Side walls, if poured separate from the top slab.

<u>Bridges</u>
Bent #3 Ftg.
Bent #8 Cap.
Abutment #1
Bridge deck
Barrier curb (Lt., Rt.)

C. Concrete test cylinders shall be numbered consecutively for each class of concrete. Class A45 paving shall be numbered separately from other Class A45 concrete.

D. The quantity represented shall be determined and noted on the test report.

4.2 Quality Control and Quality Assurance.

For quality control, use the prefix "QC", e.g., QC01, QC02, QC03, etc.

For quality assurance use the prefix "QA" and the related QC test, e.g. QA01/QC01, QA02/QC06, QA03/QC14, etc.

For independent assurance, use the prefix "IA" and the related QA and QC test numbers, e.g. IA01/QA01/QC01, IA02/QA03/QC14, etc.

For non-pay factor material, use the prefix "N", e.g. NQC01, NQC02, etc. or NQA01/ NQC01, NQA02/ NQC06, etc.

For test strip the prefix “TS”, e.g. TS01, TS02, TS03, etc.

For correlation of the plant, use prefix “COR”, e.g., COR01, COR02, etc. These are informational tests for correlation of the plant.

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4.3 Corrective Action Samples and Tests.

Corrective action samples and tests shall carry the same number as the failing test with the suffix “X”. For example, embankment E03 fails, the Contractor is immediately notified, and the corrective action completed.

The test of the corrected material or construction would be identified as E03X. If the corrective action had not produced specification compliance, e.g., E03X failed, the sample or test taken to confirm the effectiveness of the additional or new corrective effort would be identified E03XX, etc. Satisfactory results obtained on an “X” sample or test indicates that the corrective action has been successful, the material or construction has been brought into compliance, and sampling and testing can continue, using the next consecutively numbered samples, e.g., E04, E05, etc.

4.4 Process Correction Samples and Tests.

Process correction samples and tests shall carry the same number as the failing test with the suffix “PC”. For example, Class S Asphalt Concrete Aggregate Composite test 05 fails, the Contractor is immediately notified, and the plant is shut down.

The test of the corrected material would be identified as 05PC. If the process adjustment does not produce specification compliance, e.g., 05PC fails, the sample or test taken to confirm the effectiveness of the additional adjustment to the process would be identified as 05PCC, etc. After satisfactory test results are obtained, the plant shall restart, and sampling and testing would continue, using the next consecutively numbered samples, e.g., 06, 07, etc.

4.5 Failing Acceptance Samples and Tests.

Use the number as identified by the acceptance sample.

4.6 Independent Assurance Sample and Tests.

Use prefix “IA" and related test number and the related acceptance test number, e.g., IA01/01, IA02/05, IA03/10, etc.

4.7 Remedial Action Samples and Tests.

Use the suffix “R” and related test number of sample. For example, IA test number IA04/22 is outside the tolerances outlined in Section 5, remedial action test IA04R/22R is made to confirm remedial action to be successful. If remedial action is unsuccessful additional remedial action tests IA04RR/22RR, etc. will be made.

4.8 Quality Sample and Tests.

Use prefix “Q", e.g., Q01, Q02, Q03, etc.

4.9 Information Samples and Tests.

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Use prefix “Info”, e.g., Info 01, Info 02, Info 03, etc. unless otherwise noted.

4.10 Mix Design Samples and Tests.

Use prefix “MD”, e.g., MD 01, MD 02, MD 03, etc.

4.11 Certificates.

Use numerical sequence for each type of material certified, e.g., 01, 02, 03, etc.

4.12 Certified Suppliers.

Any method approved by the Certification Office that will ensure identification.

4.13 Approved Products List.

Any method approved by the Certification Office that will ensure identification.
The Approved Products List can be found at the SDDOT website.

4.14 Umbrella Certificates.

The “Certificate Group ID” number generated by the Materials Sampling and Testing (MS&T) system, or any method that will ensure identification.

4.15 Sample and Tests for other Agencies (Outside Testing).

Any method that will ensure identification.

4.16 Standby Samples.

Standby samples shall carry the number of the sample followed by an “A” or “B”. When it is necessary to test a standby specimen, the test will carry the same number followed by an “A” or “B”.

Where the Certificate of Compliance bears the number, the samples taken shall be numbered A and B. Example: Asphalt cement, the certificate is considered to be 1, the samples taken will be 01A and 01B.

5. Operational Procedures:

5.1 Acceptance Samples and Tests.

Scope.

This procedure outlines the requirements for acceptance sampling and testing by personnel under supervision of the Area Engineer to align such control to comply with FHWA requirements.

Definition.

Acceptance samples and tests include the samples and tests used for determining the acceptability of the materials and workmanship which have been or are being incorporated in the project. They are the principal basis for determining the acceptability of the projects' materials and construction.

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Operational Procedure.

Acceptance sampling and testing at the construction site will normally be performed by qualified technicians from the Area Engineer's crew and under his direction in laboratory facilities provided for that purpose. Special tests required for acceptance or samples requiring special equipment not available on the project shall be submitted to the Region or Central Testing Laboratories.

When deemed necessary by the Region Engineer to expedite the testing program or assure dependable acceptance test results, he will direct the Region Materials Engineer to assign qualified technicians to the Area Engineer to make such tests. The Area Engineer will direct the activities of the assigned personnel. They will not be allowed to take IA samples or tests on that project material. Upon request by the Area Engineer, the Central Testing Laboratory will make tests on acceptance samples.

Sampling and testing should be supplemented by sufficient visual inspection of the materials as a whole, to ascertain whether the samples and tests are reasonably representative of the entire mass. In addition, there should be sufficient observation of the construction operations and processes to determine whether they can be expected to consistently produce uniform, satisfactory results.

The number of acceptance samples and the distribution of the locations from which they are to be taken are intended to be such as to adequately assure or verify that the materials incorporated and the construction produced are acceptable in accordance with the plans and specifications including approved changes.

The sampling and testing must be such that a decision regarding acceptance of materials and workmanship can generally be made as construction progresses.

Acceptance samples shall be:

A. Taken and tested at the construction site by project, Region, or Central Testing Laboratory personnel who are not associated with the taking of IA samples for that material and project.

B. Obtained at a production or processing plant, or other source away from the project and tested in the Region or Central Testing Laboratory. Even though previously sampled at some other point by project personnel, a reasonable number of acceptance samples for aggregates are to be taken at either:

   (1) The point they are to be incorporated in the work.

   (2) The point they are to be mixed with other materials.

C. Samples of manufactured products that are not easily contaminated or otherwise not normally susceptible to changes in characteristics that are tested by the manufacturer.

   For these products:

   (1) Numerical test results or certificates as to conformity with specification requirements are to be sent to the Area Engineer's Office when shipment is made.

   This consideration shall be immediately revoked if such certification is found to be unreliable.

   (2) Occasional sampling and testing shall be done by representatives of the State to provide assurance of the reliability of the results obtained by the manufacturer or supplier.

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D. Previously accepted materials transferred from another project, when accompanied with a Letter of Transfer (DOT-70), may be accepted on the previous basis for acceptance.

E. When an acceptance test fails, and the process continues without shutting down (e.g., slump, entrained air tests) an acceptance test shall be performed immediately after the contractor has had the opportunity to correct the subsequent material.

   Samples taken and tested to confirm specification compliance of materials tested after a failing test <u>while production continues</u> are acceptance samples as they represent material produced and placed on the project; therefore, they shall be numbered as the next consecutive acceptance sample.

F. Density test: When a dry density results in a value of 105% or greater of the maximum dry density, the Engineer will perform an additional density test as close as practical to the original location. If this additional density test also results in a value greater than 105% of the maximum dry density, the Engineer will contact the Region Materials Engineer to investigate the compaction methods and testing equipment to determine the cause of the suspect result. 24

5.2 Quality Control and Quality Assurance.

Definition.

Quality Control and Quality Assurance samples and tests are used in association with Asphalt Concrete – Class Q.

Operational Procedure.

The contractor or his representative shall perform all quality control "QC" tests. A representative of the Area Office shall perform the quality assurance "QA" tests. Prior to production the QC and the QA testers shall perform, correlation tests as a method of assuring equipment and personnel are performing tests in accordance with the Materials Manual.

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Production testing procedures shall be as specified in Section 322 of the Standard Specifications.

5.3 Corrective Action Samples and Tests.

Definition.

Corrective action samples and tests are used to determine the effectiveness of any action implemented to remedy a specification deficiency detected or confirmed by a failing acceptance test.

The corrective action test represents the same lot of material or unit of work as the failing acceptance test. The corrective action test becomes the acceptance test after the entire lot or unit has been satisfactorily corrected.

Operational Procedure.

When an acceptance test fails and appropriate action is taken to correct the entire lot represented by the test, a corrective action test shall be performed to check the validity of the corrective action taken. This test shall be taken from the same location or in such a manner that it represents the same lot as the acceptance test. If the corrective action test confirms the non-specification condition has been corrected, this test becomes the basis of acceptance for the material or construction involved.

If the corrective action test determines the non-specification condition still exists, further corrective action and tests will be required until the condition has been satisfactorily corrected. Details of each corrective action shall be noted on the worksheet or report for the appropriate corrective action test.

5.4 Process Correction Samples and Tests.

Definition.

Process Correction Samples and Tests represent the effectiveness of action taken to correct a process. The material represented by the failing acceptance test has generally been mixed with other materials such as lime, asphalt, or Portland cement and placed on the project; therefore, it is impossible to correct the in-place material.

Operational Procedure.

When an acceptance test fails, and the process is shut down, the contractor shall perform a correction to the process. A process correction test shall be performed to determine effectiveness of the action taken. Before the process is allowed to continue, a passing process correction test must be performed. This process correction test does not represent any material and shall be recorded as a process correction test.

An acceptance test shall be taken shortly after the process resumes.

5.5 Failing Acceptance Samples and Tests.

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Definition.

A failing acceptance sample or test is a test that is outside specifications.

Operational Procedure.

The following procedure is to be used when the work or material incorporated into the project does not meet specifications, corrective action is not feasible and the Area Engineer has determined that the work or material can remain in place.

A. The Area Engineer will prepare a DOT-18 form setting forth the details of the non-specification work or materials including quantity, location, and an explanation of action taken as a result of the specification deviation. The Area Engineer will submit the DOT-18 form to the Region Engineer. Copies of test results or test numbers and a full explanation of the situation will accompany the DOT-18.

   Samples for acceptance tests will represent a quantity of material determined as follows: One-half of material produced from the time the previous sample was taken until the current sample is obtained plus one-half of the material produced between the time of sampling the current sample and the time the next sample is taken, except as noted below.

   (1) The first sample will represent material produced from the start of production, ahead to midpoint of when the next sample is taken.

   (2) The final sample will represent material produced back to midpoint with the previous sample and ahead to the end of production.

(3) A failing sample will represent material produced back to the midpoint with the previous sample and ahead to when production is stopped and process correction measure taken; or production continues and corrective measure is taken.

(4) The second and subsequent, consecutive, failing tests represent all material produced from the previous process correction or corrective measure ahead to when production is again stopped and/or corrective measure is taken.

(5) The next passing sample after a failure will represent material produced after production stopped and process correction measure taken; or production continues and corrective measure is taken ahead to midpoint of when the next sample is taken.

The testing frequency is irrespective of the quantity represented. A failing sample may represent more material than testing frequency.

There are exceptions to this guidance. If a test is missed, the test results from a test adjacent to a missed test cannot represent more than the minimum testing frequency. Manufactured materials represented by batch, lot, etc., will represent the entire batch, lot, etc.

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B. The Region Office will determine the price adjustment for the non-specification material that has been allowed to remain in place and attach the letter to the DOT-18. The price adjustment letter will be submitted to the Contractor by the Region Office. Price adjustment will be administered according to the “Price Adjustment Guidelines” and/or other relative information and/or personal contacts with individuals who are resource experts.

Asphalt Test Reproducibility Tolerances

Test results which fall outside the specification limits for a particular test, but within the test reproducibility tolerance as set forth below, will be acceptable.

Cut-Back Asphalt

Test	Tolerance*
Flash Point	
Tag Open Cup (Ave. of three test)	4°F
Cleveland Open Cup	15°F
Viscosity	
Kinematic, 140°F (To 3000 CS)	1.5%
Kinematic, 140°F (Above 3000 CS)	4.5%
Saybolt-Furol	4.55
Distillation	
Distillate % by vol. (Up to 347°)	1.8% pts.
Distillate % by vol. (Above 347°)	1.0% pt.
Residue % by vol	1.0% pt.

Test on Residue	
Penetration	8.0%
Solubility in CH_3 CCl_3	0.13% pt.

Emulsified Asphalt

Test	Tolerance*
Distillation	
Residue % by vol	1.0% pt.
Test on Residue	
Penetration (100 or more)	15 pen. pts.
Penetration (Less than 100)	8 pen. pts.

Asphalt Cement

Test	Tolerance*
Penetration	
Penetration, 77ºF (Less than 50)	2 pen. pts.
Penetration, 77ºF (50 or above)	4%
Flash Point	
Cleveland Open Cup	15ºF
Pensky-Marten's Closed Cup (Below 220ºF)	3°F
Pensky-Marten's Closed Cup (Above 220ºF)	13°F
Viscosity	
Kinematic, 275ºF	4.4%
Absolute, 140ºF	5.0%
Solubility in CH_3 CCl_3	0.13 pts.
Thin-film Test	
Loss on heating	20%
% of Original	4% pts.

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*When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage of the upper or lower specification limit, whichever is applicable.

5.6 Independent Assurance Sample and Tests.

Definition.

Independent Assurance (IA) activities are an unbiased and independent evaluation of sampling and testing procedures used in the acceptance program. Sampling and testing will be performed by qualified personnel. They do not provide test results for acceptance.

Operational Procedure.

Independent Assurance sampling and testing, or other procedures will be performed by qualified sampling and testing personnel as per the requirements of the South Dakota Department of Transportation Materials Testing & Inspection Certification Program Manual. Independent Assurance sampling and testing must be performed by personnel other than those performing the acceptance testing. They must be performed by Region Materials or Central Testing Laboratory personnel.

All equipment will meet the requirements of the South Dakota Department of Transportation Materials Testing & Inspection Certification Program Manual. The testing of IA samples must be performed with equipment other than that used for testing acceptance samples. Separate equipment will not be required when both acceptance and IA samples of the same material are tested in the Central Testing Laboratory.

A small portion (not more than 10%) of samples obtained and tests performed in the field may be accomplished by observation if approved by the Region Materials Engineer and the sampling and testing is closely observed and found to be in accordance with specified procedures.

It will be the responsibility of the Region Materials Engineer to document a comparison between the results of each IA test and acceptance test by using the following table:

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Acceptable Tolerances for Comparison of IA Test Results (**not** including QC/QA Asphalt Concrete and IA).

Sieves	
80 to 100% passing	± 5
50 to 79% passing	± 4
30 to 49% passing	± 3
10 to 29% passing	± 2
0 to 9% passing	± 1
Liquid Limit and Plastic Index	
L.L. 30 or Over	± 3
L.L. 18 to 29	± 2
L.L. below 18	± 3
P.I. 11 to 20	± 3
P.I. 5 to 10	± 2
P.I. 0 to 4	± 1

The tolerances shown above will apply only when there is a specification on them.

Flakiness Index	± 5
Flat & elongated particles	± 2
Fine aggregate angularity	± 1.0
Light weight particles if spec max is ≤ 1.0	± 0.5
Light weight particles if spec max is > 1.0	± 1.0
Sand Equivalent	± 7
Crushed particles	± 10
Air voids in asphalt concrete	± 1.2
Bulk specific gravity	± .020
Maximum specific gravity (Rice)	± .020
Unit weight of concrete	± 2.0 lbs./cu.ft.
Air content in fresh concrete	± 0.3
Slump Flow	± 1 in.
Temperature in fresh concrete	± 2°
In-place density, wet density	± 3.0 lbs.
Standard density, wet density	± 3.0 lbs.

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In-place density, moisture content	± 2
1-Point Curve Plot	2 curves (Ohio) above or below

When the results of 2 tests being compared fall into different tolerance groups, apply the group which permits the largest tolerance.

Example:

Acceptance test results: 47% Passing #4 Sieve
(Acceptable tolerance: Plus or Minus 3 – 30 to 49% Passing)

IA test results: 51% Passing #4 Sieve
(Acceptable tolerance: Plus or minus 4 – 50 to 79% Passing)

The tolerance to be applied will be plus or minus 4.

<u>Acceptable Tolerances for Comparison of Class Q Asphalt Concrete between QC, QA and IA</u>

Sieve 3/8 inch and larger	± 5
Sieve #4 thru #50	± 3
Sieve #100 thru #200	± 1.5
Lightweight Particles	± 1.0
Sand Equivalent	± 7
Crushed Particles	± 10
Fine Aggregate Angularity	± 1.0
Air Voids	± 1.2
Bulk Specific Gravity of Asphalt Concrete (Gyratory) @ N_{design}	± 0.020
Mixture Densification @ N_{design}	± 1.2
Maximum Specific Gravity (Rice)	± 0.020
Bulk Specific Gravity of In Place Density Cores	± 0.020

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The Region Materials Engineer will:

(1) When there are no, or only minor discrepancies, between the results of the two tests, note that fact on the report.

(2) When the comparison indicates major or repeated differences, document on the report the type or the amount of each significant variation and the proposed remedial action.

(3) Immediately following the remedial action, test to determine if the cause for variation found in the test results has been corrected. The remedial action IA (“R”) test report will contain a brief summary of the problem's detection and correction.

5.7 Remedial Action Samples and Tests

Definition.

Remedial action is to determine the effectiveness of action employed to establish satisfactory alignment of the acceptance testing and IA testing. Remedial action may consist of, but is not limited to:

A. Mechanical adjustment, calibration, repair, or replacement of equipment.

B. Changes in, review, or revisions of sampling or testing procedures.

Operational Procedure.

The IA testing organization making the remedial action test shall document on the report (DOT-17):

A. The problem requiring remedial action.

B. Remedial action taken.

5.8 Quality Samples and Tests.

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Definition.

Quality tests are performed on aggregate samples and include L.A. abrasion, soundness, clay lumps, shrinkage, organic impurities, and color. Quality tests are generally performed on samples representing the material proposed for use, or samples from a material's production site prior to its use.

Operational Procedure.
It shall be the responsibility of the Area Engineer to ensure that the file for each project under his supervision contains the results of Quality tests required by the specifications. The record may consist of:

A. The Central Testing Laboratory report of quality tests on mix design, acceptance, or IA samples.

B. Copies of the results of quality tests performed on the material being used, that may be filed elsewhere, e.g., filed in the Region Materials or the Central Testing Laboratory.

C. Copies of results of tests performed on the source of material being used, which has been sampled, tested, and reported for another project.

(1) When copies of test results are used, care shall be exercised to secure compliance with requirements of the specifications and this manual. Clearly state cross references so determination of the origin is absolute.

D. The Region Materials Engineer shall:

(1) Provide the Area Engineer, upon request, copies of results of preliminary quality tests previously made on material to be used in construction. This information in the project file enables the Area Engineer to make an early appraisal of the degree of surveillance necessary for proper job control.

(2) Make a periodic routine inquiry or examination to determine the existence in the project file of current required quality test reports or copies of results.

5.9 Information Samples and Tests.

<u>Definition</u>.

Information samples and tests are taken to evaluate, identify, investigate, and determine the acceptability of new products or material sources for potential future use. Information samples for a particular project may also be used to determine the results of a test segment or to determine additional data; e.g., only percentage passing a specific individual sieve or a particular characteristic, such as soundness, wear, etc., to provide data to establish a production or construction guide or find the percent air and slump of fresh concrete when a truck arrives. The MSTR does not apply and a DOT-18 will not be required.

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<u>Operational Procedure</u>.
When an information sample or test is submitted to the Region Materials or Central Labs, the Sample Data Sheet (DOT-1) or new product evaluation request shall be completed for and submitted with each sample or test. When using the DOT-1 state the purpose of the sample or test clearly as remarks on the Sample Data Sheet; e.g., “Info #3, for P.I. only”. Information test results for a particular project shall be reported and retained for additional project documentation.

5.10 Mix Design Samples and Tests.

<u>Definition</u>.
Mix design samples and tests are made on material produced and intended for use in combinations that are established by the Central Testing Laboratory. Mix production shall not be permitted until the design mix is obtained. Samples must be submitted to the Central Testing Laboratory in advance so tests and designs can be completed without delay to production or construction.

<u>Operational Procedure</u>.

To determine sampling and testing requirements for asphalt, lime, or Portland cement concrete materials for a mix design, consult the MSTR relating to the appropriate material or construction or contact the Region Materials Engineer.

The Sample Data Sheet and shipping envelope shall indicate what admixtures are to be used, if any, and material or project features that might be unusual.

5.11 Samples and Tests for other Agencies (Outside Testing).

The policy for performing sampling, testing, or related engineering work for outside agencies is as follows:

A. The outside agency shall submit a written request explaining the nature, extent, and required completion dates of the work along with the address or addresses to which test results and billing of the work are to be sent.

B. This written request shall be submitted to the Region Engineer when the requested work is to be performed by Region personnel. The Region Office shall forward the request to the Chief Materials and Surfacing Engineer along with a statement as to capability to do the work without interfering with the normal work schedule or Engineers in private practice, locally established, to do the type of work requested.

C. The written request shall be submitted directly to the Chief Materials and Surfacing Engineer when the requested work is to be performed by Central Testing Laboratory personnel.

D. The Chief Materials and Surfacing Engineer or the Region Engineer, upon receipt of the request, shall review the circumstances and advise the requesting agency in writing of the decision reached. Copies will be sent to the Region, Region Materials, and Area Engineers when they are involved in the requested work. Copies will be sent to the appropriate Central Office personnel when the requested work is to be performed by Central Testing Laboratory personnel.

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E. The written approval for the work, from the Chief Materials and Surfacing Engineer, shall include the accounts receivable number to which costs will be charged. A copy of the written approval shall be forwarded to Transportation Finance.

Requests may be made and approved by telephone provided written confirmation follows. Outside agencies will not be granted open authorization for a specific period of time but will be given approval on a job basis.

6. Certification Process:

6.1 Tier.

Certain materials used in highway construction present higher risks if failure occurs, depending on how they are made. The Department, therefore, has ranked the materials listed in the MSTR based on how they are used in the project. The resulting “Tiering” structure categorizes the materials from critical to non-critical. Definitions of the tiers are as follows:

Tier 1: A material that is critical to safety or costly to replace is considered extremely crucial to the overall success of the project. The Department classifies these crucial materials as “Tier 1” materials. The Department will only allow the Contractor to install a “Tier 1” material on the project when the Contractor satisfies both of the following conditions:

1. The Contractor furnishes the documents specified under the heading “Certification” in the MSTR of the Materials Manual.

2. The Certification Engineer approves that the certified material conforms to the specifications.

The Department will make payment according to the specifications for a “Tier 1” material only after the Contractor installs the approved material.

Tier 2: The Department will only allow the Contractor to install a “Tier 2” material on the project when the Contractor satisfies either of the following conditions:

1. The Contractor furnishes the documents specified under the heading “Certification” in the MSTR of the Materials Manual, or

2. The Contractor uses a material listed on the Approved Products List or furnished by a certified supplier.

The Department will make payment according to the specifications for a “Tier 2” material only after the Contractor installs the material.

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Tier 3: The Department classifies a “Tier 3” material as those materials that require no documentation under the heading “Certification” in the MSTR of the Materials Manual. The Contractor may install a “Tier 3” material on the project at any time.

The Department will make payment according to the specifications for a Tier 3 material only after the Contractor installs the material.

6.2 Certification.

Definition.

Certification is the process by which a Contractor (Umbrella Certificate only), manufacturer, or supplier certifies or guarantees that certain products, materials, or items conform to the specifications. Certification may eliminate the need for acceptance testing although the Department reserves the right to sample, test, and make final acceptance of materials after delivery to the project. The Department accepts the following certifications:

A. Certificates.

B. Certified Suppliers.

C. Items on the Approved Products List.

D. Umbrella Certificates.

The types of acceptable certifications are further discussed in this section.

The Contractor shall provide the appropriate form of certification, as required by the MSTR.

Operational Procedure.

Certification may be in the form of a report of test results or a statement of specification compliance for a material. It shall be signed by an authorized representative of the company.

Each type of certification must show the designation of each product for which the material is intended; the specific identification for each item, such as a batch, truck, car, heat, or lot number; and adequate reference to exactly determine the item and quantity represented.

Certifications may be submitted separately, or the information may be stamped or printed on shipping orders or included as part of the standard Bill of Lading.

Each certification shall be checked as received to determine that it contains the required information relative to the specifications and supporting data, and that it applies to the material supplied to the project. If the certification meets the requirements, and visual inspection of the material or product indicates conformity, it shall be dated and submitted to the Certification Engineer.

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Certifications received by the Area Engineer directly from the manufacturer, fabricator, or supplier shall be placed in the project file. A copy shall be forwarded without delay to the Certification Engineer and reviewed, approved or rejected. When the letter of transmittal containing the assigned certification, number is received by the Area Engineer, it should be treated the same as a numbered test report. The project file should contain a record of certifications received from the supplier and their approval or rejection by the Certification Engineer.

When certifications are submitted directly to the Certification Engineer by the manufacturer, fabricator, or supplier, the original certification shall be forwarded to the Area Engineer to be placed in the project file. Notice of approval or rejection will accompany the original copy.

6.3 Certificates.

Written documentation stating that the specified material is in conformity with the pertinent specification requirements of the contract.

Materials delivered without the required certificates shall not be used pending receipt of certification or satisfactory test results.

Certificates may come in different forms. Acceptable forms that may be submitted include the following:

A. Certificate of Compliance / Manufacturer’s Certificate – A signed document from a manufacturer or supplier certifying that materials indicated on the document are in compliance with the contract and specifications.

B. Certified Test Report – A signed test report from a mill or plant that certifies that materials were tested in accordance with a specific industry standard or test method. The report shall indicate the procedures followed and results obtained.

C. Certified Statement – Department furnished forms (DOT-57, DOT-77, and DOT-97) required by the MSTR. The supplier/producer shall complete the form, sign it, and return it to the Inspector.

At a minimum, certificates shall include the information specified in paragraph 6.2, operational procedures and/or in paragraph "6.6, Definition".

6.4 Certified Supplier.

<u>Definition</u>.

A certified supplier is a fabricator, mill, or plant that does not have to furnish certificates for individual heat numbers, loads, lots, or shipments to the project.
To become a certified supplier, a fabricator, mill, or plant must submit a statement to the Chief Materials and Surfacing Engineer, certifying that the material produced and supplied to all projects will conform to the specifications. This statement must be submitted at least once a year, prior to the first shipment to a project. It is understood that materials furnished by a certified supplier may be subject to testing at any time.

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<u>Operational Procedure</u>.

A list of the fabricators, mills or plants which have been certified by the Chief Materials and Surfacing Engineer shall be compiled, maintained and distributed by the Certification Engineer for use by the Area Engineer. The list may be distributed with, or as part of the Approved Products List. The certified status for the supplier will be effective through December 31st of the year in which it is issued, unless revoked earlier. It may be reinstated as directed by the Chief Materials and Surfacing Engineer.

A. Certified Producer of Cement.

(1) A statement signed by an authorized representative of the company, that the cement supplied to all projects will meet the specifications, with a request to be certified, will be submitted to the Chief Materials and Surfacing Engineer.

(2) To be certified, the cement plant shall meet the requirements of SD 416.

B. Certified Fabricator of Reinforcing Steel.

(1) A statement signed by an authorized representative of the company, that steel supplied to projects will meet specifications, shall be submitted to the Chief Materials and Surfacing Engineer. Certified copies of mill test results, representing the fabricator's steel stock on

hand, shall be available in his file for review by the Chief Materials and Surfacing representative.

(2) The certified fabricator's steel stock shall be randomly sampled by a representative of the Department of Transportation. The sample shall be obtained from steel represented by heat numbers or lots received since the previous sample was taken. The sample shall be submitted to the Central Testing Laboratory.

(a) When tests confirm non-specification material or product, the certified fabricator shall be notified of the deviation and may be removed from the certified list until the deviation and cause have been corrected to the satisfaction of the Chief Materials and Surfacing Engineer.

(b) Reinforcing steel supplied by a certified fabricator, which has not been subject to sampling at the Fabricator's plant, such as epoxy coated steel shipped directly to the project from the manufacturer and coater, shall be considered as supplied by a non-certified plant.

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(3) A certified fabricator shall forward to the Engineer for each shipment to the project, a record of the reinforcing steel lengths, shapes, and sizes. The information may be submitted as a copy of the bar list, shipping or packing list, or Bill of Lading.

(4) A non-certified fabricator is required to forward to the Engineer, for each shipment of reinforcing steel to the project, a certified copy of the mill test report of chemical analysis and physical properties for each heat or lot number.
Deliveries to the project shall be identified by heat number and checked in the field against heat numbers appearing on certified analysis. Bars having heat numbers not covered by certified analysis shall not be placed in the work until certification is obtained.

C. Certified Lime Plant (Mill).

(1) A statement signed by an authorized representative of the lime plant (Mill), that hydrated lime supplied to projects will meet specifications, along with the certified analysis most recently made in the plant's laboratory, shall be submitted to the Chief Materials and Surfacing Engineer with the request to be certified.

(2) During production, the certified plant shall provide the Central Testing Laboratory, weekly certified analysis of its product, reporting the following:

(a) Percent calcium and magnesium oxide.

(b) Percent free water or mechanical moisture.

(c) Accumulative percentage, by weight, of residue retained on the #6, #20, and #100 sieves.

(3) A sample shall be obtained at the plant on a random schedule, during production, by a representative of the Department of Transportation. The sample, with copies of results of tests made by the plant since the Department of Transportation's last sampling, shall be submitted to the Central Testing Laboratories.

(4) The Central Testing Laboratory report shall include, as remarks, comparison of its test results with those of the plant for corresponding material.

When tests confirm non-specification material or product, the certified plant shall be notified of the deviation and may be removed from the certified list until the deviation and cause have been corrected.

6.5 Items on the Approved Products List.

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Definition.
The Approved Products List is a record prepared, revised, maintained, and distributed by the Central Testing Laboratory. Items or brand name products qualified for the list are those which have developed and maintained a history of satisfactory results from acceptance tests and plant inspections and tests, or for which the Department has verified specification compliance and field performance. Certificates of Compliance will not be required for named products from the Approved Products List, unless otherwise specified.

A. The list, by brand name, may contain such items as: Accelerators, air entraining agents, castings, concrete pipe (Release dates), epoxies, liquid membrane cures, paint, retarders, water reducing agents, metal products, wood products, etc.

B. This method provides several items that the Contractor may order without a delay in testing.

C. Items on the Approved Products List shall be tested in accordance with MSTR.

D. The Area Engineer should contact the Region Materials Engineer or the Certification Engineer if there are questions about the Approved Products List.

E. When inspections or tests reveal failing material or products, the producer will be notified by the Chief Materials and Surfacing Engineer of the deviations. Failure to take satisfactory corrective action within a specified time limit will result in suspension and removal from the Approved Products List.

6.6 Umbrella Certificates.

Definition.

A single written document stating that the materials listed or the identified component materials of a system or assembly, including miscellaneous items, are in conformity with the pertinent specification requirements of the contract.

The certificate includes an entry for the following:

A. Project number
B. County.
C. PCN number.
D. Location.
E. Contractor - Name and address.
F. Subcontractor - Name and address. (If applicable)
G. Component description.
H. Certifying manufacturer of each component.
I. Heat or lot number. (As applicable)
J. Contractor signature, title, and date.
K. Name, title, and date for individual preparing the document.

Operational Procedure.

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Umbrella Certificates shall be submitted for items such as guardrail, lighting and traffic control, signing, chain-link systems and bridge drains as required by the MSTR. The information specified above shall be provided on Department furnished forms (DOT-99).

The Prime Contractor is responsible for completing the certificate. If a subcontractor is going to perform the work covered by the certificate, the subcontractor may fill in the information; however, the Prime Contractor must sign the certificate. Each component material that is to be included on the Umbrella Certificate will be identified as such on the DOT-14. The Prime Contractor will not be allowed to submit individual certification documents for the component materials in lieu of completing a DOT-99 form.

Materials certified by an Umbrella Certificate will be inspected to confirm that the proper materials are used and are installed according to the plans and specifications.

The Contractor shall furnish the Engineer with an original copy of the completed DOT-99 when the work begins. The Engineer shall verify that all materials shown as requiring Umbrella Certification on the DOT-14 are included on the form. A copy of the DOT-99 shall be forwarded to the Certification Engineer.

If a construction change order (CCO) is issued that affects items covered by an already submitted Umbrella Certificate, the Project Engineer will verify that the Umbrella Certificate is still an accurate representation of the items or materials required. Based on the Project Engineer's determination, the Prime Contractor may be requested to submit a revised Umbrella Certificate to reflect the changes to the contract.

Payment for the materials or components will be made only after approval of the Umbrella Certificate by an appropriate Department representative and the materials have been installed on the project.

6.7 Verification Methods.

The methods by which the Department determines the acceptability of materials to be placed on the project include the following:

A. Sampling and Testing – Some materials may require samples be taken and tests performed to determine that the material being certified is in conformity with the plans and specifications. Materials to be sampled and/or tested will be identified in the MSTR.

B. Documented Inspection – Inspection will be performed as necessary to verify conformance with specifications. Inspection may include taking measurements, performing calculations, and verifying the condition of materials furnished to the site. Inspection may also consist of verifying that materials furnished to the site are representative of those materials identified by certification documents. Documentation of the inspection is to be included in the diary or on the CM&P system, or on forms provided for a particular material.

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C. Random Audit of Contractor's Records – Verification of Contractor's ability to produce the required certifications. The Prime Contractor must build and maintain a file of the identified certifications and retain them for a period of three years after the final payment is received on the project. If any litigation, claim, negotiation, audit or other action involving the records has been started before the expiration of the 3-year period, the records must be retained until the completion of the action and resolution of all issues which arise from it, or until the end of the regular 3-year period, whichever is later.

The records shall be available for review upon request by the Department. Beginning on the date that the Department receives the completed DOT-99 form, random audits of certification records may be conducted by Department personnel. The purpose of the audits is to verify that the contractor is maintaining the proper paperwork.

D. Annual Inspection of Suppliers – On an annual basis, the Department will randomly select projects and conduct audits of certified suppliers. Random visits of supplier plants or fabricator shops are intended to verify that the facilities meet Department standards.

7. Computations and Reports:

7.1 Report.

Each required field test shall be recorded in the Materials, Sampling, and Testing system (MS&T). If test report is not available in MS&T, the test shall be documented as determined by the Region Materials Engineer.

The Region and Central Testing Laboratories shall retain the original reports of tests performed in their respective laboratory.

The original copy of tests or worksheets made by the Area Engineer, but not entered into MS&T system shall be retained in the project file. These tests will be made available to the Region Materials Engineer upon request.

The Contractor shall be advised immediately of all test failures (refer to RSTC 5 Identification).

Reports of test results shall be recorded only as the whole number or decimal required by the specification, e.g., for a specification requirement: “10-35% passing #40 sieve”, the report need only show the percent (As a whole number) passing the #40 sieve.

7.2 Computations.

Computations shall be carried one place beyond the reporting figure, and all test results shall be reported to the whole number or decimal required by the specification.

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Rounding from the computations to the reporting figure shall be the last step in calculating the test results.

When the requirement appears as a fraction, that fraction shall be interpreted as a decimal rounded to the nearest one hundredth (0.01) for computations.

Discrepancies may arrive between hand calculations and MS&T computations. In these instances, the results in MS&T shall govern.

Rounding.

If the first digit after the digit to be retained has a value of less than 5, the retained figure is not changed. If the first digit after the digit to be retained has a value of 5 or more, the digit to be retained is increased by one. No result, whether intermediate or final shall be rounded more than once.

Compliance will be based upon interpreting the reporting results as though they were rounded to the terms (whole numbers, decimals, or fractions reduced to decimals) of the specification. Thus, the minus #200 material reported as 8.4% shall be considered having no deviation from specifications that require 4–8% passing the #200 sieve. It would, however, be a deviation from specifications requiring 4.0–8.0% passing the #200 sieve.

8. Availability and Filing:

8.1 Acceptance Samples and Tests.

Original reports of acceptance sampling and testing not entered into the MS&T system, are to be retained in the Project Engineer's file and made available for examination by the FHWA Engineer. The reports shall show the source of the samples and where, when, and by whom the sampling and testing was done.

These test reports shall remain part of the official project record. Results of acceptance tests need not be submitted to the FHWA, unless specifically requested.

8.2 Independent Assurance Samples and Tests.
Test reports of the IA sampling and testing are to be made available in the Region Laboratory and the project file for examination by the FHWA inspecting Engineer.

Results of IA tests made by Central Testing Laboratories shall be forwarded to the participating Region or Area Laboratory with copies filed in the appropriate Region Materials and Central Testing Laboratory offices.

Results of tests made by the Central Testing Laboratories on comparative samples submitted by AASHTO Resource and CCRL, and the reports of the test equipment and procedure inspections made by those organizations are to be filed in the Central Testing Laboratory Office.

Test reports of the IA sampling and testing need not be submitted to the FHWA Division Office, unless requested.

9. Electronic Reports and Filing:

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In lieu of paper test reports, forms and worksheets, SDDOT reports can be completed electronically in the SDDOT Materials, Sampling, and Testing system (MS&T). Electronic tests, forms and reports which are created and available in the MS&T system are acceptable as filed electronically and do not need to be placed in the project file. Electronic copies stored on the MS&T system are acceptable as signed documents.

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South Dakota Department of Transportation

Minimum Sample and Test Requirements (MSTR)

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1. Asphalt Construction:

General Notes:

The Area Engineer must furnish representative samples of component mineral aggregate materials to the Bituminous Engineer to establish the design mix. The samples submitted will be tested for quality in the Central Laboratory. Mix production will not be permitted until the mix design has been obtained from the Bituminous Engineer. For mix designs, submit representative virgin mineral aggregate samples and recycled asphalt pavement (RAP) samples proportionate to the bin splits proposed for use during construction. The total aggregate submitted for mix designs will be from 400 to 500 pounds.

When quality tests are required by specifications, one sample per 50,000 ton of virgin mineral aggregate will be submitted to the Central Laboratory. The first required quality test will be performed on material submitted for mix design and additional quality tests will be performed on composite samples submitted to the Central Laboratory. Aggregate production for asphalt concrete, base course, and similar materials from the same source used on one or more projects simultaneously requires only the single minimum test frequency for quality; however, results must be reported separately for each material for each project file. For quarried ledge rock aggregate that has a satisfactory quality record and has been used in asphalt for five years or more, the quality test requirements may be reduced to once per year. Sample size: 120 lbs., 4 bags; plus, an additional 60 lbs., 2 bags, when soundness is required. (DOT-1) 24

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Small Quantities:

Samples or tests on bituminous mixtures will not be specifically required for project quantities that do not exceed approximately 100 ton per day or approximately 500 ton per project, provided there are appropriate certificates and tests to ensure that the sources of supply have recently furnished satisfactory similar material and construction. Acceptance may be based on documented Visual Inspection for equipment, method of placement, compaction, temperature, etc., or mixture may be tested at the direction of the project engineer.

Asphalt Concrete Composite:

Written certification from the producer stating that the asphalt concrete composite conforms to the specifications (DOT-97) and a Certificate of Compliance from the refinery for the asphalt binder used in the mixture will be furnished in duplicate to the Engineer. The Contractor will provide a job-mix formula (DOT-97) with supporting mix design to the Bituminous Engineer prior to production. The Engineer may accept the mixture based on the Certificate of Compliance, Visual Inspection for equipment, method of placement, compaction, temperature, etc.

Calibration and Process Correction Tests:

Prior to production of asphalt concrete, certified technicians will conduct comparison tests at the plant with a split companion cold feed calibration sample of virgin aggregate to assure that all associated equipment and procedures provide comparable results. Comparison test results will meet the requirements of the mix design report and will conform to the tolerances in this manual. The split companion calibration testing will continue until the results meet the requirements of the mix design report and are within the listed tolerances. The split companion calibration testing will be performed on each mix type produced prior to production of that mix type.

Calibration and process correction ("PC") samples taken and tested when production is stopped are to verify the proper calibration of the plant and to determine the effectiveness of changes in bin splits or other action taken to change the gradation and quality of the aggregate. Satisfactory test results are the basis for allowing production to resume; however, since production is shut down and these samples do not represent material actually produced for use, they will not be used as acceptance samples.

If production is not shut down after a failing test and the next sample is taken and tested to confirm the effectiveness of the process correction, this test is also an acceptance test, as it actually represents material produced and placed on the project. The sample will be numbered as the next consecutive acceptance sample.

IA testing is not required on Contractor furnished and Contractor furnished & placed material.

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QC Test Frequency Reduction

The Contractor may request to reduce the QC testing frequency when the QC samples and the QA samples indicate acceptable results within the specifications located in Section 322 of the Standard Specifications for Roads and Bridges and the tolerances from R.S.T.C for sand equivalent, lightweight particles, crushed particles, and fine aggregate angularity and the Engineer and the Contractor are both confident that future production will meet specifications. The reduction in test frequency will be authorized in writing by the Area Engineer.

The Area Engineer will notify the Contractor in writing of the reduction in testing frequency and a copy of this letter will be forwarded to the Region Materials Engineer and Certification Program Administrator. A reduction in testing frequency may be revoked by the Area Engineer at any time.

The frequency of tests performed may be reduced using the following procedure. The QC technician will complete all tests on the first lot of material produced. A reduction in the frequency of testing will be allowed based upon the average test results obtained from five consecutive tests of material tested by the QC technician. This reduction in test frequency for any of the tests shown in the QC Test Frequency Reduction Guidelines will remain in effect as long as the test results remain within the range of the testing frequency currently being used.

The frequency of the QC testing for sand equivalent, lightweight particles, and crushed particles may be further reduced beyond what is shown in the QC Test Frequency Reduction Guidelines by the Area Engineer. The Area Engineer may reduce the frequency beyond what is shown in the QC Test Frequency Reduction Guidelines based on an evaluation of test results from the material source.

QC TEST FREQUENCY REDUCTION GUIDELINES

Sand Equivalent

10 or more above minimum	Reduce test frequency to 1 test per lot
7 to 9 above minimum	Reduce test frequency to 2 tests per lot
4 to 6 above minimum	Reduce test frequency to 3 tests per lot
Within 3 of minimum	No reduction in test frequency

+#4 and -#4 Lightweight Particles (less than 1.95 Specific Gravity)

Results of 0.0% lightweight particles	Reduce test frequency to 1 test per lot
1.5% or more below maximum	Reduce test frequency to 1 test per lot
1.1 to 1.4% below maximum	Reduce test frequency to 2 tests per lot
0.6 to 1.0% below maximum	Reduce test frequency to 3 tests per lot
Within 0.5% of maximum	No reduction in test frequency

Crushed Particles

Results of 100% crushed faces	Reduce test frequency to 1 test per lot
25% or more above minimum	Reduce test frequency to 1 test per lot
16 to 24% above minimum	Reduce test frequency to 2 tests per lot
6 to 15% above minimum	Reduce test frequency to 3 tests per lot
Within 5% of minimum	No reduction in test frequency

Fine Aggregate Angularity

2.5% or more above minimum	Reduce test frequency to 1 test per lot
2.0 to 2.4% above minimum	Reduce test frequency to 2 tests per lot
1.5 to 1.9% above minimum	Reduce test frequency to 3 tests per lot
Within 1.4% of minimum	No reduction in test frequency

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QC/QA Dispute Resolution System

If the differences between the QC and QA results are greater than the allowed tolerance in R.S.T.C. or SD 317, the Engineer will investigate the reason for the difference. The investigation may include review and observation of test procedures and equipment. The QA technician will test the next QC sample as soon as a difference between any QC and QA test result is found. The Engineer may require that a sample be tested jointly by the Contractor's QC technician, the Engineer's QA technician, and the Region Materials Engineer. The Region Materials Engineer test results or, if necessary, the Department’s Materials & Surfacing Central Laboratory test results will be the referee used for acceptance and will determine which sample test results will be incorporated into the pay factor calculations only when a dispute between the QA and QC sample cannot be resolved.

1.1 Asphalt Concrete, Hot Mix (Includes Base and Surfacing Courses).

A. Aggregate, Composite.

(1) Tier 3.

(2) Certification.
See “General Notes”.

(3) Acceptance.
Class D, E, G, HR, S one sample per plant, per 1,000 ton of mix (1,000 ton of virgin aggregate for Class HR), tested for composite gradation, sand equivalent and fine aggregate angularity. Class S will

not be tested for sand equivalent and fine aggregate angularity. (DOT-69)

Crushed and lightweight particle tests will be made:

(a) On the first 5 samples and then for each 5,000 ton of mix thereafter. 24

(b) Following a failing test or change in the mix proportions

If equipment and or operations indicate taking and testing separate bin samples is required or desired, test will be mathematically combined to produce the composite gradation.

Material used for samples will be from the bins used for gradation determinations. (DOT-68)

Lightweight particles, crushed particles, sand equivalent and fine aggregate angularity testing will not be required when 100% of the material (excluding mineral filler and additives) used in the composite is ledge rock material (DOT-69).

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Class Q one sample per plant, per 1,000 ton for QC of mix 5,000 ton for QA, tested for composite gradation, crushed particles, light weight particles, sand equivalent and fine aggregate angularity. (DOT-69).

(4) Independent Assurance.
Class D, E, G, HR, S one sample per plant, per 10,000 ton of mix. None required for contract quantities less than 500 ton.

Lightweight particles, crushed particles, sand equivalent and fine aggregate angularity testing will not be required when 100% of the material (excluding mineral filler and additives) used in the composite is ledge rock material (DOT-69).

Class Q one sample per plant, per 15,000 ton of mix. None required for contract quantities less than 500 ton.

B. Asphalt Binder.
(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required for each conveyance or load of asphalt delivered to a project. The original and one copy should be received with each load delivered to the project.

NOTE: The Department is a member of a Combined State Binder Group. The group includes surrounding state Department of Transportation and a variety of suppliers of asphalt binder materials who have become certified through the process outlined by the group's publication. The certification and testing requirements will be the same for materials received from these suppliers as with other suppliers.

(3) Acceptance.
One randomly selected sample per 250 ton, per type, grade, and source. Sample size: two 1 qt. samples. A certificate of compliance for each conveyance or load the sample represents must be submitted with each sample. (DOT-1) 24

The sample will be obtained from an in-line-sampling valve located between the storage unit and the mix plant. (SD 301)

Detailed analysis will be made on the 1st sample of each type or grade, from each source, then on a random basis for each 250 ton per type, grade, and source. 24

Identification tests may be made on all samples for which the detailed analysis is not made.

(4) Independent Assurance.
One per project by observation of acceptance sample. (DOT-1)

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None required for contract quantities less than 100 ton.

C. Asphalt Binder Content.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Calculated daily using measured quantity of asphalt and tonnage of mix produced for each mix design. (DOT-89)

The asphalt binder content will be carried over and calculated with the next day of production if less than 500 ton of material is produced for the day. In case that there is no next day of production, an asphalt binder content will be measured and reported for the smaller than 500 ton day.

If asphalt concrete is being produced by a commercial source that is supplying two or more different types of mixes with different binder contents throughout the day, the binder content may be determined by using one of the following methods:

a) Stick the tank before each change of making different types of mixes as shown above for determining the quantity of binder used and the daily binder content.

b) Determine the binder content by using the ignition oven test method (AASHTO T 308) with at least one test per day for determining the quantity of binder used and the daily binder content.

c) The quantity of asphalt binder may be determined using a certified or calibrated pump/flow meter. The pump/flow meter will be certified or calibrated annually.

i Certification must be done by a state scale inspector, a licensed private testing company or a qualified representative of the pump/flow meter manufacturer and a letter of certification be retained in the plant control shack.

ii Calibration will be performed by the Contractor and will be witnessed by the DOT. The Contractor will provide all equipment for initial and subsequent calibration checks; furnish the DOT with a copy of all calibration checks; use a calibration vessel with a volume of at least 1,000 gallons; ensure the weigh scales have been tested and certified and provide copies to the DOT; and furnish the DOT a copy of the test report showing the asphalt cement specific gravity. Spot check failure will require the Contractor to perform a new calibration. The DOT may request additional calibrations throughout the construction season. Use the printout sheet from the plant which has the pump/flow meter readings showing the amount of binder added into the mix furnished to the project to determine the quantity of binder used and the daily binder content.

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(4) Independent Assurance.
None required.

D. <u>RAP Content</u>

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per day. (DOT-93).

(4) Independent Assurance.
None required.

E. <u>RAP in Asphalt Concrete</u>

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One sample per day, tested for sieve analysis and moisture.
(DOT-35) (DOT-3) (SD 305)

(4) Independent Assurance.
None required.

F. <u>Lime Content</u>
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Calculated daily using weighed quantity of lime and tonnage of mix produced. (DOT-33Q)

Lime supplied by non-certified lime plants will require 1 acceptance sample per 750 tons.

(4) Independent Assurance.
None required.

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G. <u>Density, In Place</u>.
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
<u>Class D, E, G, HR</u> one per lot of mix or one day's production, whichever is less. A lot will consist of 1,000 ton. A new lot will begin at the start of work each day and each time the mix design or source of material is changed. The last lot of the day may represent up to 1,500 ton. (DOT-42)

If required by specifications, two randomly located cores per 1,000 ton lot will be taken for determination of in place density. The average of the two cores density results will be the value used for density. (DOT-42Q, DOT-86) 24

<u>Class Q</u>: One per 1,000 ton sublot will be taken for determination of in place density. The average of the two core density results will be the 1,000 ton sublot value used for density in the pay factor calculations. (DOT-42Q)

<u>Class S:</u> Three randomly located cores taken within the first 1,000 tons of hot mix placed. Send to the Central Lab for informational testing.

(4) Independent Assurance.
Class D, E, G, HR, one per 10,000 ton. None required for contract quantities less than 500 ton.

Class Q: One taken during the first 5,000 tons of hot mix tested and then at a minimum frequency of one core per 15,000 tons thereafter.

H. Theoretical Maximum Specific Gravity (Rice)
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Class D, E, G, HR one per 1,000 ton. (DOT-42)

Class Q one per 1,000 ton for QC, one per 5,000 ton for QA. Sample to be obtained from the windrow in front of the laydown machine. (DOT-86)

(4) Independent Assurance.
Class D, E, G, HR one per 10,000 ton. None required for contract quantities less than 500 ton.

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To verify that the end product is representative of what was actually designed, area personnel will provide the Region Materials Laboratory with a sample (50 to 60 lbs.) of un-compacted mix from the first regularly scheduled theoretical maximum specific gravity (Rice) test. The Region Materials Laboratory will perform theoretical maximum specific gravity (Rice) test for comparative purposes with the acceptance test and will perform tests to determine the bulk specific gravity (Gyratory) and the percent air voids. Report results to the Bituminous Engineer.

Class Q one per 15,000 ton. None required for contract quantities less than 500 ton.

I. Bulk Specific Gravity.
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Class D, E, G, HR None required.

Class Q one per 1,000 ton for QC, 5,000 ton for QA. Sample to be obtained from the windrow in front of the laydown machine. (DOT-86)

(4) Independent Assurance.
Class D, E, G, HR one per 10,000 ton. None required for contract quantities less than 500 ton. (DOT-42)

Class Q One per 15,000 ton.

J. Mixture Densification, Voids in Mineral Aggregate and Dust to Binder Ratio. (Class Q)

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per 1,000 ton for QC, 5,000 ton for QA. Sample to be obtained from the windrow in front of the laydown machine (DOT-86)

(4) Independent Assurance.
One per 15,000 ton.

K. Moisture Content of Mix (Class Q and HR)

(1) Tier not applicable.

(2) Certification.
None required.

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(3) Acceptance.
One per 10,000 ton. Sample to be obtained from the windrow in front of the laydown machine. (DOT-35)

(4) Independent Assurance.
None required.

L Drain Down (Class S)

(1) Tier not applicable

(2) Certification
None required.

(3) Acceptance
One per day (DOT-91)

(4) Independent Assurance
None required.

M Stabilizing Additive (Class S)

(1) Tier not applicable

(2) Certification
None required.

(3) Acceptance
One per day (DOT-94)

(4) Independent Assurance
None required.

1.2 Cold In Place Recycling.

A. Aggregate.
   - (1) Tier 3.
   - (2) Certification.
     None required.
   - (3) Acceptance.
     One sample per day. (DOT-3)
   - (4) Independent Assurance.
     None required.

B. Density, Standard.
   - (1) Tier not applicable.
   - (2) Certification.
     None required.
   - (3) Acceptance.
     A minimum of one test strip will be completed to determine the target density. When there is significant change in mix proportions, weather conditions or other controlling factors, the Engineer may require completion of additional test strip(s) to check target density. (DOT-28)
   - (4) Independent Assurance.
     None required.

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C. Density, In Place.
   - (1) Tier not applicable.
   - (2) Certification.
     None required.
   - (3) Acceptance.
     One per mile, per lane surfaced. (DOT-41)
   - (4) Independent Assurance.
     None required.

D. Moisture Content (Prior to Compaction).
   - (1) Tier not applicable.
   - (2) Certification.
     None required.
   - (3) Acceptance
     One per 1/2 mile, per lane processed. (DOT-35)

After the Contractor has informed the Engineer that the moisture specification has been met, the Engineer will perform the acceptance moisture tests. These moisture tests will be performed within the same areas as the density in place.

(4) Independent Assurance.
None required.

E. Moisture Content (After Compaction).
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per mile, per lane surfaced. (DOT-35)

After the Contractor has informed the Engineer that the moisture specification has been met, the Engineer will perform the acceptance moisture tests. These moisture tests will be performed within the same areas as the density in place.

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(4) Independent Assurance.
None required.

1.3 Asphalt Surface Treatment.

A. Cover Aggregate, Types 1 and 2.
(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per 500 ton, tested for gradation. One sample per 2,000 ton tested for P.I., and if required by specification flakiness index and crushed particles. (DOT-3 & DOT-61)

Crushed particles testing will not be required when 100% of the material is ledge rock material. 24

(4) Independent Assurance.
One sample per project. None required on quantities less than 1,500 tons.

B. Cover Aggregate, Type 3.
(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per 1,500 ton, tested for gradation, P.I., crushed particles and flakiness index. (DOT-3 & DOT-61)

(4) Independent Assurance.
One sample per project. None required on quantities less than 1,500 tons.

C. <u>Mineral Aggregate for Microsurfacing</u>

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per 500 ton, tested for gradation. One sample per 2,000 ton tested for P.I., + #4 lightweights - #4 lightweights and if required by specification crushed particles. (DOT-3)

(4) Independent Assurance.
One sample per project. None required on quantities less than 1,500 tons.

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1.4 Asphalt Liquid.

A. <u>Material</u>.

(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required for each conveyance or load of asphalt delivered to the project. The original and one copy should be received with each load delivered to the project.

(3) Acceptance.
One randomly selected sample per 200 ton, per type, grade, and source. Water added to dilute emulsified asphalt is not included in the 200 ton sampling frequency. Diluted emulsified asphalt will be sampled and tested. If water is added to dilute emulsified asphalt, note the dilution rate on the DOT-1. Sample sizes: Emulsions, two 1/2 gal. samples; all other asphalts, two 1 qt. samples. A Certificate of Compliance for each conveyance or load the sample represents must be submitted with each sample. (DOT-1) 24

Asphalt delivered in a transport and pup ("Trailer") will be considered as one conveyance if it is from the same source and of the same grade.

Detailed analysis will be made on the first sample of each type or grade, from each source. Then on a random basis for each 200 ton per type, grade, and source. Identification or detailed tests may be made on samples for which the detailed analysis is not required. 24

(4) Independent Assurance.
None required.

1.5 Crack Sealing of Asphalt Concrete.

A. Sealant.

(1) Tier 2.

(2) Certification.
Item used must be on the Approved Products List.

(3) Acceptance.
One 5 lb. sample representing each lot or batch will be taken from the application wand during the sealing process. The sample will be placed in a Teflon or silicone lined box having a minimum capacity of 5 lbs. None required for contract quantities of 200 lbs. or less. (DOT-1)

Visual Inspection will consist of measuring the width and depth of the routed vessel to ensure proper dimensions are obtained according to the plans.

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(4) Independent Assurance.
None required.

B. Backer Rod.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 2 ft. length submitted with the sealant. (DOT-1)

None required if less than 200 lbs. of sealant is used.

(4) Independent Assurance.
None required.

1.6 Milling (Surface Texture)

A. Cold Milling.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per day for mainline. A lot will consist of one day's production. (DOT-55A)

None required for project quantities less than 2,000 square yards. Acceptance will be based on documented Visual Inspection.

(4) Independent Assurance.
None required

B. Micro-Milling.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per day. A lot will consist of one day’s production. (DOT-55A)

None required for project quantities less than 2,000 square yards. Acceptance will be based on documented Visual Inspection.

(4) Independent Assurance.
None required.

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2. Subbase, Base Course, and Gravel Cushion Construction:

General Notes:

When quality tests are required by specifications, one sample per 50,000 ton per source will be submitted to the Central Laboratory for testing. Aggregate production for asphalt concrete, base course, subbase, gravel cushion, etc., from the same source used on one or more projects simultaneously requires only the single minimum test frequency for quality; however, results must be reported separately for each material for each project file. Sample size: 120 lbs., 4 bags.

Samples and tests on aggregates will not be required for quantities less than 500 ton, provided there are prevailing test results to indicate the source has furnished satisfactory similar material. The quantity and source of the material will be provided to the Region Materials Engineer and the Chief Materials and Surfacing Engineer for review and approval. If approval is granted, acceptance will be based on documented Visual Inspection for equipment, method of placement, etc. Method of compaction must be approved by the Region Materials Engineer and Chief Material & Surfacing Engineer.

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Prior to the first in place density test, the Area Engineer will submit a 60 lb., 2 bag sample to the Region Materials Laboratory where a 4-point determination will be made for each source, combination or type of material produced, including the specified additive or treatment where required. When changes in gradation which may affect density results occur, contact the Region Materials Engineer to determine if an additional 4-point will be required.

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When the material to be used on a project is from an established quarry on which a 4-point determination was previously made, it will be permissible to use that 4-point provided the 1-points fall within the range established by it. If the 1-points do not fall within the established range, contact the Region Materials Engineer to determine if an additional 4-point will be required.

2.1 Subbase and Base Course,

A. Aggregate, Composite.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample of composite mixture per 3,000 ton, tested for gradation, L.L., and P.I. Report the percentage and source of each component material used. (DOT-3)

If required by specifications, a crushed particles test will be performed each 6,000 ton. Crushed particle testing will not be required when material consists of 100% ledge rock material, 100% recycled Portland cement concrete pavement or 100% recycled asphalt pavement.

(4) Independent Assurance.
One sample of composite mixture per 15,000 ton. None required for contract quantities less than 1,000 ton.

If required by specifications, a crushed particles test will be performed each 6,000 ton. Crushed particle testing will not be required when material consists of 100% ledge rock material, 100% recycled Portland cement concrete pavement or 100% recycled asphalt pavement.

B. Density, In Place

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per mile, per lift, per roadbed surface or site just prior to application of prime or subsequent course. Compacted lifts may be combined, not to exceed 6 in. total thickness, for testing purposes. (DOT-41)

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(4) Independent Assurance.
One per 4 miles of roadbed surface. None required for contract quantities less than 1,000 ton.

C. Density, Standard

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One 1-point determination using material from or adjacent to the hole for each in place test. When the 1-point determination deviates more than 2 percentage points below or 1 percentage point above optimum moisture, another 1-point (nearer to optimum moisture) will be made. If the maximum density deviates outside the 4-point range, the Region Materials Engineer will be contacted. (DOT-41)

(4) Independent Assurance.
One per 4 miles of roadbed surface. None required for contract quantities less than 1,000 ton.

2.2 Gravel Cushion,

A. Aggregate, Composite.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample of composite mixture per 3,000 ton, tested for gradation, L.L., and P.I. Report the percentage and source of each component material used. (DOT-3)

If required by specifications, a crushed particles test will be performed each 6,000 ton. Crushed particles test is not required when material consists of 100% recycled portland cement concrete pavement or 100% recycled asphalt pavement.

(4) Independent Assurance.
One sample of composite aggregate per 15,000 ton.
None required for contract quantities less than 1,000 ton.

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3. Miscellaneous Granular Materials:

General Notes:

When quality tests are required by specifications, one sample per 50,000 ton per source will be submitted to the Central Laboratory for testing. Aggregate production for asphalt concrete, base course, subbase, gravel cushion, etc. from the same source used on one or more projects simultaneously requires only the single minimum test frequency for quality; however, results must be reported separately for each material for each project file. Sample size: 120 lbs., 4 bags. (DOT-1)

3.1 Gravel and Sand for Maintenance Stockpiles.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per 3,000 ton. (DOT-3)

Back

(4) Independent Assurance.
None required.

3.2 Gravel Surfacing.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample of composite mixture per 3,000 ton. (DOT-3)

None required for contract quantities less than 100 ton.

(4) Independent Assurance.
One sample of composite mixture per source. None required for contract quantities less than 1,000 ton.

3.3 Blotting Sand for Prime Coat and Sand for Flush Seal.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per project. (DOT-3)

(4) Independent Assurance.
None required.

3.4 Granular Bridge End Backfill.

A. Aggregate.
- (1) Tier 3.
- (2) Certification.
  None required.
- (3) Acceptance.
  One sample per 1,000 ton. (DOT-3)
- (4) Independent Assurance.
  None required.

B. Density, In Place.
- (1) Tier not applicable.
- (2) Certification.
  None required.
- (3) Acceptance.
  None required.
- (4) Independent Assurance
  None required.

Back

3.5 Gabion Fill (Rock or Stone).

A. Aggregate.
- (1) Tier 3.
- (2) Certification.
  None required.
- (3) Acceptance.
  Documented Visual Inspection for size and source.
- (4) Independent Assurance.
  None required.

3.6 Porous Backfill.

A. Aggregate.
- (1) Tier 3.
- (2) Certification.
  None required.

(3) Acceptance.
One sample per 250 ton. (DOT-3)

The Project Engineer may reduce the testing frequency to 1 per 2,000 ton after the first three passing tests provided the source remains the same and provided there is no apparent change in the properties of the material. If observations by the Project Engineer cause concern that specifications compliance is questionable, the testing frequency may return to the 1 per 250 ton.

(4) Independent Assurance.
None required.

3.7 Riprap.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

Back

(3) Acceptance.
Documented Visual Inspection for size and source.

If requested by the Engineer, the Contractor will provide a sample of riprap weighing at least 5 ton meeting the gradation for the class specified.

The weight per cubic foot will be determined on this sample. The sample may be a part of the finished riprap covering. This sample will be used as a frequent reference for judging the gradation of the riprap supplied.

Any difference of opinion between the Engineer and the contractor will be resolved by dumping and checking the gradation of two random truckloads of riprap. The mechanical equipment, a sorting site, and labor to assist in checking gradation will be provided by the contractor at no additional cost to the State.

(4) Independent Assurance.
None required.

3.8 Pit Run.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection for size and source, and as determined by the Engineer a sieve analysis may be performed to verify the plans specified gradation. (DOT-3)

(4) Independent Assurance.
None required.

B. Density, In Place.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One in place density per ½ mile, per site, per zone. The zones are defined in item 3 under the “Reduction of 1-point Determinations” in the “General Notes” for subgrade construction (Embankments). (DOT-41)

(4) Independent Assurance.
None required.

Back

C. Density, Standard.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One 1-point determination using material from or adjacent to the hole for each in place test. (DOT-41)

(4) Independent Assurance.
None required.

3.9 Slope Protection Aggregate.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per source, per project. (DOT-3)

(4) Independent Assurance.
None required.

3.10 Salvaged and Full Depth Reclamation Materials.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per day. (DOT-3)

None required on surface preparation.

(4) Independent Assurance.
None required.

B. Density, In Place (when required by specification).

(1) Tier not applicable.

(2) Certification.
None required.

Back

(3) Acceptance.
One per mile, per lift, per roadbed surface. (DOT-41)

None required if less than 500’.

(4) Independent Assurance.
None required.

C. Density, Standard (when required by specification).

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
A minimum of one test strip per lift will be completed to determine the target density. When there is significant change in mix proportions, weather conditions or other controlling factors, the Engineer may require completion of additional test strip(s) to check target density. (DOT-28)

None required if less than 500’.

(4) Independent Assurance.
None required.

3.11 Pipe and Box Culvert Undercut Backfill (Granular)

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per source, per project. (DOT-3)

(4) Independent Assurance.
None required.

B. Density, In Place.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per each 1 foot zone per installation. (DOT-41)

Back

The density in the top 1 foot zone will be taken in the top lift of the undercut backfill immediately prior to installation of the pipe or box culvert.

Where insulating board is used, the density will be taken in the lift below it.

(4) Independent Assurance.
None required.

C. Density, Standard.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One 1-point determination using material from or adjacent to the hole for the in place test. 1-point may be referred when undercut depth exceeds 1 foot and multiple in place densities are required for the installation.

(4) Independent Assurance.
None required.

3.12 Cold Milled Asphalt Concrete and Placing Cold Milled Material.

A. Milled Material.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per mile. (DOT-3)

(4) Independent Assurance.
None required.

3.13 MSE Backfill.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per 5,000 yd^3 / 7,000 ton. (DOT-3)

(4) Independent Assurance.
One sample per project.

Back

3.14 Granular Material for Box Culvert and Pipe Bedding.

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per 10,000 ton. (DOT-3)

(4) Independent Assurance.
One sample per 50,000 ton.
None required on quantities of 3,000 ton or less.

3.15 Miscellaneous Granular Materials

A. Aggregate.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per project. (DOT-3)

(4) Independent Assurance.
None required.

B. Rock, Clay, Sand Filler and Miscellaneous Granular Materials.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample prior to blending with aggregate per 750 ton.

(4) Independent Assurance.
None required.

C. Density, In Place.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per project, or other specified frequency, if density requirements are required by plans.

Back

(4) Independent Assurance.
None required.

D. Density, Standard.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One 1-point determination using material adjacent to the hole for each project. (DOT-41) 1-point may be referenced to similar material on the project.

(4) Independent Assurance.
None required.

4. Subgrade Construction (Embankments):

General Notes:

Embankment, berms and pipe backfill will each require a separate set of numbers for density and moisture tests.

The Central Laboratory will make preliminary tests for soils representing the major excavation areas and soil types. The results will be recorded for reference on the soils profile.

During construction, at least one acceptance test for gradation, L.L., and P.I. will be made to verify A-3 or A-2-4(0) soil classifications per source, per project, per day. (DOT-3) An independent assurance test will be made per 200,000 yd^3 on this material. This requirement is waived for the ordinary compaction method.

When material meeting specifications for fine aggregate as per Section 800.2.E. is hauled to the project from a commercial source to be used as pipe backfill, one acceptance sieve analysis will be required per source, per project, per 500 yd^3. (DOT-3)

Visual observations will be made to detect possible changes in soil characteristics. When there is doubt about soil classification, contact the Region Materials Engineer.

Back

Moisture and Density Testing:

Compaction testing of soils consists of determining the in-place density of the material and calculating the percent compaction based on a maximum dry density. The maximum dry density will be determined using the one-point proctor method (SD 104).

Soils not compatible with the “Ohio Family of Curves” or the “Lightweight Family of Curves” will require a 4-point (SD 104) to determine target optimum moisture and maximum dry density. In this case, a 1-point determination will not be used until a 4-point is performed to establish optimum moisture and maximum dry density. Contact the Region Materials Engineer when soil is not compatible with either family of curves. If a soil meets both family of curves, the Ohio Family of Curves will take precedence.

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When the soil encountered contains + 3/4” materials, the 1-point or 4-point determinations will be made to determine optimum moisture on the - 3/4” material as per SD 104.

A target moisture and density will be determined prior to or at the same time the initial testing begins within each 1/2 mile segment.

When a density test is performed at the time the embankment is being placed and compacted, the moisture determination is acceptable as a moisture control test. (DOT- 35).

Reduction of 1-Point Determinations:

The requirements for 1-point determinations outlined in paragraph 4.1 G. (3) and 4.3 B. (3) may be reduced, if the following conditions are met:

1. One-point determinations will be made on the first three tests (moisture tests or density tests) performed within each 1/2 mile segment.

2. Maximum dry densities of these three 1-point determinations must be within a spread of 6 lbs/ft^3.

3. When the above is satisfied, the minimum number of 1-point determinations (moisture tests or density tests) required per 1/2 mile segment, for each roadbed, will be as follows:

Zone:	Depth:	Minimum required:
1	0 to 1 ft.	2*
2	1 ft. to 3 ft.	1
3	3 ft. to 5 ft.	1
4	5 ft. to bottom	1 per 5 ft.

*In accordance with Section 120, this density will be performed within the upper 6 inches while the grade is prepared for surfacing. 24

Additional 1-point determinations will be made as required by changes in soil types within the 1/2 mile segment.

Back

A density or moisture test may refer to a 1-point determination within 2,000 ft. of the test location, including backfill for pipe or box culverts.

When a 1-point determination is not made for a test and the test results in a failing moisture, failing density, or unusually high moisture or density, a 1-point determination will be made using material from the test location to ensure that the proper curve data is being used to determine the target moisture or density. This 1-point determination may be used for subsequent re-testing at the same location.

4.1 Specified Density (In Place).

A. Embankment (Includes Subgrade Topping, Ordinary and Heavy Roadway Shaping).
   (1) Tier not applicable.

   (2) Certification.
   None required.

   (3) Acceptance.
   One per 1/2 mile, per roadbed, per zone. The zones are defined in item 3 under “Reduction of 1-Point Determinations” in the “General Notes” for this section. (DOT-41)

   (4) Independent Assurance.
   One per 200,000 yd^3 of excavation.
   None required for contract quantities less than 10,000 yd^3.

B. Berms.
   (1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per berm, per structure, per zone. (DOT-41)

Zone:	Depth:	Minimum required:
1	0 to 1 ft.	2*
2	1 ft. to 3 ft.	1
3	3 ft. to 5 ft.	1
4	5 ft. to bottom	1 per 3 ft.

*In accordance with Section 120, the second density will be performed within the upper 6 inches while the grade is prepared for surfacing. 24

(4) Independent Assurance.
A minimum of one per project.

C. <u>Bridge End Embankment</u>

(1) Tier not applicable.

Back

(2) Certification.
None required.

(3) Acceptance.
Prior to placing the bridge end embankment, one density test will be required for the scarified and recompacted approach berm. In addition, three density tests will be required for each abutment backwall less than 7 ft. tall. Four density tests will be required for backwalls 7 ft. tall or over. Zones for density test will be equally spaced. (DOT-41)

(4) Independent Assurance.
A minimum of one per project.

D. <u>Cross Pipe Pre-Installation Density</u> (Does not include utility, storm sewer, gas, or water main).

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One below rural mainline cross pipe per installation prior to installing pipe. None required if pipe is undercut. (DOT-41)

(4) Independent Assurance.
None required.

E. <u>Pipe Undercut Backfill (Soil)</u>.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per each 1 foot zone per installation (DOT-41)

The density in the top 1 foot zone will be taken in the top lift of the undercut backfill immediately prior to installation of the pipe or box culvert. 1-point may be referred when undercut depth exceeds 1 foot and multiple in place densities are required for the installation.

(4) Independent Assurance.
None required.

F. <u>Pipe and Box Culvert Backfill</u>

(1) Tier not applicable.

(2) Certification.
None required.

Back

(3) Acceptance.

(a) Cross pipe, storm sewer pipe, sanitary sewer pipe, water main pipe, and box culvert. (DOT-41)

1. Minimum Requirements per Installation.
    a. On round pipe 24 in. or less in diameter or arch pipe 30 in., or less, one test approximately halfway up and one test in the 2 ft. of backfill above the pipe.

    b. On round pipe that is 30 in. up to 72 in. in diameter, arch pipe that is 36 in. up to 84 in., or box culverts up to 6 ft. in height, one test in the lower one-half, one test in the upper one–half and one test in the 2 ft. of backfill above the pipe or box culvert.

    c. On round pipe greater than 72 in. in diameter, arch pipe 96 in. or greater, or box culverts greater than 6 ft. in height, one test in the bottom one-third, one test in the middle one-third, one test in the top one-third and one test in the 2 ft. of backfill above the pipe or box culvert. Testing locations within the zones will alternate from side to side of the pipe or box culvert. If a different source of backfill material or compaction procedure is used on either side, each zone will be tested on both sides.

2. After the minimum requirements have been met, one test per installation, per 3 ft. of backfill beginning 2 ft. above the top of the pipe or box culvert will be taken

up to the elevation where normal grading operations commence over the pipe or box culvert.

(b) Approach Pipe.
The same as "(a) cross pipe, storm sewer pipe, sanitary sewer pipe, water main pipe, and box culvert", except none required for farm and field approaches.

(4) Independent Assurance.
(a) Longitudinal Pipe (Storm Sewer, Sanitary Sewer or Water Main).
One per 2,000 lineal feet. None required if total installation is less than 200 lineal feet.

(b) Cross pipe and box culvert.
One per 10 installations. None required if project has a single installation that totals less than 200 lineal feet.

(c) Approach pipe.
None required.

Back

The definition of "Per installation" as shown for density tests will be:

Each pipe or box culvert placed its entire length at one time.

Two or more pipes at one site when backfill is placed uniformly around all pipes and compactive effort is uniform around each pipe.

Each segment laid at different times such as in one-half length installations.

Each 300 lineal foot segment of cross, storm sewer, sanitary sewer, and water main pipe or portion thereof.

G. Density, Standard (Target).
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One 1-point determination using material from or adjacent to the hole for each in place test. (DOT-41)

(4) Independent Assurance.
One 1-point determination per in place density.

4.2 Ordinary Compaction Method.

A. Density.
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Obtained as per ordinary compaction methods (DOT-41)

(4) Independent Assurance.
None required.

B. Density, Standard (Target).

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One 1-point determination using material from or adjacent to the hole for each in place test. (DOT-41)

(4) Independent Assurance.
None required.

Back

4.3 Moisture Content.

A. Embankment (Includes Select Subgrade Material, and Berms, Excludes Ordinary Compaction).

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
As required to fix control, then one every 2 hours at each construction area. (DOT-35)

A representative sample is to be taken from soil being processed and compacted.

If the moisture content for an in place density test is not within the specified moisture limits for the project, the density will be considered as failing and will be corrected.

(4) Independent Assurance.
None required.

B. Box Culvert, and Pipe Backfill.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
None required.

If moisture test taken independent of density test, moisture will be documented on DOT-35.

(4) Independent Assurance.
None required.

C. Moisture, Standard (Target).

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One 1-point determination using material from or adjacent to the hole for each in place test. (DOT-35)

(4) Independent Assurance.
None required.

Back

5. Portland Cement Concrete Paving (PCCP) Construction:

General Notes:

For Special Provision for Contractor Furnished Mix Designs for PCCP:

All job mix designs for Portland cement concrete paving will be formulated by an approved testing firm. The concrete paving mix design will be verified by the Central Laboratory.

The samples of all materials to be used by both the testing firm and the Central Laboratory will be taken at the same time and split proportionately.

The Project Engineer will be notified prior to sampling and submitting mix design aggregate to the Central Lab.

For all other PCCP:

All job mix designs for Portland cement concrete paving will be either approved or formulated by the Concrete Engineer and may be tested in the Central Laboratory.

Samples of the aggregates will be submitted to the Central Testing Laboratory at least 40 days prior to anticipated use on the project for Quality and/or Design Mix testing/verification.

Back

Material from proposed aggregate sources must be submitted when a new or modified mix is required or desired. The following quantities are required to be submitted for each mix design in bags no larger than 80 lbs. or buckets no larger than 5 gallons:

Fine aggregate	750 lbs.
Coarse aggregate	1100 lbs.*
Cement**	210 lbs.
Fly Ash***	65 lbs.
Air Entraining Agent	8 oz.
Water Reducing Agent(s)	32 oz.

*A minimum of 350 lbs. for each size.

** A complete Certified Chemical Analysis and Physical Test Report are required for cement other than GCC Dacotah Rapid City.

*** A complete Certified Chemical Analysis and Physical Test Report are required for fly ash.

Quality tests and other special tests on aggregates that require equipment not available at the Region Materials Laboratory and field labs will be made in the Central Laboratories on samples representing each 31,500 yd^3.

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For ledge rock aggregate that has a satisfactory quality record and has been used in concrete for five years or more, the quality test requirements may be reduced to once per year.

The sample sizes for all fine and coarse quality tests require 60 lbs. of each material. (DOT-1)

For contract quantities less than 50 yd^3 of concrete, certification and acceptance will be as per Section 7.1.A., except one air content determination, one slump test, and one set of cylinders per source. (DOT-23). 24

Back

5.1 Materials.

A. Aggregate, Fine and Coarse.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per 1,000 yd^3 of concrete for each size and source. Fine and coarse aggregate be sampled and tested simultaneously. (DOT-3 / DOT-68)

When flat and elongated is specified, one sample tested per the first 15,000 yd^3 then one per 30,000 yd^3 thereafter.

Resampling because of a deviation from specifications of one of the aggregates requires resampling and retesting of only that material which failed.

When 100% of the material used in the coarse aggregate is ledge rock material, lightweight particle testing for the coarse aggregate is not required.

When test results for lightweight particles in fine aggregate for five consecutive tests indicate passing results with an average of 0.4% or less and no individual test over 0.6%, the test frequency may be reduced to 1 test for lightweight particles in fine aggregate per 5,000 yd^3. Normal testing frequency will resume for the remainder of the project if there are any failing tests. In addition, the lightweight particles in fine aggregate test will also be completed for all samples selected for independent assurance (IA) testing.

(4) Independent Assurance.
One sample per 15,000 yd^3 of concrete paving for each size. None required for contract quantities less than 500 yd^3. Lightweight particle test will not be required for coarse aggregate. One flat & elongated sample per project if required.

B. Aggregate, Fine and Coarse, Moisture Content.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One sample per 2 hours of paving operations for each size. (DOT-35)

Moisture testing may be reduced by the Engineer when automated concrete batching equipment with fine aggregate, or fine and coarse aggregate, moisture sensing capability is used. When only fine aggregate moisture sensors are used, the concrete plant will use a coarse aggregate moisture (DOT-98A) acceptable to the Engineer. Any moisture sensor will be accurate to 1.0% of the aggregate total moisture.

When the moisture testing is reduced, a moisture test for each size of aggregate will be made at the start of production and every 10,000 yd^3 or one per month, whichever happens first.

(4) Independent Assurance.
None required.

C. Cement.

(1) Tier 2.

(2) Certification.
From a certified supplier: None required.

From a non-certified supplier: A Certificate of Compliance is required for each acceptance sample obtained.

Back

(3) Acceptance.
One sample per 10,000 yd^3 of paving. Two 4 lb. samples. (DOT-1)
None required for contract quantities less than 500 yd^3.

(4) Independent Assurance.
None required.

D. Water.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One 8 oz. sample in a plastic container per source prior to use. Frequency of testing thereafter to be determined by any changes (Runoff, growth of algae, etc.) affecting the source. (DOT-1)

Testing is not required for water from municipal supplies except in the north part of the Rapid City Region (Contact the Region Materials Engineer regarding this area).

(4) Independent Assurance.
None required.

E. Chemical Admixtures (Includes Air Entraining, Water Reducing, Accelerators, Retarders, etc.).

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 8 oz. sample in a plastic container per type, lot, and source. (DOT-1)

Material must be thoroughly stirred, air agitated, or otherwise properly mixed to disperse all settlement just prior to sampling.

(4) Independent Assurance.
None required.

F. Fly Ash.
(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required and must be submitted with each acceptance sample obtained.

Back

(3) Acceptance.
One sample per 10,000 yd^3 of paving. The sample will be a 4 lb. sample taken from a randomly selected conveyance. (DOT-1).

(4) Independent Assurance.
None required.

5.2 Strength Tests.

A. Compressive Strength.
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One set of cylinders for the first 250 yd^3 (for 1st days production); thereafter, one set of cylinders per 1500 yd^3 of concrete produced from each plant per day. (DOT-23)

No more than 2 sets per day will be required.

A set of cylinders will consist of a minimum of 4 cylinders. Two cylinders will be used for compressive strength at 28 days (One cylinder is tested at 28 days and the other is saved for the backup). The other two cylinders will be used for early breaks (normally at 7 and 14 days). If additional early breaks are desired or required, additional cylinders must be made.

If early break cylinders are not available (already tested, etc.), it is preferred that 4 in. diameter cores be used to determine the strength of hardened concrete for purposes of opening to traffic. If cores cannot be obtained the impact test hammer may be used to determine the approximate strength of hardened concrete.

(4) Independent Assurance.
None required.

5.3 Fresh (Plastic) Concrete Tests.

A. Air Content, Unit Weight, Slump, and Temperature.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Air content, unit weight, slump, and temperature determinations will be made each time a cylinder for compressive strength determination is made. Additional determinations will be made to ensure proper control, and not less than one determination will be made for each 2 hours of mixing-pouring operations. (DOT-23)

Back

(4) Independent Assurance.
One air content, unit weight, slump, and temperature determination per 15,000 yd^3 of paving. None required for contract quantities less than 500 yd^3 of concrete. The slump tests may be by observation of acceptance tests.

5.4 Measurements.

A. Longitudinal Surface.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
When profilograph testing is not required, test in accordance with SD 417. (DOT-29)

On projects where profilograph tests are required, coordinate with the contractor. Operation of the profilograph is the responsibility of the contractor. Calibration of the profilograph must be made after 1/2 mile of paving is available and periodically, (At DOT discretion), from then on.

A spot check will be made on each project, with a 10’ straight edge to verify the effectiveness of corrective action taken to satisfy the acceptance requirements.

(4) Independent Assurance.
None required.

B. Texture.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per 10,000 yd^2 lot. (SD 418) (DOT-55)

(4) Independent Assurance.
None required.

C. Thickness.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Coordinate with the Concrete Engineer (Coring to check thickness is a responsibility of the Concrete Engineer unless quantity is less than 4,000 yd^2).

For projects with contract quantities less than 4,000 yd^2, cores will not be taken, unless requested by the Area Engineer. A minimum of four depth checks will be made on the plastic concrete. (Miscellaneous Test Document)

(4) Independent Assurance.
None required.

Back

D. Width.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Coordinate with the Concrete Engineer (Checking width for each coring unit is a responsibility of the Concrete Engineer unless quantity is less than 4,000 yd^2).

For projects with contract quantities less than 4,000 yd^2, a width check will be made for each different paved width. (Miscellaneous Test Document)

(4) Independent Assurance.
None required.

5.5 Curing Materials.

A. Liquid Membrane Curing Compound.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 8 oz. sample in a plastic or glass container per type, lot, and source. Sampling will occur from the end of the spray nozzle. (DOT-1)

(4) Independent Assurance.
None required.

B. Burlap and Cotton Mat.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required

C. Polyethylene Sheeting.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

5.6 Joint Materials.

A. Preformed Expansion Type (Includes Non-Extruding and Resilient Bituminous and Non-Bituminous Types).

(1) Tier 3.

(2) Certification.
None required.

Back

(3) Acceptance.
One sample at least 6 in. x 36 in. x full thickness. The sample must be packaged to prevent distortion or breakage in handling and shipment.

None required for contract quantities less than 25 ft^2; acceptance will be based on Visual Inspection, for size and type.

(4) Independent Assurance.
None required.

B. Hot Poured Elastic Type.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 5 lb. sample representing each lot or batch will be taken from the application wand during the sealing process. The sample will be placed in a Teflon or silicone lined box having a minimum capacity of 5 lbs. (DOT-1)

Back

None required for contract quantities of 200 lbs. or less.

(4) Independent Assurance.
None required.

C. Backer Rod (Hot Pour).

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 2 ft. length submitted with the joint material. (DOT-1)

None required if less than 200 lbs. of sealant is used, acceptance will be based on Visual Inspection, for size and type.

(4) Independent Assurance.
None required.

D. Silicone.

(1) Tier 2.

(2) Certification.
Item used must be on the Approved Products List.

(3) Acceptance.
One component silicone: One 1 pt. sample (In paint sample can) per lot, per source. (DOT-1)

In Place: 1 random sample approximately 3 in. in length will be cut per 1/10 mile of roadbed from the in place material to check bonding, width, thickness, shape and non-adherence to backer rod. The results of these measurements will be documented. (DOT-10)

Test cannot fail bond check that is performed in less than 7 days.

Acceptance samples of silicone or in place tests are not required for projects that have 500 ft. or less of joints to be sealed, provided basis of acceptance is documented.

(4) Independent Assurance.
None required.

E. Backer Rod (Silicone).
(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

Back

5.7 Keyways.

A. Material.
(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection of dimension measurements.

(4) Independent Assurance.
None required.

6. Portland Cement Concrete Structure Construction:

General Notes:
When specified, the Contractor will design and be responsible for the performance of all concrete mixes used for structural concrete. The mix design data and support information for each mix will be reported to the Concrete Engineer on a DOT-24.

Quality, acceptance and independent assurance (IA), sampling, testing, and certification of the aggregates, admixtures, etc. used in Contractor mix design concrete will be performed by DOT personnel in accordance with the provisions of this section as they are incorporated into the work.

The Department will continue to perform job mix designs for special Portland cement concrete structural construction. The designs will be formulated and tested in the Central Laboratory. The following material quantities for this testing will be submitted to the Central Laboratory in bags no larger than 80 lbs. or buckets no larger than 5 gallons

Fine aggregate	750 lbs.
Coarse aggregate	1,100 lbs.*
Cement**	210 lbs.
Fly Ash***	65 lbs.
Air Entraining Agent	8 oz.
Water Reducing Agent(s)	32 oz.

Back

*A minimum of 300 lbs. for each size.

** A complete Certified Chemical Analysis and Physical Test Report are required for cement other than GCC Dacotah Rapid City.

*** A complete Certified Chemical Analysis and Physical Test Report are required for fly ash.

Samples of new aggregate sources or sources not tested within the last 5 years will be submitted to the Central Laboratory at least 40 days prior to use.

Quality tests and other special tests on aggregates that require equipment not available at the Region Materials Laboratory and field labs will be made in the Central Laboratories on samples representing each 31,500 yd^3.

For quarried ledge rock aggregate that has a satisfactory quality record and has been used in concrete for five years or more, the quality test requirements may be reduced to once per year.

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The sample sizes for Quality tests are as follows: Sand, 30 lbs.; limestone, quartzite, or granite, 60 lbs. (DOT-1)

For contract quantities less than 10 yd^3 of concrete, certification and acceptance will be as per Section 7.1.A., except one air content determination, one slump test, and one set of cylinders per source. (DOT-23).

6.1 Materials.

A. Aggregate, Fine and Coarse.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per 200 yd^3 of concrete for each size and source. Fine and coarse aggregate will be sampled and tested simultaneously. (DOT-3)

Resampling because of a deviation from specifications of one of the aggregates requires resampling and retesting of only that material which failed.

When 100% of the material used in the coarse aggregate is ledge rock material, lightweight particle testing is not required.

(4) Independent Assurance.
One sample for each size. None required for contract quantities less than 100 yd^3 of concrete. Lightweight particle test will not be required for coarse aggregate.

Back

B. Aggregate, Fine and Coarse, Moisture Content.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One sample per day for each size, prior to beginning of production, and additional samples not to exceed 200 yd^3. (DOT-35)

Not required on low slump deck overlays.

Moisture testing may be reduced by the Engineer when automated concrete batching equipment with fine aggregate, or fine and coarse aggregate, moisture sensing capability is used. When only fine aggregate moisture sensors are used, the concrete plant will use a coarse aggregate moisture (DOT-98A) acceptable to the Engineer. Any moisture sensor will be accurate to 1.0% of the aggregate total moisture.

When the moisture testing is reduced, a moisture test for each size of aggregate will be made at the start of production and every 10,000 yd^3 or one per month, whichever happens first.

(4) Independent Assurance.
None required.

C. Cement.

(1) Tier 2.

(2) Certification.
From a certified supplier: None required.
From a non-certified supplier: A Certificate of Compliance is required for each acceptance sample obtained.

(3) Acceptance.
One sample per type for each contract. Two 4 lb. samples. (DOT-1)

None required for contract quantities less than 50 yd^3.

(4) Independent Assurance.
None required.

D. Water.

(1) Tier 3.

(2) Certification.
None required.

Back

(3) Acceptance.
One 8 oz. sample in a plastic container per source prior to use. Frequency of testing thereafter to be determined by any changes (Runoff, growth of algae, etc.) affecting the source. (DOT-1)

Testing is not required for water from municipal supplies except in the north part of the Rapid City Region (Contact the Region Materials Engineer regarding this area).

(4) Independent Assurance.
None required.

E. Chemical Admixtures (Includes Air Entraining, Water Reducer, Accelerators, Retarders, etc.).

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 8 oz. sample in a plastic or glass container per type, lot, and source. (DOT-1)

Material must be thoroughly stirred, air agitated, or otherwise properly mixed to disperse all settlement just prior to sampling.

(4) Independent Assurance.
None required.

F. Fly Ash.

(1) Tier 2

(2) Certification.
A Certificate of Compliance is required for each acceptance sample obtained.

(3) Acceptance.
One randomly selected 4 lb. sample per contract. (DOT-1)

None required for contract quantities less than 50 yd^3 of concrete. A certificate of compliance for each conveyance the sample represents must be submitted with each sample.

(4) Independent Assurance.
None required.

6.2 Strength Tests.

A. Compressive Strength.

(1) Tier not applicable.

Back

(2) Certification.
None required.

(3) Acceptance.
One set of cylinders (Made from the same batch of concrete) per 200 yd^3 of concrete, per day for each class of concrete from each plant.

Strength tests for bridge deck concrete will be 1 per 100 yd^3 of concrete per day. (DOT-23)

A set of cylinders will consist of a minimum of 4 cylinders. Two cylinders will be used for compressive strength at 28 days (One cylinder is tested at 28 days and the other is saved for the backup). The other two cylinders will be used for early breaks (Normally at seven and 14 days). If additional early breaks are desired or required, additional cylinders must be made.

It is recommended that cylinders be used to determine the attained strength of the hardened concrete. The impact test hammer may be used to determine the attained strength of hardened concrete for permitting traffic use and for comparative or confirmation tests. (DOT-9) When possible, the impact hammer should be tested on a concrete cylinder prior to breaking and adjust the correction factor for the comparative or confirmation tests.

(4) Independent Assurance.
None required.

6.3 Fresh (Plastic) Concrete Tests.

A. Air Content, Unit Weight, Slump, and Temperature.

(1) Tier not applicable.

(2) Certification.
Drilled Shaft Construction Report (DOT-297).

(3) Acceptance.
Air content, unit weight, slump, and temperature determinations will be made each time a cylinder for compressive strength determination is made. Additional determinations will be made to ensure proper control, and not less than one determination for each 2 hours of mixing-placing operations. (DOT-23)

Additional determinations for air content, unit weight, slump, and temperature will be made for each one hour of mixing-placing operations on bridge decks.

Drilled Shaft:

Back

Fresh Concrete tests will be made on every load of concrete before it is placed. When a pour of 18 cu. yds. or less is made, all concrete will be on site and the concrete in each conveyance will be tested before any concrete is placed.

Self-Consolidating Concrete (SCC):

First Truckload: The following fresh (plastic) concrete tests will be performed on the concrete from the first truckload of any individual concrete placement.

Slump Flow and VSI, J-Ring, Temperature, Air Content, and Unit Weight.

Subsequent Truckloads: After the first truckload, fresh (plastic) concrete tests will be performed on the concrete from all subsequent truckloads at the following frequency:

Slump Flow and VSI: Slump flow spread will be tested at a rate of every other conveyance.

J-Ring: J-Ring will be tested at a rate of one out of every four conveyances.

The Slump Flow and the J-Ring tests will be performed on the same conveyance. The tests will be performed concurrently or subsequently with no more than six minutes elapsed time between the slump flow and J-ring tests.

Temperature: Temperature will be tested at a rate of one out of every four conveyances.

Air Content and Unit Weight: Air content and unit weight will be tested at a rate of one out of every four conveyances. Additional determinations will be made if more than 2 hours has passed from the previous test.

(4) Independent Assurance.
One air content, unit weight, slump, and temperature determination per contract. None required for contract quantities less than 100 yd^3 of concrete. (DOT-23) The slump tests may be by observation of acceptance tests.

Self-Consolidating Concrete (SCC) - Slump flow, visual stability index, and J-ring testing may be by observation of acceptance tests.

6.4 Curing Materials.

A. Liquid Membrane Curing Compound.
(1) Tier 2.

(2) Certification.
APL: None required.

Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 8 oz. sample in a plastic or glass container per type, lot, and source. Sampling will occur from the end of the spray nozzle. (DOT-1)

(4) Independent Assurance.
None required.

B. Burlap.
(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

C. Film (Sheet Materials Including Waterproof Paper, Polyethylene Sheeting, White Burlap-Polyethylene Sheeting, etc.).
(1) Tier 3.

(2) Certification.
None required.

Back

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

6.5 Joint Materials.

A. Strip Seal and Preformed Elastomeric Open Cell Compression Type with Lubricant/Adhesive.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required for both the joint seal and lubricant/adhesive.

(3) Acceptance.
Documented Visual Inspection for correct size, shape, etc.

(4) Independent Assurance.
None required.

Back

B. Preformed Expansion Type (Includes Non-Extruding and Resilient Bituminous and Non-Bituminous Types).

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample at least 6 in. x 36 in. x full thickness. The sample must be packaged to prevent distortion or breakage in handling and shipment.

None required for contract quantities less than 25 ft^2; acceptance will be based on Visual Inspection, for size and type.

(4) Independent Assurance.
None required.

C. Hot Poured Elastic Type.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 5 lb. sample representing each lot or batch will be taken from the application wand during the sealing process. The sample will be

placed in a Teflon or silicone lined box having a minimum capacity of 5 lbs. (DOT-1)

None required for contract quantities of 200 lbs. or less.

(4) Independent Assurance.
None required.

D. Silicone.

(1) Tier 2.

(2) Certification.
Item used must be on the Approved Products List.

(3) Acceptance.
Documented Visual Inspection to verify that the item used is on the Approved Products List and that installation is in accordance with plan details.

(4) Independent Assurance.
None required.

Back

E. Backer Rod.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
Documented Visual Inspection to verify that the item used is on the Approved Products List and that installation is in accordance with plan details.

(4) Independent Assurance.
None required.

6.6 Commercial Textured and Special Surface Finish.

A. Materials.

(1) Tier 2.

(2) Certification.
Item used must be on the Approved Products List.

(3) Acceptance.
Documented Visual Inspection to verify that the item used is on the Approved Products List and that installation is in accordance with plan details.

(4) Independent Assurance.
None required.

6.7 Abutment Backwall Coating.

A. Materials.

(1) Tier 2.

(2) Certification.
Item used must be on the Approved Products List.

(3) Acceptance.
Documented Visual Inspection to verify that the item used is on the Approved Products List.

(4) Independent Assurance.
None required.

6.8 Measurement of Texture.

A. Tined Surface.

(1) Tier not applicable.

(2) Certification.
None required.

Back

(3) Acceptance.
One per structure, per pour. (SD 418) (DOT-55)

(4) Independent Assurance.
None required.

6.9 Measurement of Deck Roughness.

A. Surface.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
On projects where profilograph tests are required, coordinate with the contractor. Operation of the profilograph is the responsibility of the contractor. Calibration of the profilograph is required.

When profilograph testing is not required, test in accordance with SD 417. (DOT-29)

(4) Independent Assurance.
None required.

7. Portland Cement Concrete Miscellaneous Construction - Class M:

7.1 Materials and Plants.

A. Requirements.

(1) Tier 2.

(2) Certification.
Prior to placement, each supplier of Portland cement concrete, “Class M”, will furnish the Area Engineer with a signed statement certifying that the “Class M” concrete meets specification requirements (DOT-57).

None required if material is listed on “Concrete Pipe Release Dates” report.

(3) Acceptance.
One air content determination, one slump test, and one set of cylinders per source. (DOT-23)

Self-Consolidating Concrete: One air content, slump flow, visual stability index, J-ring, temperature of fresh concrete, and one set of cylinders per placement. Additional determinations may be made to ensure proper control of mixing-placing operations (DOT-23).

Back

None required for contract quantities less than 50 yd^3 of concrete.

Visual Inspection required if less than 50 yd^3 24

None required if material is listed on “Concrete Pipe Release Dates” report

(4) Independent Assurance.
None required.

B. Preformed Expansion Type Joint Material (Includes Non-Extruding and Resilient Bituminous and Non-Bituminous Types).

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample at least 6 in. x 36 in. x full thickness. The sample must be packaged to prevent distortion or breakage in handling and shipment. (DOT-1)

None required for contract quantities less than 25 ft^2; acceptance will be based on Visual Inspection, for size and type.

(4) Independent Assurance.
None required.

8. Roadway Lighting and Traffic Control:

General Notes:

If the acceptability of any item is questionable, the Region Traffic Engineer will be notified. He may request a sample be submitted for approval, may make an inspection, or may approve the item by other means.

Where the specifications contain the "Or equal" clause, it is understood that other makes of equal size, quantity, quality, and performance may be accepted if approved by the Region Traffic Engineer prior to installation.

8.1 Materials.

A. Standard Items of Electrical Equipment.

Circuit breakers
Conduit, sleeves, couplings, and fittings
Dry type transformers, etc.
Electric cables (Conductor)
Fused Y connector kits
In-line fuse holder connectors
Weatherproof cases with multiple contactors and fuses

Back

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection for stamps or markings indicating size, type, and approval by UL, IPCEA, NEMA, or other recognized agency. It will also be ascertained and documented that the items are the correct size and type for the intended use.

(4) Independent Assurance.
None required.

B. Miscellaneous Hardware Items.

Electrical junction boxes (not on APL).
Ground rods and clamps

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection to verify that the items are of adequate size and compatible type for the intended use.

(4) Independent Assurance.
None required.

C. <u>Items that are on the Approved Products List</u>.

Detector Loop Sealer.
Detector Unit
Electrical Junction Box
MASH Compliant Pedestal Signal Pole
MASH Compliant Pedestrian Push Button Pole
Pedestrian Push Buttons
Photoelectric Cells.
Traffic Signal Controller - TS2
Video Detection Systems

(1) Tier 2.

(2) Certification.
Item used must be on the Approved Products List.

(3) Acceptance.
Documented Visual Inspection to verify that the item used is on the Approved Products List. If the identification is doubtful or the item is not on the list, the Region Traffic Engineer will be notified, and his approval of the item requested.

Back

(4) Independent Assurance.
None required.

D. <u>Items Requiring Approval of Catalogue Cuts or Shop Drawings</u>.

Anchor Bolts
Battery Backup System for Traffic Signal
Detector units (Not on APL)
Emergency Preemption Unit
Fiber Optic Cable
Lowering Devices
Luminaires
Optical Detector
Pedestal Signal Poles (Not on APL)
Pedestrian Push Buttons (Not on APL)
Pedestrian Push Button Pole (Not on APL)
Pre-formed Detector Loops (When factory made and not fabricated by the Contractor in accordance with plan details)
Radar Detection Systems
Rectangular Rapid Flashing Beacon
*Signal and Luminaire poles
Signal heads and accessories
Solar Powered Flashing Beacon
Traffic Signal Controllers and accessories (Not on APL).
Transmitter and Receiver units and accessories.
Video Detection Systems (Not on APL)
Wireless In-pavement Detection Systems

*Signal and lighting poles (Listed here as a “Tier 1” material only to satisfy the requirement that Shop Drawings and Registered PE Certificate must be approved prior to fabrication. See following page for Umbrella Certification requirements for these materials).

(1) Tier 1.

(2) Certification.
Prior to installation, the Contractor will submit catalogue cuts or shop drawings (5 copies) to the Traffic Design Engineer for review. Approved catalogue cuts and shop drawings will be forwarded to the Area Engineer.

(3) Acceptance.
Documented Visual Inspection to ensure that the items delivered for use on the project are the same as indicated by the catalogue cuts or shop drawings and that the items have not been damaged by shipping and handling.

(4) Independent Assurance.
None required.

Back

E. <u>Items Requiring an Umbrella Certificate for the Material</u>.
Fixed and breakaway bases.
Mast arms and luminaires extensions.
Signal and lighting poles.
Span wire and pole clamps.
Transformer bases.

(1) Tier 2

(2) Certification.
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certified Copy of the Mill Test Report for castings, and structural and tubular sections showing both physical and chemical properties.

(3) Acceptance.
Documented Visual Inspection for correct size, obvious defects in fabrication, shipping, and handling damage, etc.

(4) Independent Assurance.
None required.

9. Erosion and Sediment Control

9.1 Materials.

A. Erosion Control Devices
   (1) Tier 3.

   (2) Certification.
   APL: None required.
   Non-APL: A Certificate of Compliance is required.

   (3) Acceptance.
   Documented Visual Inspection.

   (4) Independent Assurance.
   None required.

B. Fertilizer.
   (1) Tier 2.

   (2) Certification.
   A Bill of Lading, bag label, tag, or other document is required to confirm name and address of manufacturer, brand, grade, and a guaranteed analysis showing minimum percentages of total nitrogen, available phosphoric acid, and water soluble potash.

   None required for contract quantities less than 500 lbs.

   (3) Acceptance.
   None required.

   (4) Independent Assurance.
   None required.

C. Fiber Mulch.
   (1) Tier 2.

   (2) Certification.
   A Certificate of Compliance is required.

   (3) Acceptance.
   Documented Visual Inspection to verify that the packages are marked by the manufacturer with air dry content.

   (4) Independent Assurance.
   None required.

D. Seeds.
   (1) Tier 2.

Back

(2) Certification.
A Certificate of Seed Analysis or Certified Test Report for each lot of seed to be used on the project. Certification is not required on projects requiring 100 lbs. of seed or less.

(3) Acceptance.
Field obtained seed samples for determination of South Dakota noxious weeds will be taken at the following frequency: (SD 512) (DOT-1)

0 to 500 lbs.	None required
500 to 1,000 lbs.	One sample
every 1,000 lbs. thereafter	One sample

Samples taken to satisfy the requirements shown above will be tested for South Dakota noxious weed content only. SDSU seed laboratory will randomly select a number of these samples per year and do a detailed analysis. The random selection will be influenced by possible irregularities noted while conducting the noxious weed checks.

Back

Documented Visual Inspection to ensure that the seed bag tags are from the same lot covered by the Certification.

(4) Independent Assurance.
None required.

E. Mulch.
(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Visual Inspection.

(4) Independent Assurance.
None required.

F. Mycorrhizal Inoculum.
(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required.

(3) Acceptance.
None Required.

(4) Independent Assurance.
None required.

10. Buildings and Rest Area Construction:

General Notes:

Minimum Sample and Test Requirements (MSTR), listed in other sections of this manual, will apply when the same material items are used for the construction in this section. This refers to material items such as Portland cement concrete, reinforcing steel, seeding, fencing, and any other items appearing elsewhere in this manual.

Where the specifications contain the "Or equal" clause, it is understood that other makes of equal size, quantity, quality, and performance may be accepted, if approved by the Area Engineer prior to use.

Shop drawings, brochures, and schedules, used as a basis for approval, must be submitted in accordance with specifications to the Central Office for review and approval. Items accepted based on certification, brochures, or shop drawings will be visually inspected in the field to verify compliance with requirements. Documentation of this inspection will be made in the diary. Documented inspection will also be made on items accepted based on labels, identification tags, or other means.

10.1 Materials.

Back

A. Brick.
  (1) Tier 3.

  (2) Certification.
  None required.

  (3) Acceptance.
  Documented Visual Inspection to verify that units are sound and free from cracks and other defects.

  (4) Independent Assurance.
  None required.

B. Insulation.
  (1) Tier 3.

  (2) Certification.
  None required.

  (3) Acceptance.
  Documented Visual Inspection.

  (4) Independent Assurance.
  None required.

C. Building Block (Hollow or Solid).
  (1) Tier 3.

  (2) Certification.
  None required.

(3) Acceptance.
Documented Visual Inspection to verify that units are sound and free from cracks and other defects.

(4) Independent Assurance.
None required.

D. Basin and Manhole Block.
(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection to verify that units are sound and free from cracks and other defects.

(4) Independent Assurance.
None required.

Back

E. Miscellaneous Hardware Items.
Faucets, copper pipe, and fittings.
Light fixtures and other electrical items.
Lock sets, hinges, and door closures.
Other plumbing items and fixtures, etc.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection for stamps or markings indicating size, type, and approval by UL, NEMA, or another industry recognized agency. It will also be ascertained and documented that the items are the correct size and type for the intended use.

(4) Independent Assurance.
None required.

11. Miscellaneous Incidental and Manufactured or Fabricated Items:

11.1 Aluminum.

A. <u>Cast, Framing, Handrail, Hardware, and Sheet (Includes Extruded Types)</u>.

(1) Tier 2.

(2) Certification.
A Certified Copy of the Mill Test Report showing the chemical and physical tests for each heat or lot number.

(3) Acceptance.
Documented Visual Inspection for measurements.

(4) Independent Assurance.
None required.

11.2 Bearing Pads.

A. <u>Bronze or Copper</u>.

(1) Tier 2.

Back

(2) Certification.
A Certificate of Compliance is required for each type and source.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

B. <u>Elastomeric</u>.

(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required for each source.

When furnished by pre-stressed fabricator - Umbrella Certification. (DOT-99)

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

C. <u>Preformed Fabric.</u>

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
One sample per source. Sample size: 6 in. x 6 in. x full thickness. (DOT-1)

(4) Independent Assurance.
None required.

11.3 Bolt Assemblies (Bolts, Nuts, Washers, and Direct Tension Indicators)

A. High-Strength Bolts

(1) Tier.

(a) ASTM F3125 grades A325 and A490 high-strength bolt assemblies used on steel girder or truss bridges. Tier 1.

(b) All other bolt assemblies not covered by the provisions in (a) above. Tier 2.

(2) Certification.

(a) Bolt assemblies.
A Certified Copy of the Mill Test Report.

Back

(b) Bolt assemblies used in guardrail, signing and lighting
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certified Copy of the Mill Test Report.

A307 bolts including guardrail bolts, eye bolts, ribbed, and unfinished used in non-critical applications may be accepted in the Certification Office by Certificate of Compliance.

(3) Acceptance.

(a) Grade A325 high-strength bolt assemblies used on steel girder or truss bridges.

I. Rotational capacity.

One sample of three bolt assemblies (Excluding direct tension indicators - DTI) for each bolt diameter, length, and lot number, tested for rotational capacity in accordance with SD 507. (DOT-96)

A bolt assembly is defined as a bolt, nut and washer(s) that are from the same rotational capacity lot # as is to be used in the work and as tested by the Supplier.

II. Direct tension indicator (DTI).

One sample of three direct tension indicator bolt assemblies for each diameter, length and lot number of bolt and for each lot number of direct tension indicator, tested in accordance with SD 503. (DOT-96). For bolts defined as short bolts in SD 503, an additional three direct tension indicator bolt assemblies with bolts meeting the minimum length requirements specified in the Short Bolts for DTI Testing table, will be furnished.

A direct tension indicator bolt assembly is defined as a bolt, nut, washer(s) and direct tension indicator that are from the same lot as is to be used in the work.

(b) All other bolt assemblies Documented measurements and Visual Inspection for size markings and coating.

(4) Independent Assurance.
None required.

B. Anchor Bolts, Nuts and Washers.
(1) Tier 1.

(2) Certification
A Certified Copy of the Mill Test Report.

Back

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

C. Tie Bolts (Precast Box Culvert and Reinforced Concrete Pipe)
(1) Tier 2.

(2) Certification.
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certified Copy of the Mill Test Report.

(3) Acceptance.
Documented measurements and Visual Inspection.

(4) Independent Assurance.
None required.

11.4 Bridge Deck Drains / Abutment Joint Drains.

A. Material.
(1) Tier 2.

(2) Certification.
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce for each component either a Certified Copy of the Mill Test Report or a Certificate of Compliance.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

11.5 Bridge Paint.

A. Bridge Paint and Primer.

(1) Tier 2

(2) Certification.
Item used must be on the Approved Products List unless otherwise specified.

(3) Acceptance.
None.

Back

(4) Independent Assurance.
None required.

B. Bridge Field Painting – Surface Preparation.

(1) Tier 3

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection when steel is abrasive blast cleaned.

(4) Independent Assurance.
None required.

C. Bridge Field Painting – Paint Application.

(1) Tier 3

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection of dry film thickness (DFT).

(4) Independent Assurance.
None required.

11.6 Castings and Cast Iron.

A. Bridge Hardware.
(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required for each source.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

B. Drop Inlet Frames, Grates, Box Curb Assemblies, etc.
(1) Tier 2.

(2) Certification.
Item used must be from an Approved Products List manufacturer.

(3) Acceptance.
Documented Visual Inspection for manufacturer, size, and type.

Back

(4) Independent Assurance.
None required.

C. Grid Floor.
(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required for each source.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

11.7 Cattle Guards.

A. Material.
(1) Tier 2.

(2) Certification.
A Certified Copy of the Mill Test Report

(3) Acceptance.
Documented Visual Inspection and measurements.

(4) Independent Assurance.
None required.

11.8 Chloride.

A. Calcium, Sodium, and Magnesium.

(1) Tier 2.

(2) Certification.
A Bill of Lading is required for each source per shipment.

(3) Acceptance.
Granular formulation: One 3 lb. sample per shipment in a metal, plastic, or glass container. (DOT-1)

Liquid formulation: One 8 oz. sample per shipment in a plastic or glass, air-tight container. (DOT-1)

Randomly select three approximately equal portions to make the composite sample.

(4) Independent Assurance.
None required.

11.9 Controlled Density Fill/Flowable Fill.

Back

A. Material.

(1) Tier 2.

(2) Certification.
Prior to furnishing, the supplier of controlled density fill will provide the Area Engineer with a signed statement certifying that the controlled density fill meets the specification requirements. (DOT-77)

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

11.10 Drainage Fabric.

A. Material.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

When supplied by pre-cast fabricator - Umbrella Certification. (DOT-99)

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

11.11 Epoxy-Resin Adhesive.

A. Material.

(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required for each type and source.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

11.12 Fencing.

A. Barb and Smooth Wire.

(1) Tier 2.

Back

(2) Certification.
A Certificate of Compliance including the statement "Melted and Manufactured in the United States".

(3) Acceptance.
One sample per 50 spools. Sample length to contain 6 barbs. (DOT-1)

None required if less than 500 lineal feet of a fence type is used on a contract. Acceptance will be based on documented Visual Inspection for wire gauge, barbs, and coating.

(4) Independent Assurance.
None required.

B. Chain-Link System (Includes Fabric, Posts, Rails, Fittings, and Hardware).

(1) Tier 2.

(2) Certification.
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certificate of Compliance for each source.

(3) Acceptance.
For fabric, one sample per 50 rolls. Sample length will be full vertical section containing 6 vertical wires. (DOT-1)

None required if less than 500 lineal feet of a fence type is used on a contract. Acceptance will be based on documented Visual Inspection for gauge and coating.

For chain-link posts, rails, fittings, and hardware, acceptance will be based on documented Visual Inspection for size and coating.

(4) Independent Assurance.
None required.

Back

C. <u>Woven Wire</u>.
(1) Tier 2.

(2) Certification.
A Certificate of Compliance including the statement “Melted and Manufactured in the United States”.

(3) Acceptance.
One sample per 50 rolls. Sample length will be 3 ft. containing 3 stay [vertical] wires. (DOT-1)

None required if less than 500 lineal feet of a fence type is used on a contract. Acceptance will be based on documented Visual Inspection for gage, spacing, and coating.

(4) Independent Assurance.
None required.

D. <u>Brace Wire</u>.
(1) Tier 2.

(2) Certification.
A Certified Copy of the Certificate of Compliance including the statement “Melted and Manufactured in the United States”.

(3) Acceptance.
Documented Visual Inspection for gage and coating.

(4) Independent Assurance.
None required.

E. <u>Miscellaneous Fasteners, Staples, Ties, etc.</u>
(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection for measurement, size, and coating.

(4) Independent Assurance.
None required.

F. Gates (Tubular Frame).

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection for size, gauge, and coating.

(4) Independent Assurance.
None required.

G. Steel Posts.

(1) Tier 2.

(2) Certification.
A Certified Copy of the Certificate of Compliance stating, “Melted and Manufactured in the United States”.

(3) Acceptance.
One lot of 5 posts per 1,000 of each size, per source will be inspected in the field for length and weight and the results documented. (Miscellaneous Test Document)

Back

(4) Independent Assurance.
None required.

H. Wood Posts.

(1) Tier 2.

(2) Certification.
Job site accepted posts: A Certificate of Compliance covering posts, preservatives, and treatment is required.

Plant site accepted posts: None required.

(3) Acceptance.
Job site accepted posts: One sample per charge or shipment. Sample size: A minimum of 20 cores taken approximately midpoint of the posts. No more than one core per post is permitted. The minimum core length will be a minimum of half the diameter of the posts. (DOT-1)

If contract quantities are less than 100 post acceptance will be based on documented Visual Inspection for size, soundness, and straightness

Plant site accepted posts: For bundled posts, the State Inspector must retrieve the tag and send it to the Certification Engineer with documentation of the date, tag number(s), number of posts, size of posts, and the name of the supplier. Each bundle that has a DOT numbered tag may be accepted without further testing. (DOT-1)

If contract quantities are less than 100 posts, bundle tags are not required; however, Visual Inspection for size and type will be documented to verify that the posts came from a certified supplier.

Bundles received that are not tagged must be sampled at the job site. Posts should not be used until satisfactory test results are received.

(4) Independent Assurance.
None required.

11.13 Gabion Baskets.

A. Material.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One sample per shipment and source when baskets are fabricated in the field. Sample size: One 2 ft. section of the wire basket material. (DOT-1)

Back

Documented Visual Inspection of gabions for dimensions, gauge of wire mesh and tie wires, tie spacing, etc.

None required for prefabricated gabions.

(4) Independent Assurance.
None required.

11.14 Mailbox Assemblies.

A. Material.

(1) Tier 2.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection.

Visual Inspection will document that the post support assembly used is 1) an approved product, 2) 4” x 4” square or 4” round wood post (As per standard plate), or 3) an alternate approved by the Engineer prior to installation. If an alternate support assembly is to be utilized, the Contractor will provide written certification that the alternate mailbox support assembly meets the test level 3 crash testing requirements of NCHRP 350 or MASH. Visual Inspection will also document that the post support assembly utilized was installed in accordance with the standard plate and/or the manufacturer's installation instructions.

(4) Independent Assurance.
None required.

11.15 MSE/Geotextile Fabric.

A. <u>Material</u>.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

Material Certification obtained from supplier should be submitted with sample.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

Back

11.16 Pavement Markings

A. <u>Traffic Marking Paint</u>

(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required per type, source and lot. (It may be in the form of a manufacturer's certified analysis from the label on the container.)

(3) Acceptance.
One 1 pt. sample per type, source, and lot. (DOT-1)

None required for contract quantities less than 20 gal.

No sample required on epoxy paint.

(4) Independent Assurance.
None required.

B. <u>Permanent Plastic Pavement Markings.</u>

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
Field inspection documenting that the materials and installation procedures are in accordance with manufacturer's recommendations.

(4) Independent Assurance.
None required.

C. Reflective Media.
(1) Tier 3.

(2) Certification.
A Certificate of Compliance is required for each type of media.

(3) Acceptance. 24
None required.

(4) Independent Assurance.
None required.

11.17 Piling.

Back

A. Pre-Cast and Pre-Stressed Concrete.
The Minimum Sample and Test Requirements (MSTR) outlined in paragraph 11.21 will apply.

B. Steel Beam or Sheet (Includes Corrugated Pipe).
(1) Tier 2.

(2) Certification.
A Certified Copy of the Mill Test Report for each heat or lot number. Pile Reports (DOT-203 & DOT-204).

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

C. Timber (Treated).
(1) Tier 2.

(2) Certification.
A Treatment Certificate from the treating plant showing analysis of treating agent, the retention, and depth of the penetration.

Prior to driving operations, the inspector will verify that the Treatment Certificate represents the actual piling shipped.

Each piling will be tagged or stamped with a number, such as a charge number. This number will also appear on the Treatment Certificate.

The Treatment Certificate will state where the stamps and tags are located on the piling.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

D. Piling Shoes.
(1) Tier 3.

(2) Certification.
A Certified Copy of the Mill Test Report for each heat or lot number. 24

(3) Acceptance.
Documented measurements and Visual Inspection.

(4) Independent Assurance.
None required.

Back

E. Pile Tip Reinforcement.
(1) Tier 3.

(2) Certification.
A Certified Copy of the Mill Test Report for each heat or lot number. 24

(3) Acceptance.
Documented measurements and Visual Inspection.

(4) Independent Assurance.
None required.

11.18 Pipe.

A. Concrete.
(1) Tier 2.

(2) Certification.
None required.

(3) Acceptance.
The Central Testing Laboratory will periodically load test each size and type at the plant or perform compressive strength tests on cylinders made by the manufacturer. The type and quantity of testing is at the discretion of the Central Testing Laboratory. Results will be documented in the form of a Concrete Pipe Release Date report.

Prior to installation, a documented field inspection for valid release dates, defects, or damage will be made.

If the pipe is 84” or larger, it will be inspected and tested in accordance with 11.21 F

One sample for each size and source of fine and coarse aggregate will be sampled and tested for quality and sieve analysis annually. (DOT-1, DOT-3)

(4) Independent Assurance.
None required.

B. Corrugated Metal.
(1) Tier 2.

(2) Certification.
APL: None required.

Non-APL: Shipping list showing fabricator, size, gauge, heat numbers, quantity (Including end sections); and Certified Mill Test Reports for all metal used in fabrication of the culvert.

(3) Acceptance.
APL: Documented Visual Inspection for size, gauge, and heat number.

Back

Non-APL: One sample for each heat number and gauge. Sample size: three pieces, each at least 2 1/4 in. x 2 1/4 in. (DOT-1)

Documented Visual Inspection for size, gauge, and heat number.

(4) Independent Assurance.
None required.

C. PVC.
(1) Tier 2.

(2) Certification. 24
Certificate of compliance is required.

(3) Acceptance.
Documented Visual Inspection for manufacturer, size, and type.

(4) Independent Assurance.
None required.

D. Polyethylene
(1) Tier 2.

(2) Certification.
APL: None required.

Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
Documented Visual Inspection for manufacturer, size, and type.

(4) Independent Assurance.
None required.

E. High-Density Polyethylene.

(1) Tier 2

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
Documented Visual Inspection for manufacturer, size, and type.

(4) Independent Assurance.
None required.

F. Steel Pipe

(1) Tier 2

Back

(2) Certification.
A Certified Copy of the Mill Test report for each heat or lot number will be furnished.

A Certificate of Compliance for the coating.

(3) Acceptance.
Documented Visual Inspection for size, and type.

(4) Independence Assurance.
None required.

G. HDPE Slip Line Pipe

(1) Tier 2.

(2) Certification.
Certificate of Compliance is required.

(3) Acceptance.
Documented Visual Inspection for size, and type.

(4) Independent Assurance.
None required.

11.19 Polyethylene Sheeting.

A. Material.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

11.20 Polymer Modified Asphalt Growth Joint and Asphalt Bridge Joint.

A. Joint System.

(1) Tier 2.

(2) Certification.
Item used must be on Approved Products List.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

Back

B. Binder.

(1) Tier 2.

(2) Certification.
Certificate of Compliance.

(3) Acceptance.
None required

(4) Independent Assurance.
None required.

11.21 Pre-cast and Pre-stressed Concrete.

If the Contractor proposes to utilize an out of state supplier to fabricate pre-cast or pre-stressed concrete components, the Contractor will notify the Department and the components will be fabricated in accordance with the contract specifications. The Department may allow testing and certification quality control procedures to be performed in accordance with the other state Department's quality control procedures under a separate agreement between the two states.

A. Aggregate, Fine and Coarse.

(1) Tier 3

(2) Certification.
None required.

(3) Acceptance.
One sample per project for each size. Fine and coarse aggregate will be sampled and tested simultaneously. (DOT-3)

The moisture testing requirements on fine and coarse aggregate are waived in this application.

Resampling because of a deviation from specifications of one of the aggregates requires resampling and retesting of only that material which failed.

When 100% of the material used in the coarse aggregate is ledge rock, lightweight particle testing is not required. If independent assurance (IA) fails, acceptance testing will resume. 24

(4) Independent Assurance.
One sample per project for each size and source. None required if acceptance testing performed by Region Materials personnel. None required for contract quantities less than 100 $yd^{3.}$

A quality sample will be submitted for each size annually. This test may be shared throughout the year.

Back

B. Cement.
(1) Tier 2.

(2) Certification.
Umbrella Certification. (DOT-99)

(3) Acceptance.
One sample per type, per year, per plant. Annual sample from each plant may be shared throughout the year.

(4) Independent Assurance.
None required.

C. Chemical Admixtures (Includes Air Entraining, Water Reducer, Accelerators, Retarders, etc.).
(1) Tier 2.

(2) Certification.
Umbrella Certification. (DOT-99)

(3) Acceptance.
One sample per type, per year, per plant. Annual sample from each plant may be shared throughout the year.

(4) Independent Assurance.
None required.

D. Fly Ash.
(1) Tier 2.

(2) Certification.
A Certificate of Compliance is required for load sampled.

(3) Acceptance.
One sample per type, per year, per plant. Annual sample from each plant may be shared throughout the year.

(4) Independent Assurance.
None required.

E. Water.

(1) Tier 3.

(2) Certification.
None Required.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

Back

F. Concrete, Strength Tests.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Cylinders, to determine the release time for pre-stressing steel and that the minimum design compressive strength requirements are met, will be made by the fabricator, and witnessed by the Engineer or his representative (DOT-23, DOT-54).

The producer will ensure that the cylinders are cured under identical conditions for the same length of time as the precast units.

A group of test cylinders will be made for each line of precast units, for each pour, or for each curing chamber, whichever is less. In addition, one group of test cylinders will be made for each class of concrete for each day's production, not to exceed 150 cubic yards.

For beams a set of cylinders is to be made for each day's production, each set of cylinders is to represent a specific number of beams, but not to exceed 160 ft. of casting bed.

A group of test cylinders will consist of a minimum of four (4) cylinders to determine strength of concrete for prestress transfer and compressive strength of pre-cast items. Two will be used to determine design strength if contractor desires to deliver or obtain Acceptance prior to 28-day age and two for the 28-day tests (one back-up cylinder).

When tests of the cylinders above indicate at least minimum design compressive strength, the pre-cast or pre-stressed concrete items may be delivered, and the 28-day cylinder tests waived.

(4) Independent Assurance.
None required.

G. Fresh (Plastic) Concrete Tests. (Air Content, Unit Weight, Slump, and Temperature).

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
Air content, unit weight, slump and temperature of fresh concrete will be determined as required to maintain control and when strength test specimens are made (DOT-23, DOT-54).

Self-Consolidating Concrete (SCC):

Air Content, unit weight, slump flow, visual stability index, J-ring, and temperature of fresh concrete will be made each time a cylinder for compressive strength determination is made. Additional determinations will be made to ensure proper control, and not less than one determination for each 2 hours of mixing-placing operations (DOT-23).

Back

(4) Independent Assurance.
One per project.

H. Metal Components.

(1) Tier 2.

(2) Certification.

(a) Bars, plates, structural shapes, and anchorage assembly. A Certified Copy of the Mill Test Report for each heat number.

(b) Pre-stressing strands.
A Certified Copy of the Mill Test for each shipment.

(c) Reinforcing wire mesh.
A Certified Copy of the Mill Test for each shipment.

(d) Reinforcing bars.
Certification will be in accordance with paragraph 11.24 D.(2).

Umbrella Certification - (DOT-99) When pre-cast/pre-stressed components are fabricated within the State of South Dakota.

(3) Acceptance.
  (a) Bars, plates, structural shapes, and anchorage assembly.
  None required.

  (b) Pre-stressing strands.
  One sample per shipment. Sample size: One 2 ft. section.

  (c) Reinforcing wire mesh.
  None required.

  (d) Reinforcing bars.
  Acceptance will be in accordance with paragraph 11.24 D.(3).

(4) Independent Assurance.
None required.

11.22 Precast Concrete Products Miscellaneous.

This includes all Items listed on the DOT-54 form that are not class pipe or pipe ends. This also includes right-of-way monuments, drop inlets, manholes and other precast concrete products not covered under MSTR 11.17, 11.18, or 11.21.

Back

A. Material.
  (1) Tier 3.

  (2) Certification.
  None required.

  (3) Acceptance.
  Concrete
  The Central Testing Laboratory will perform compressive strength tests on cylinders made by the manufacturer and document the results in the form of a Concrete Pipe Release Date report.

  Prior to installation, a documented Visual Inspection for valid release dates, defects, or damage will be made. (DOT-214)

  One sample for each size and source of fine and coarse aggregate will be sampled and tested for quality and sieve analysis annually. (DOT-1, DOT-3)

  (4) Independent Assurance.
  None required.

11.23 Signing Materials.

A. Aluminum (Sheet and Extruded).
  (1) Tier 2.

  (2) Certification.
  Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certified Copy of the Mill Test Report.

(3) Acceptance.
Documented measurements and Visual Inspection.

(4) Independent Assurance.
None required.

B. Posts.
(1) Tier 2.

(2) Certification.
(a) Steel.
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certified Copy of the Mill Test Report.

(b) Wood.
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certificate of Compliance covering posts, preservative, and treatment for each type and source.

(3) Acceptance.
(a) Steel.
Documented measurements and Visual Inspection, as applicable, for coating, weight per foot, hole spacing, etc.

(b) Wood.
Prior to use, documented inspection and Visual Inspection for size, soundness, and straightness.

(4) Independent Assurance.
None required.

C. Reflective Sheeting.
(1) Tier 2.

(2) Certification.
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certificate of Compliance.

(3) Acceptance.
Documented Visual Inspection for type of sheeting.

(4) Independent Assurance.
None required.

Back

11.24 Steel.

A. Guardrail Cable.

(1) Tier 2.

(2) Certification.
Umbrella Certificate. (DOT-99)

If records are audited, the Contractor must produce a Certified Copy of the Mill Test Report.

(3) Acceptance.
Documented Visual Inspection for size and coating.

(4) Independent Assurance.
None required.

B. Smooth Dowel Bars (Includes Bars in Dowel Bar Assemblies).

(1) Tier 2.

(2) Certification.
A Certified Copy of the Mill Test Report for the steel, and when the bars are epoxy coated, a Certificate of Compliance stating that the coating material and coating process conforms to specifications.

Back

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

C. Support Baskets for Dowel Bars and Tie Bars.

(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

D. Reinforcing Bars, Deformed Dowel Bars, and Deformed Tie Bars.

(1) Tier 2.

(2) Certification.
From a certified supplier: None required.

From a non-certified supplier, all epoxy coated bars and stainless steel: A Certified Copy of the Mill Test Report showing the chemical analysis and physical properties for each heat or lot number will be furnished. Deliveries to the project will be identified by heat numbers, using metal or weather and wear resistant tags wired to the bundles.

A Certificate of Compliance stating that the epoxy coating, the coating process, and the quality/production report(s) conform to specifications.

(3) Acceptance.
One sample, two 24 in. lengths, per source, per project from a randomly selected size, (do not submit bars larger than #8 for testing) representing not more than 3 sizes or 3 heat numbers to be tested for physical properties in the Central Laboratory for all bars (Excludes black steel listed on the Approved Products List). (DOT-1)

From a certified supplier and for uncoated bars: Documented Visual Inspection for rust scales, proper grade markings, and signs of mishandling.

From a non-certified supplier, all epoxy coated bars and stainless steel: Documented Visual Inspection on delivery to the project including heat number, size, length, shape, and condition of shipment.

Back

On epoxy coated bars, check for voids, holes, cracks, and handling and shipping damage to epoxy coatings. Each bundle of steel will be marked with a metal or weather and wear resistant tag showing the heat number(s) represented. The tags will be secured to the appropriate bundles, so the heat numbers can be checked against the shipping papers and the Certified Mill Test Reports.

(4) Independent Assurance.
None required.

E. Wire Ties and Spacers.
(1) Tier 3.

(2) Certification.
None required.

(3) Acceptance.
Documented Visual Inspection.

(4) Independent Assurance.
None required.

F. Reinforcing Wire Mesh.
(1) Tier 3.

(2) Certification.
A Certified Copy of the Mill Test Report showing the chemical analysis and physical properties for each heat or lot number will be

furnished. Deliveries to the project will be identified by heat numbers, using metal or weather and wear resistant tags wired to the bundles.

(3) Acceptance.
Documented Visual Inspection for gage, spacing and coating.

(4) Independent Assurance.
None required.

G. <u>Structural (Includes Steel Bridge Girders, Trusses, Arches, Main Supporting Members, Steel Bridge Rail, Steel Diaphragms, Sign Bridges, Splice Plates and Bearings)</u>.

(1) Tier 1.

(2) Certification.
A Certified Copy of the Mill Test Report for each heat or lot number. Also, shop fabrication inspector's report certifying that material used is represented by the mill test.

(3) Acceptance.
Documented measurements and Visual Inspection for size and coating.

Back

(4) Independent Assurance.
None required.

H. <u>Miscellaneous Steel (Includes all steel not addressed in 11.24 G)</u>.

(1) Tier 2.

(2) Certification.
A Certified Copy of the Mill Test Report for each heat or lot number. Also, shop fabrication inspector's report (If applicable) certifying that material used is represented by the mill test.

(3) Acceptance.
Documented measurements and Visual Inspection for size and coating.

(4) Independent Assurance.
None required.

I. <u>Guardrail and Steel Guardrail Posts</u>.

(1) Tier 2.

(2) Certification.
Umbrella certificate. (DOT-99) Refer to 11.3.A for guardrail bolts.

If records are audited, the Contractor must produce a Certified Copy of the Mill Test Report.

(3) Acceptance.
Documented measurements and visual inspection for size, type, and coating.

(4) Independent Assurance.
None required.

J. <u>W Beam Guardrail Flared End Terminal, and W Beam Guardrail Tangent End Terminal</u>

(1) Tier 2

(2) Certification.
None required. Must be from APL.

(3) Acceptance
Documented Visual Inspection for size, type, and coating.

(4) Independent Assurance.
None required.

K. <u>High Tension Cable Guardrail</u>

(1) Tier 2

Back

(2) Certification.
Certificate of Compliance.

(3) Acceptance
Documented Visual Inspection for size, type, and coating.

(4) Independent Assurance.
None required.

L. <u>Insert Assemblies for Guardrail</u>.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certified Copy of the Mill Test Report.

(3) Acceptance.
Documented measurements and Visual Inspection for size, type, and coating.

(4) Independent Assurance.
None required.

M. <u>Rebar Splice</u>.

(1) Tier 2.

(2) Certification.
Certificate of Compliance.

(3) Acceptance.
Visual Inspection of epoxy coating when applicable.

(4) Independent Assurance.
None required.

N. Concrete Inserts.

(1) Tier 2.

(2) Certification.
Certificate of Compliance.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

11.25 Timber.

A. Structural.

(1) Tier 2.

Back

(2) Certification.
A Grade Certificate by a Certified Lumber Association inspector for each shipment.

A treatment certificate, if applicable, by the company applying the treating agent, for each shipment. The certificate will show analysis of treating agent, penetration, and retention. This certificate may be submitted as an "open file" so that subsequent shipments from the same treatment may be referred to the certificate on file by tagging or other means of identification.

A Certificate of Origin by the fabricator, jobber, or other supplier stating that the shipment of material furnished is that represented by the grade, or grade and treatment, certificate above.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

B. Guardrail Posts.

(1) Tier 2.

(2) Certification.
Job site accepted posts: A Certificate of Compliance covering posts, preservatives, and treatment is required.

Plant site accepted posts: None required.

(3) Acceptance.
Job site accepted posts: One sample per charge or shipment.

Sample size: A minimum of 20 cores taken approximately midpoint of the posts. No more than one core per post is permitted. The minimum core length will be 3 in. (DOT-1)

None required for contract quantities less than 20 posts.

Documented Visual Inspection for size, soundness, and straightness.

Plant site accepted posts: Bundled guardrail posts will have a round tag stamped "South Dakota Department of Transportation Inspected" and a number. In addition, each post will have "DOT" in 1/2 in. letters stamped on one end.

For bundled posts, the State inspector must retrieve the tag and send it to the Certification Engineer with documentation of the date, tag number(s), number of posts, size of posts, soundness, straightness and the name of the supplier. Each bundle that has a DOT numbered tag may be accepted without further preservative testing.

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For loose posts that are stamped "DOT" on one end, documentation must show the number of posts, size of posts, date, supplier, and a statement that each post was stamped.

If contract quantities are less than 20 posts, bundle tags are not required, however, Visual Inspection will be documented to verify that posts came from a certified supplier.

Bundles received that are not tagged must be sampled at the job site. Posts should not be used until satisfactory test results are received.

(4) Independent Assurance.
None required.

C. Plank, etc.

(1) Tier 2.

(2) Certification.
A Certificate of Compliance covering the item and, if applicable, treating agent and treatment is required.

(3) Acceptance.
Documented Visual Inspection or size, straightness, etc..

(4) Independent Assurance.
None required.

11.26 Concrete Patching Materials.

A. Material

(1) Tier 2.

(2) Certification
A Certificate of Compliance is required.

(3) Acceptance
Visual Inspection.

(4) Independent Assurance.
None required.

Back

12. Pavement Restoration:

General Notes:

The Minimum Sample and Test Requirements (MSTR) outlined in paragraph 5.1 A. will apply to the aggregate, except that a minimum of one independent assurance (IA) test will be required per project. None required for contract quantities less than 100 yd^3.

The Minimum Sample and Test Requirements (MSTR) outlined in paragraphs 6.1 B. through 6.5 E. will apply to the balance of the materials unless changed below.

Self-Consolidating Concrete: Air Content, unit weight, slump flow, visual stability index, J-ring, and temperature of fresh concrete will be made each time a cylinder for compressive strength determination is made. Additional determinations will be made to ensure proper control, and not less than one determination for each 2 hours of mixing-placing operations (DOT-23).

Samples or tests will not be specifically required for contract quantities of 25 yd^3 or less. Documentation of visual inspection that materials, methods, and equipment are satisfactory, will be provided.

Back

12.1 PCC Pavement Repair.

A. Silicone.

(1) Tier 2.

(2) Certification.
Item used must be on the Approved Products List.

(3) Acceptance.
One component silicone: One 1 pt. sample (In paint sample can) per lot, per source.

In Place: After the silicone has cured 7 days, 5 random samples approximately 3 in. in length will be cut per 1/2 mile of roadbed from the in place material to check bonding, width, thickness, shape and non-adherence to backer rod. The results of these measurements will be documented. (SD 421)

When only the joints within or adjacent to the repair areas are sealed, the lot of 5 samples will be selected per 7,500 yd^2 of area repaired.

Acceptance samples of silicone or in place tests are not required for projects that have 500 ft. or less of joints to be sealed provided, the basis of acceptance is documented.

(4) Independent Assurance.
None required.

B. Backer Rod.

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
None required.
Perform test according to A (3) under silicone.

(4) Independent Assurance.
None required.

C. Hot Poured Elastic Type.

(1) Tier 2.

(2) Certification.
APL: None required.

Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 5 lb. sample representing each lot or batch will be taken from the application wand during the sealing process. The sample will be placed in a Teflon or silicone lined box having a minimum capacity of 5 lbs.

None required for contract quantities of 200 lbs. or less.

(4) Independent Assurance.
None required.

Back

D. Backer Rod (Hot Pour).

(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 2 ft. length submitted with the joint material. (DOT-1)

None required if less than 200 lbs. of sealant is used, provided basis of acceptance is documented.

(4) Independent Assurance.
None required.

12.2 Joint and Spall Repair.

A. Concrete from Ready-Mix Plants.
The minimum sample and test requirements outlined in paragraph 5.1 A. and paragraphs 6.1 B., 6.1 C., 6.1 D., and 6.1 E. will apply, except as follows.

Acceptance samples of cement from a non-certified supplier and each size aggregate will be taken when:

(1) There has been a delay of three or more days' production of material used on the project.

(2) The production of the ready-mix plant indicates that the material represented by the prior samples has been exhausted on other construction.

B. Commercial Pre-Packaged Mix.
Item is classified as a Tier 2 material.

C. Fly Ash.
The minimum sample and test requirements outlined in paragraph 6.1 F. will apply, except the acceptance samples will consist of one sample per source. Sample size: 4 lb. sample per 25 ton.

D. Silicone.
(1) Tier 2.

Back

(2) Certification.
Item used must be on the Approved Products List.

(3) Acceptance.
One component silicone: One 1 pint. sample (in paint sample can) per lot, per source. (DOT-1)

In Place: After the silicone has cured 7 days, 5 random samples approximately 3 in. in length will be cut per 1/2 mile of roadbed from the in place material to check bonding, width, thickness, shape and non-adherence to backer rod. The results of these measurements will be documented. (SD 421)

When only the joints within or adjacent to the repair areas are sealed, the lot of 5 samples will be selected per 7,500 yd^2 of area repaired.

Acceptance samples of silicone, or in place tests are not required for projects that have 500 ft. or less of joints to be sealed, provided, the basis of acceptance is documented.

(4) Independent Assurance.
None required.

E. Backer Rod.
(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
None required.

(4) Independent Assurance.
None required.

F. Hot Poured Elastic Type.
(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 5 lb. sample representing each lot or batch will be taken from the application wand during the sealing process. The sample will be placed in a Teflon or silicone lined box having a minimum capacity of 5 lbs. (DOT-1)

None required for contract quantities of 200 lbs. or less.

(4) Independent Assurance.
None required.

Back

G. Backer Rod (Hot Pour).
(1) Tier 2.

(2) Certification.
APL: None required.
Non-APL: A Certificate of Compliance is required.

(3) Acceptance.
One 2 ft. length submitted with the joint material. (DOT-1)

None required if less than 200 lbs. of sealant is used, provided basis of acceptance is documented.

(4) Independent Assurance.
None required.

H. Epoxy Resin
(1) Tier 2.

(2) Certification
A Certificate of Compliance is required.

(3) Acceptance
None.

(4) Independent Assurance.
None required.

12.3 Pavement Jacking and Undersealing.

A. Portland Cement.
The minimum sample and test requirements outlined in paragraph 6.1 C. will apply, except the acceptance samples from a non-certified supplier will be one per 50 ton, per source.

B. Fly Ash.
The Minimum Sample and Test Requirements (MSTR) outlined in paragraph 6.1 F. will apply, except the acceptance samples will consist of one sample per 5 conveyances. The sample will be a 4 lb. sample taken from a randomly selected conveyance.

C. Water.
The Minimum Sample and Test Requirements (MSTR) outlined in paragraph 6.1 D. will apply.

D. Strength Tests.
The Minimum Sample and Test Requirements (MSTR) outlined in paragraph 6.2 A. will apply, except strength tests for acceptance will be at the rate of one set of cylinders per day.

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Watertight, one piece, plastic cylinder molds will be used for making cylinders.

E. Flow Test.
(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per day for the first three days, thereafter each time the mix is changed. (ASTM C 939)

(4) Independent Assurance.
None required.

F. Jacking Foam.
(1) Tier 2.

(2) Certification.
Certificate of Compliance.

(3) Acceptance.
Visual Inspection.

(4) Independent Assurance.
None required.

13. Bridge Deck Restoration:

General Notes:

The Minimum Sample and Test Requirements (MSTR) outlined in paragraphs 6.1 through 6.5 and 6.9 will apply unless changed below.

Testing for moisture content in the fine & coarse aggregate will not be required for this material.

13.1 Density Tests, Low Slump Bridge Deck Concrete.

A. Density, In Place.
- (1) Tier not applicable.
- (2) Certification.
  None required.
- (3) Acceptance.
  One test per day, per structure, per 1,000 yd^2. (DOT-56)
- (4) Independent Assurance.
  One per project.

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B. Density, Standard.
- (1) Tier not applicable.
- (2) Certification.
  None required.
- (3) Acceptance.
  Two unit weight determinations made on the first pour, then one unit weight determination per pour thereafter. (DOT-56)
- (4) Independent Assurance.
  None required.

13.2 Bridge Deck Polymer Chip Seals

A. Polymer
- (1) Tier 2.
- (2) Certification
  Item must be on the Approved Products List
- (3) Acceptance
  Pull off test performed by Contractor as specified in Section 491 of the Standard Specifications.
- (4) Independent Assurance.
  None required.

B. Concrete Patching Materials

(1) Tier 2.

(2) Certification
A Certificate of Compliance is required.

(3) Acceptance
Visual Inspection.

(4) Independent Assurance.
None required.

C. Aggregate

(1) Tier 3.

(2) Certification
Certified Analysis.

(3) Acceptance
Moisture Content.
One per structure. (DOT-35)

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(4) Independent Assurance.
None required.

13.3 Measurement of Bridge Deck Texture.

A. Tined Surface.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
One per structure, per pour, per 1,000 yd^2. (SD 418) (DOT-55)

(4) Independent Assurance.
None required.

13.4 Measurement of Bridge Deck Roughness.

A. Surface.

(1) Tier not applicable.

(2) Certification.
None required.

(3) Acceptance.
When profilograph testing is not required, test in accordance with SD 417. (DOT-28)

On projects where profilograph tests are required, coordinate with the contractor. Operation of the profilograph is the responsibility of the Contractor. Calibration of the profilograph is required.

(4) Independent Assurance.
None required.

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Table of Contents

Soils Section

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Method of Soil Sample Preparation

---

1. Scope:

This procedure is used for preparing disturbed soil samples for testing.

2. Apparatus:

2.1 Sieves. 3/8”, #4, #10, and #40 conforming to ASTM E11. 18

2.2 Soil pulverizer. A jaw crusher, wooden hammer, mechanical rubber covered pestle or mechanical pulverizer approved by the Chief Materials and Surfacing Engineer.

2.3 Sample splitter conforming to SD 213.

2.4 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to 0.01 lb and also one that is readable to the nearest 0.01 gram.

2.5 Miscellaneous: Pans, scoops, brushes, etc. for handling materials.

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2.6 Drying oven capable of maintaining a temperature not exceeding 140°F.

2.7 Measure. A watertight, metal cylindrical measure with the top and bottom true and even, calibrated in accordance with SD 205.

2.8 Funnel with a large mouth that will allow passage of the material.

2.9 A steel straightedge at least 10” in length.

3. Procedure:

3.1 Obtain a sample in accordance with SD 201.

3.2 Weigh the material to the nearest 0.1 gram and dry it to a constant weight as defined in SD 108, in an oven at a temperature not exceeding 140°F.

3.3 Break the soil into particle sizes approximately 3/8” using the jaw crusher, wooden hammer or rubber covered pestle.

NOTE: If the jaw crusher is used, the rock in the sample retained on the 3/8” sieve must be removed prior to crushing.

3.4 After breaking down the sample to approximately 3/8” size, place it in the mechanical pulverizer until the soil will pass a #10 sieve. A rubber covered pestle may be used.

3.5 Obtain the loose weight of the material in accordance with SD 205, paragraph 3.5 and 4.1, except, the material is introduced into the measure through the funnel held at a height of 6”.

3.6 Obtain a sample of material to perform the individual tests. A sufficient amount of material retained on the #10 sieve is required to obtain a representative gradation, and depending on the maximum particle size, shall not be less than the amount shown in the following table:

Diameter of Largest Particle	Minimum Mass of Portion
3/8”	500 grams
1”	2000 grams
2”	4000 grams
3”	5000 grams

When only a small percentage of the material will be retained on the #10 sieve, adherence to the minimum weight requirements in the above table may not be necessary.

3.7 Using the 3/8” #4, and #10 sieves, determine the sieve analysis in accordance with SD 202.

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3.8 Using the material passing the #10 sieve weigh out a 50 g sample for use in SD 102.

NOTE: If the material is shale, the sample for SD 102 is taken from material passing the #40 sieve.

3.9 Using material passing the #10 sieve, obtain a sample for determining the plasticity Index in accordance with SD 207, paragraph 3.2 thru 3.3.

4. Report:

None required.

5. References:

AASHTO T 87
ASTM E11
SD 102
SD 201
SD 202
SD 205
SD 207
SD 213

Mechanical Analysis of Soils (Colloid Test)

---

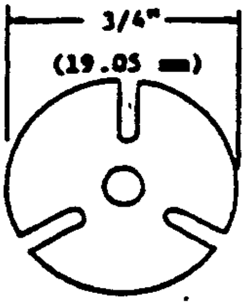
1. Scope:

This test for the quantitative determination of the distribution of particle sizes in soil.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Stirring apparatus. A mechanically operated stirring apparatus consisting of an electric motor suitably mounted to turn a vertical shaft at a speed not less than 10,000 revolutions per minute without load, with a replaceable stirring paddle made of rubber similar to the design shown below:



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2.3 Hydrometer identified as 152H conforming to AASHTO T88.

2.4 Glass graduate 18" in height, 2 1/2" in diameter and graduated for a volume of 1000 mL.

2.5 Thermometer accurate to 1°F.

2.6 Sieves. A #40 and #200 sieve conforming to ASTM E11.

2.7 Beaker with a minimum capacity of 400 mL.

2.8 Evaporating dish with a minimum capacity of 70 mL.

2.9 Drying oven capable of maintaining a temperature of 230° ± 9°F.

2.10 Stock solution containing 40g of sodium hexametaphosphate per liter of distilled water.

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3. Procedure:

3.1 Obtain a 50 g soil sample prepared in accordance with SD 101.

3.2 Place the sample in the glass beaker and add 125 mL of the stock solution. Stir the mixture and allow it to soak for a minimum of 12 hours. 22

3.3 Transfer the mixture to the stirring apparatus cups, add distilled water to fill the cups approximately 1/2 full and mix for 1 minute.

3.4 Transfer the mixture to the glass graduate, add distilled water to bring the volume to 1000 mL.

3.5 Cover the mouth of the graduate and shake for 1 minute.

3.6 Record the time on the worksheet and following a 90 minute sedimentation period, make hydrometer and temperature readings and record. Record the reading to the nearest 0.5 g per liter and the temperature to the nearest 1°F.

NOTE: The hydrometer is read at the top of the meniscus.

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3.7 Wash the material in the glass graduate over a #200 sieve and dry the material retained in an evaporating dish in an oven at a temperature of 230° ± 9°F.

3.8 Sieve the dry material on the #40 and #200 and record the weights retained on each sieve to the nearest 0.1 gram.

4. Report:

4.1 Calculations.

A. Sieve Analysis.

(1) Compute the sieve analysis in accordance with SD 202.

B. Percentage of Soil in Suspension.

(1) Determination of Composite Correction for Hydrometer Reading:

a. Equations for percentages of soil remaining in suspension are based on the use of distilled or demineralized water. A dispersing agent is used in the water, however, and the specific gravity of the resulting liquid is appreciably greater than that of distilled or demineralized water.

b. Both soil hydrometers are calibrated at 68°F, and variations in temperature from this standard temperature produce inaccuracies in the actual hydrometer readings. The amount of the inaccuracy increases as the variation from the standard temperature increases.

c. Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied.

d. The net amount of the corrections for the three items enumerated is designated as the composite correction, and may be determined experimentally.

e. For convenience, a graph or table of composite corrections for a series of 1° temperature differences for the range of expected test temperatures may be prepared and used as needed. Measurement of the composite corrections may be made at two temperatures spanning the range of expected test temperatures, and corrections for the intermediate temperatures calculated assuming a straight-line relationship between the two observed values.

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f. Prepare 1000 mL of liquid composed of distilled or demineralized water and dispersing agent in the same proportion as will prevail in the sedimentation (Hydrometer) test. Place the liquid in a sedimentation cylinder and the cylinder in the constant temperature water bath, set for one of the two temperatures to be used. When the temperature of the liquid becomes constant, insert the hydrometer, and, after a short interval to permit the hydrometer to come to the temperature of the liquid, read the hydrometer at the top of the meniscus formed on the stem. For hydrometer 152H the composite correction is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

(2) The percentage of the dispersed soil in suspension represented by different corrected hydrometer readings depends upon the amount of soil dispersed. The percentage as dispersed soil remaining in suspension is calculated as follows:

P = Percentage of originally dispersed soil remaining in suspension.

R = Corrected hydrometer reading.

W = Weight in grams of soil originally dispersed.

For hydrometer 152H;

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

If the sample is 50 g, the percentage of dispersed soil in the suspension is twice the corrected hydrometer reading.

To convert the percentages of soil in suspension to percentages of the total test sample including the fraction retained on the #10 sieve, the percentage of originally dispersed soil remaining in suspension is multiplied by the expression:

$$\frac{100\% - \text{retained on \#10 sieve}}{100}$$

C. Report the total percentages passing each sieve size and the percentage of material in suspension at the designated sedimentation time to the nearest 0.1.

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5. References:

AASHTO T 88
ASTM E11
SD 101
SD 202

Soil Classification

---

1. Scope:

This procedure is for classifying soils and aggregate.

2. Apparatus:

2.1 For sieve analysis see SD 202.

2.2 For mechanical analysis (Colloid) see SD 102.

2.3 Liquid limit and plasticity index see SD 207.

3. Procedure:

3.1 Field Classification.

A. Obtain the sieve analysis in accordance with SD 202 and the liquid limit and plasticity index in accordance with SD 207.

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B. With the required data from SD 202 and SD 207, determine the classification from the chart, figure 1.

C. Enter the chart from the left and proceed to the right. The first group which the test data fits is the correct group classification.

D. A-7 group only. To determine the subgroup of A-7 soil, use the following:

(1) Subtract 30 from the liquid limit of the soil. If the P.I. is equal to or less than the L.L. minus 30, the subgroup is A-7-5.

If the P.I. is greater than the L.L. minus 30, the subgroup is A-7-6.

Examples:

L.L. = 43 P.I. = 11

L.L. 43 - 30 = 13

The P.I. of 11 is less than 13; therefore, the subgroup is A-7-5.

L.L. = 43 P.I. = 15

L.L. 43 - 30 = 13

The P.I. of 15 is more than 13; therefore, the subgroup is A-7-6.

E. Determination of Group Index.

(1) The following must be known to determine the group index: The percent passing the #200 sieve, liquid limit and plasticity index.

Example:

Soil type A-6
Percent passing the #200 = 65
Liquid limit = 32
Plasticity index = 13

(2) The group index is the sum of the values determined from figure 2. and figure 3.

(3) Enter figure 2. with 65 percent passing the #200 and a liquid limit of 32. 23

Follow the line for 65 percent passing the #200 up to the line marked L.L. 40 or less. This will give you a value of 6.

(4) Using figure 3, enter the chart on the line marked passing the #200, 55 or more.

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(5) Follow the line marked 55 to the point (By interpolation) for a P.I. of 13. This will give a value of 1.

(6) Total the values obtained from figure 2. and figure 3.

6 + 1 = 7

The group index is 7.

3.2 Central Laboratory.

A. The sieve analysis may be taken from SD 102 or SD 202.

B. The procedure in the Central Laboratory is the same as shown in paragraph 3.1.

C. The Central Laboratory will also determine the textural classification from figure 4.

D. To use this chart, obtain the percent clay and percent silt from the colloid test, SD 102.

E. Enter the chart with the known percent clay and percent silt, where the lines cross is the textural classification.

4. Report:

Report the gradation, liquid limit, plasticity index and soil classification on a DOT-3.

5. References:

AASHTO M145
SD 102
SD 202
SD 207
DOT-3

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CLASSIFICATION OF HIGHWAY SUBGRADE MATERIALS
(With suggested subgroups)

General Classification	Granular Materials (35% or less passing the #200)							Silt-Clay Materials (More than 35% passing the #200)			
Group Classification	A-1			A-2							A-7
	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 A-7-6
Sieve Analysis Percent Passing:											
#10	0-50										
#40	0-30	0-50	51-100								
#200	0-15	0-25	0-10	0-35	0-35	0-35	0-35	36-100	36-100	36-100	36-100
Characteristics of fraction passing #40											
Liquid Limit				0-40	41+	0-40	41+	0-40	41+	0-40	41+
Plasticity Index	0-6		N.P.	0-10	0-10	11+	11+	0-10	0-10	11+	11+
Group Index	0		0	0		0-4		0-8	0-12	0-16	0-20
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel, & Sand		Fine Sand	Silty or Clayey Gravel & Sand				Silty Soils		Clayey Soils	
General Rating As Subgrade	Excellent to Good					Fair to Poor					

Figure 1

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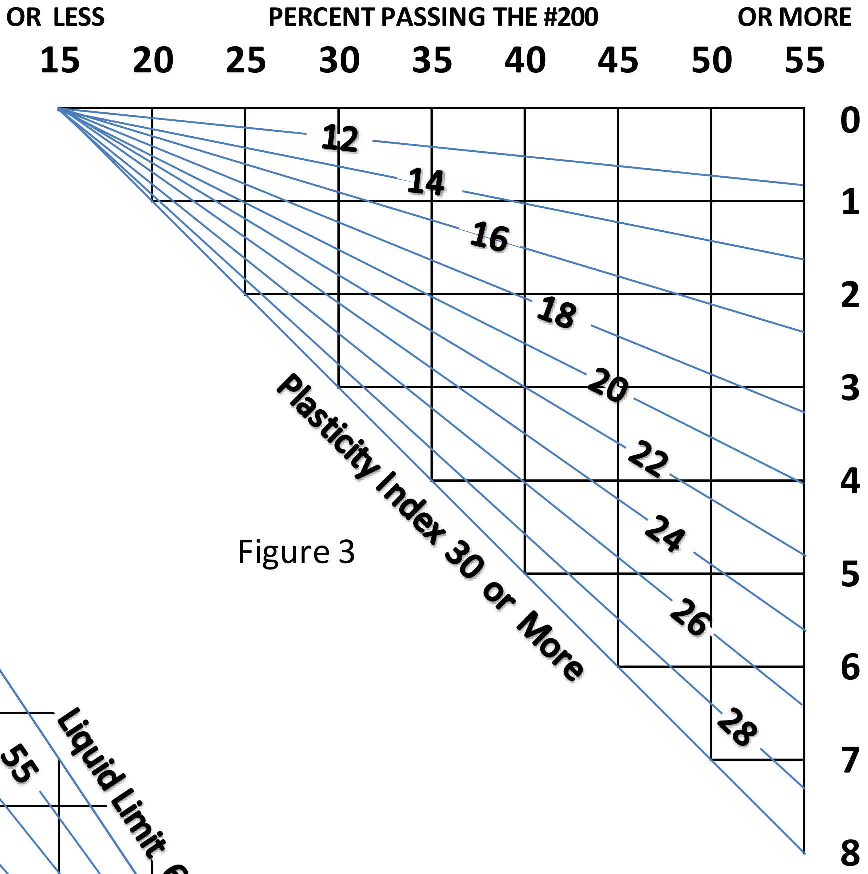

Figure 3

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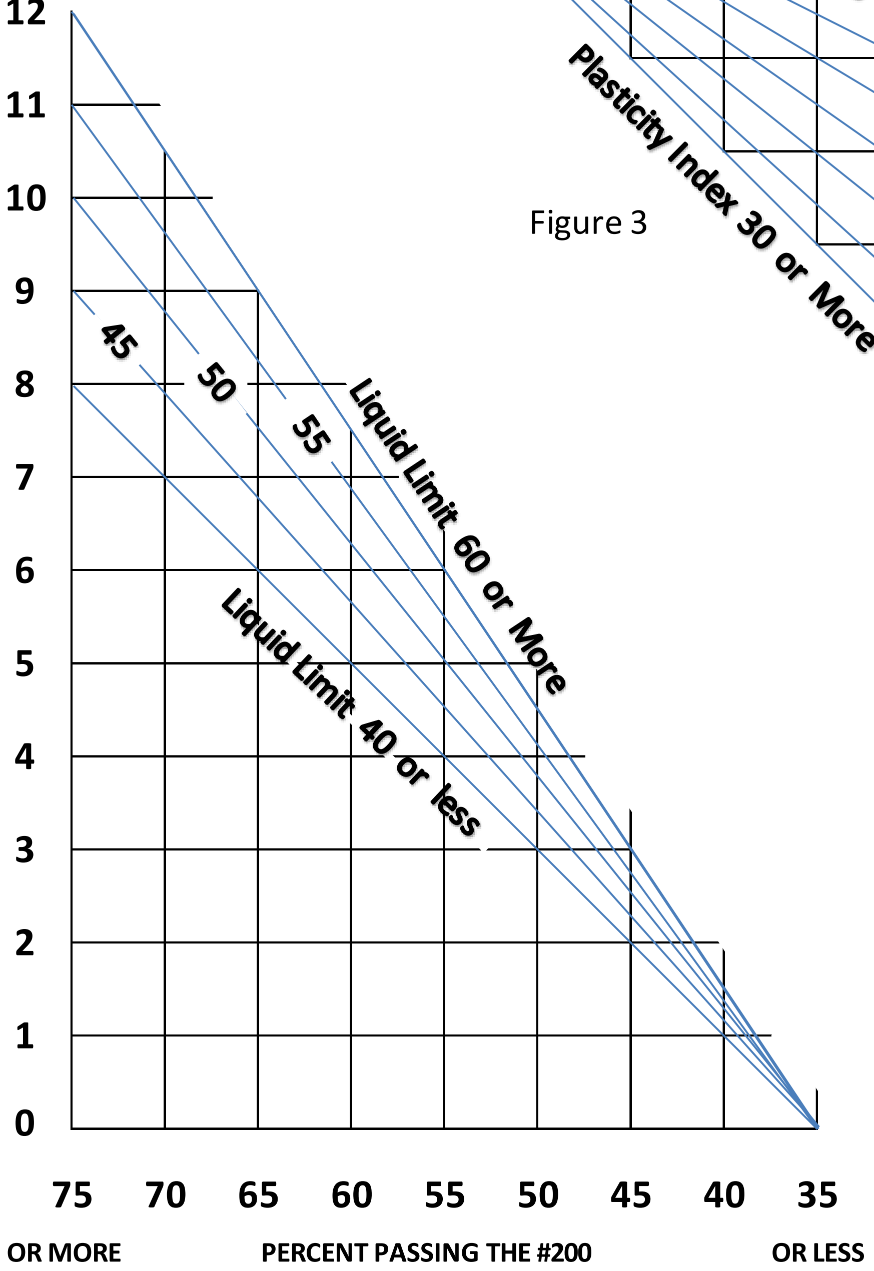
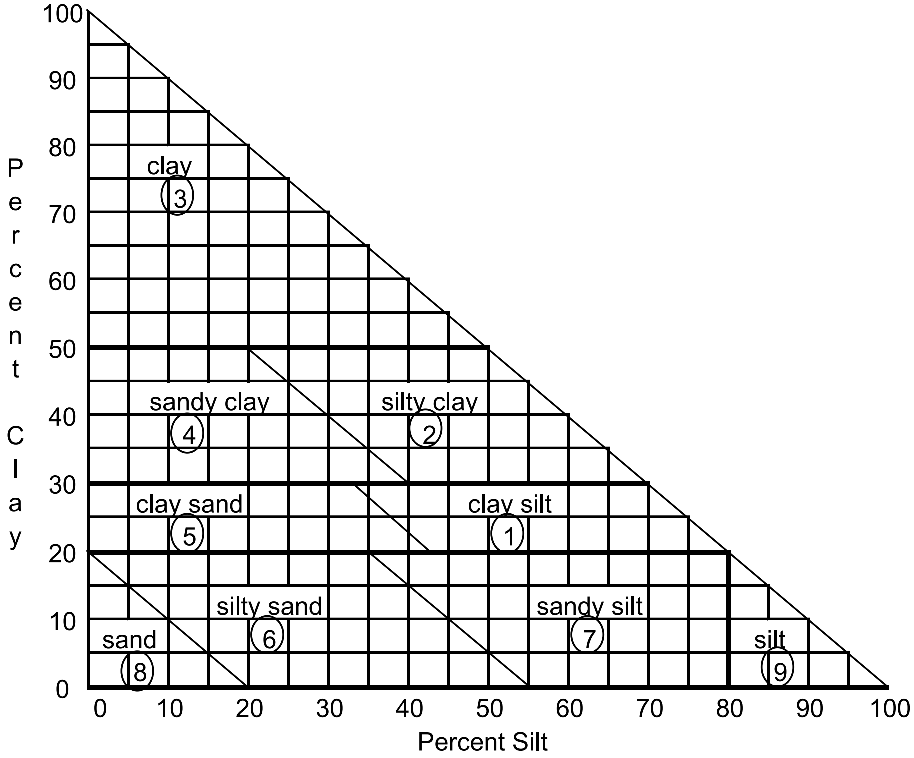


Figure 2

TEXTURAL CLASSIFICATION CHART



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1. 0% - 19% retained #10 sieve = Use fine classification (1) thru (9).

2. 20% - 49% retained #10 sieve. Use fine classification determined from the minus #10 sieve analysis (soil textures 1 thru 9). Add the word "Gravelly" ahead of the fine classification (i.e. Gravelly sand). Use the fine classification (1) thru (9) on the soils profile.

3. 50% - 84% Retained #10 sieve = Clayey, silty or sandy gravel. (10) Soil texture indicated on soil profile

4. 85% - 100% retained #10 sieve = Gravel (10).

SOIL LEGEND

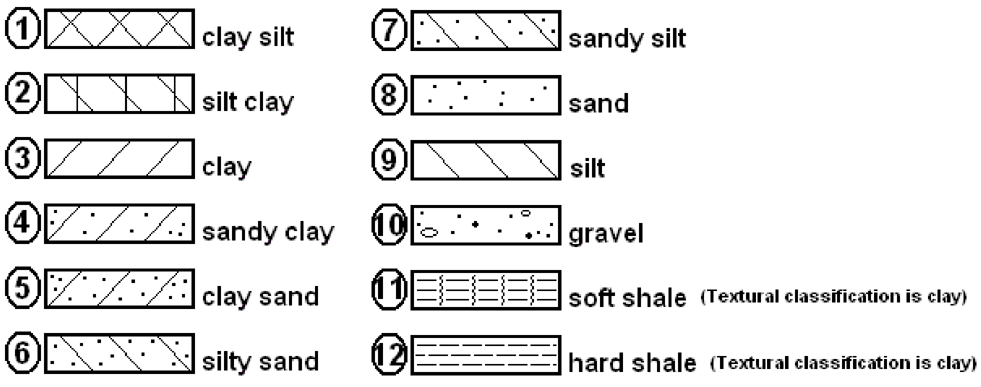

Figure 4

Moisture-Density Relations of Soils, Aggregates, and Specified Mixtures

1. Scope:

This test is to establish the moisture-density relationship of soils, aggregates and mixtures.

Definitions.

Compaction: The act of increasing the unit weight of the soil, aggregate or mixture, by mechanically compressing the material into a closer state of contact. For a given compactive effort, the density of the material tested will normally increase until optimum moisture content is reached, then the density will begin to decrease. It should be noted that there have been cases where the apparent decrease in density was followed by another increase in density. These secondary or "False" plateaus in the moisture-density curve should always be checked to determine the valid data.

The Percent Compaction: This is the ratio of the density of the material, as placed during construction, to the maximum density of a representative specimen of the same material.

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Density: The density of a material is the weight per unit volume, in lbs./ft^3 in dry condition.

One-Point (Standard) Test: A rapid test where the wet density and moisture content measurements for the test material are used to select a curve from a family of curves to be the standard.

Four-Point (Standard) Test: The results of four or more moisture-density tests are plotted with density values as the ordinate or vertical scale and the moisture content (Percentage) as the abscissas or horizontal scale. When the plotted points are joined by a smooth curve, the maximum density at optimum moisture may be determined. (Figure 2, 3, 5 and 6) The moisture content corresponding to the peak of the curve will be termed “Optimum Moisture” of the material. The dry density in lbs./ft^3 at optimum moisture content will be termed the “Maximum Density”.

Optimum Moisture: The moisture content corresponding to the maximum density.

Maximum Density: The highest value for density, calculated on the basis of dry weight of material per cubic foot, shown on the moisture density curve.

2. Apparatus:

2.1 Molds. A 4" diameter or 6" diameter mold meeting the requirements of AASHTO T 99.

2.2 Rammer. A 5.5 lb. rammer conforming to AASHTO T 99.

A mechanical rammer may be used, if approved by the Chief Materials and Surfacing Engineer.

2.3 Sample extruder (Optional) such as a jack, frame, or other device adapted for extruding compacted specimens from the mold.

2.4 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.01 lb. and also one that is readable to the nearest 0.1 gram.

2.5 Sieves and screens. A 3/4" and a #4 sieve. A #4 rough screen will be approximately 12" x 18" in size. #4 sieves intended for use in sieve analysis testing will not be used for pushing wet material through as shown in paragraph 3.2 B.

2.6 Oven.

A. An oven, for determining moisture content, capable of maintaining a temperature of 230° ± 9°F.

B. An oven for drying soil samples at a temperature not exceeding 140°F.

Other methods of moisture determination shown in SD 108 may be used.

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24

2.7 Containers for moisture content samples.

2.8 Steel straightedge at least 12" in length.

2.9 Miscellaneous: Tools, plastic bags, beakers, cans, pails, shovel, spatula, knife, spoons and trowel.

3. Procedure:

Method 1 Four Point - For testing materials passing a #4 sieve using a 4" mold.

Method 2 One Point - For testing material passing a #4 sieve using a 4” mold.

Method 3 Four Point - For testing material passing a 3/4” sieve using a 6” mold.

Method 4 One Point - For testing material passing a 3/4” sieve using a 6” mold.

3.1 Method 1 (Soil).

A. Obtain a sample of soil weighing approximately 30 lbs.

B. Dry the sample in an oven at a temperature not exceeding 140°F.

C. Using the apparatus described in SD 101, break the sample down to pass the #4 sieve. Care must be taken not to break any rock retained on the #4 sieve. Sieve the sample on a #4 sieve and discard any granular material retained.

D. Reduce the sample to 5 specimens, weighing approximately 5 lbs. each.

E. Thoroughly mix one of the specimens with a measured amount of water to dampen it to approximately 4 to 6 percentage points below optimum.

F. Place the specimen in a plastic bag and seal the top to prevent moisture loss. Allow the specimen to cure for a minimum of 12 hours.

G. Mix the remaining specimens in the same manner as shown in paragraphs E. and F., increasing the measured water by approximately 2 percentage points over the preceding specimen. The percent of increase should be at a uniform rate.

H. The test specimen is then formed in the 4" mold, with collar attached, in three approximately equal layers, to a total compacted depth of approximately 5". Compact each layer using 25 uniformly distributed blows from the rammer dropping free from a height of 12" above the surface of the soil in the mold. Clean rammer head prior to compacting the next layer to ensure the calibrated rammer head is still 5.5 lbs. 24

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During compaction, the mold will rest firmly on a dense, uniform, rigid and stable foundation. The following are satisfactory as a base on which to rest the mold during compaction: a block of concrete weighing at least 200 lbs., a sound concrete floor, concrete box culverts, bridges and PCC pavement.

I. Immediately following compaction, remove the extension collar, carefully trim the compacted material even with the top edge of the mold with a knife and straightedge. Holes in the surface of the molded material caused by removal of coarse particles will be patched with finer material removed in trimming.

Weigh the mold and compacted moist specimen in lbs. to the nearest 0.01 lb. Record the weight on the DOT-40 as "Weight of mold and wet specimen".

J. Remove the moist specimen from the mold, slice vertically through the center of the specimen and take a representative sample from one of the cut faces for moisture determination.

Weigh a moisture test specimen of at least 100 g to the nearest 0.1 g and dry in an oven at 230° ± 9°F to a constant weight as per SD 108.

Other methods of moisture determination shown in SD 108 may be used.

K. After drying, weigh and record the weight of the moisture samples to the nearest 0.1 gram.

L. Test each of the remaining specimens, as shown in paragraphs H. thru K.

Continue this series of determinations until there is either a decrease or no change in the wet unit weight per cubic foot. If the plotted points of either the dry density or wet density do not form a curve, additional determinations will be performed to form the curve.

M. Complete the calculations on the DOT-40 as shown in figure 1.

N. Results of the calculations (Moisture content and corresponding wet and dry densities) are plotted on the graph (DOT-40) using density values as ordinates and moisture contents as abscissas. Draw a smooth curve connecting the points established by plotting results of four or more tests, figures 2 and 3. 24

Back

The moisture content corresponding to the peak of the dry density curve will be termed "Optimum Moisture" for the compacted material.

O. The dry unit weight density lbs./ft^3 of the compacted material at optimum moisture content shall be termed “Maximum Density”.

P. Validation of the family of curves:

1. Determine the maximum dry density and optimum moisture from the 4-point dry density curve. This should be at the peak of the dry density curve.
2. Select a moisture content 1 1/2 to 2 percentage points below optimum moisture.
3. Using this moisture content, find the corresponding wet density on the wet density curve of the 4-point.
4. Plot this wet density and moisture content on the family of curves proposed for use on the project to determine the curve to be used for the standard.

Select the curve nearest the plotted point. If the plotted point is between two curves and there is doubt as to which curve is closest, use the curve below the plot.

3.2 Method 2 (Soil).

A. Obtain a sample of approximately 5 lbs. of soil.

B. Break up the sample using fingers, a trowel or a pine board to push the sample through a #4 rough screen.

C. If the sample appears to be above optimum moisture, dry it sufficiently in an oven at a temperature not exceeding 140° F to bring it to approximately optimum.

If the sample appears too dry, add and mix sufficient water to bring it near optimum.

D. Mold and take a moisture sample, as shown in paragraphs 3.1 H through 3.1 J. (Use form DOT-35 for moisture tests and DOT-41 for density tests.)

E. Using the "1-point determination" wet density and the "1-point" moisture determination, enter the family of curves, figure 7 or figure 8, to obtain the maximum density and optimum moisture.

Back

Select the curve nearest the plotted point. If the plotted point is between two curves and there is doubt as to which curve is closest, use the curve below the plot. 24

If the 1-point moisture content deviates from optimum (for the curve selected) by more than 2 percentage points below or 1 percentage point above, a second 1-point will be made at or nearer optimum and within the tolerance shown.

3.3 Method 3 (Soils and/or Granular Material).

A. Obtain a sample of approximately 60 lbs. in accordance with SD 201.

The tester may elect to obtain more material and mix individual samples at varying percentages of moisture. If so elected, follow the procedure shown in method 1 and obtain samples approximately 15 lbs. each and use a 3/4" sieve and a 6" mold.

B. Dry the sample in an oven at a temperature not exceeding 140° F.

C. Sieve the sample on a 3/4" sieve, discarding the material retained.

D. Weigh the sample and add sufficient water to bring it to approximately 4 percentage points below optimum.

E. The test specimen is then formed in the 6" mold in three approximately equal layers to a total depth of approximately 5". Compact each layer using 56 uniformly distributed blows from the rammer dropping 12" above the surface of the material in the mold. Clean rammer head prior to compacting the next layer to ensure the calibrated rammer head is still 5.5 lbs.

During compaction, the mold will rest firmly on a dense, uniform, rigid and stable foundation. The following are satisfactory bases on which to rest the mold during compaction: A block of concrete weighing at least 200 lbs., a sound concrete floor, concrete box culverts, bridges and PCC pavement.

F. Immediately following compaction, remove the extension collar and carefully trim the compacted material even with the top edge of the mold with a straightedge. Holes in the surface of the molded material caused by removal of coarse particles will be patched with finer material removed in trimming.

Weigh the mold and compacted moist specimen in lbs. to the nearest 0.01 lb. Record on a DOT-40 as "Weight of mold and wet specimen".

G. Remove the specimen from the mold, slice vertically through the center of the specimen and take a representative sample from one cut face for moisture determination.

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Weigh a moisture test specimen of at least 100 grams for soil and 500 grams for granular material to the nearest 0.1 g and dry in an oven at a temperature of 230° ± 9°F to a constant weight as per SD 108.

Other methods of moisture determination as shown in SD 108 may be used.

H. After drying, weigh and record the weights of the moisture sample to the nearest 0.1 gram.

I. Complete the calculation on the DOT-40 as shown in figure 4.

J. Thoroughly break up the remaining portion of the specimen until it will pass a 3/4" sieve, and add it to the remaining portion of the sample being tested. Add sufficient water to increase moisture content of the sample between 1 and 2 percentage points and repeat the procedure in paragraphs 3.3 E. through 3.3 I.

Continue this series of determinations until there is either a decrease or no change in the wet unit weight per cubic foot. If the plotted points of either the dry density or wet density do not form a curve, additional determinations will be performed to form the curve.

K. Results of calculations (Moisture content and corresponding wet and dry densities) are plotted on the graph using density values as ordinates and moisture contents as abscissas. Draw a smooth curve connecting the points established by plotting results of 4 or more tests. (Figures 5 and 6).

L. The moisture content corresponding to the peak of the dry density curve will be termed "Optimum Moisture" for the compacted material.

M. The dry unit weight corresponding to the peak of the dry density curve will be termed "Maximum Density" of the compacted material.

N. Prior to using any family of pre-drawn curves, it will be checked, using project material and the 4-point system. This can be done by comparison of the wet density curves.

1. Determine the maximum dry density and optimum moisture from the 4-point dry density curve. This should be at the peak of the dry density curve.
2. Select a moisture content 1 1/2 to 2 percentage points below optimum moisture.
3. Using this moisture content, find the corresponding wet density on the wet density curve of the 4-point.
4. Locate the wet density and moisture content on the family of curves proposed for use on the project to determine the curve to be used for the standard. 24

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Select the curve nearest the point. If the point is between 2 curves and there is doubt as to which curve is closest, use the curve below the point.

3.4 Method 4 (Soils and/or Granular Material).

A. Obtain a sample of approximately 15 lbs.

B. Sieve the sample on a 3/4" sieve and discard any material retained.

C. If the sample appears to be above optimum moisture, dry it sufficiently in an oven at a temperature not exceeding 140° F to bring it to approximately optimum.

If the sample appears dry, add and mix sufficient water to bring it near optimum.

D. Mold and take a moisture sample, as shown in paragraphs 3.3 E. through 3.3 I. (Use the DOT-41 for density tests.)

E. Using the “1-point determination” wet density and the “1-point” moisture determination, enter the family of curves figure 7 or figure 8 to obtain the maximum density and optimum moisture.

Select the curve nearest the plotted point. If the plotted point is between 2 curves and there is doubt as to which curve is closest, use the curve below the plot.

Base Course & Subbase Construction: When the moisture in the 1-point determination deviates by more than 2 percentage points below or 1 percentage point above optimum moisture, another 1-point (nearer to optimum moisture) will be made. 24

The maximum dry density from this curve should be within ± 3 lbs./cu. ft. of the 4-point maximum dry density. If the curves fail to check within this range, contact the Region Materials Engineer.

3.5 When Methods 2 and 4 are used in conjunction with SD 105 and SD 106, the material for testing is taken from or adjacent to the in-place density test hole and the DOT-41 form is used.

4. Report:

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4.1 Calculations.

Calculate the moisture content and corresponding dry unit weight in lbs./ft^3 as follows:

$$w = \frac{A - B \times 100}{B - C}$$

and

$$W = \frac{W1 \times 100}{w + 100}$$

Where:

w = Percentage of moisture in specimen, based on dry weight of soil.

A = Weight of container and wet soil/granular material.

B = Weight of container and dry soil/granular material.

C = Weight of container.

W = Dry weight in lbs./ft^3 of compacted material.

W_1 = Wet weight in lbs./ft^3 of compacted material.

4.2 Report.

A. Report the following:

(1) The optimum moisture content, as a percentage, to the nearest 0.1.

(2) The maximum density in lbs./ft^3 to the nearest 0.1 lb.

(3) Test results will be reported on form DOT-40.

5. **References**:

AASHTO T 99
SD 101
SD 105
SD 106
SD 108
SD 201
SD 205
DOT-35
DOT-40
DOT-41

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DOT-40
9-14
File No. 16

SOUTH DAKOTA
DEPARTMENT OF TRANSPORATION

DENSITY SHEET

PROJECT IM 090-7(14)125 COUNTY Washington PCN 7140

OPERATOR Marv C. Cleason CHECKED BY RJH DATE 8/8/96

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Specimen Number	1	2	3	4	5	
Can Number	9	3	2	8	4	
Weight of Can and Wet Material	164.7	192.7	142.0	121.7	133.2	
Weight of Can and Dry Material	151.0	174.2	127.0	107.2	117.0	
Weight Loss (Moisture) Speedy Reading	13.7	18.5	15.0	14.5	16.2	
Weight of Can	14.0	16.0	17.5	13.9	15.8	
Weight of Dry Material	137.0	158.2	109.5	93.3	101.2	
Percent Moisture	10.0	11.7	13.7	15.5	16.0	

Weight of Mold and Wet Specimen	13.83	14.10	14.21	14.11	13.96	
Weight of Mold	9.71	9.71	9.71	9.71	9.71	
Weight of Wet Specimen	4.12	4.39	4.50	4.40	4.25	
Factor of Mold No. 2-90	29.98	29.98	29.98	29.98	29.98	
Wet Density Wet Wt. x Factor	123.5	131.6	134.9	131.9	127.4	
Dry Density PCF	112.3	117.8	118.6	114.2	109.8	

PLOT WET AND DRY CURVES ON REVERSE SIDE

Figure 1

DOT-40
1-95

DENSITY SHEET
File # 16

COUNTY Washington PROJECT I 96-7 (14) 513 PCN 7140
FIELD NO. 2 LAB NO. 278 DATE 8-8-96
SOURCE Borrow Pit #6 TYPE OF MATERIAL Clay
4-POINT DATA: OPTIMUM MOISTURE 13.1 MAXIMUM DENSITY 118.8
CURVE VALIDATION: FAMILY Ohio CURVE Small J MAX. DENSITY 118.1
GRANULAR MATERIAL 4-POINT RANGE ______ TO ______

(SEE REVERSE SIDE FOR CALCULATIONS)

Back

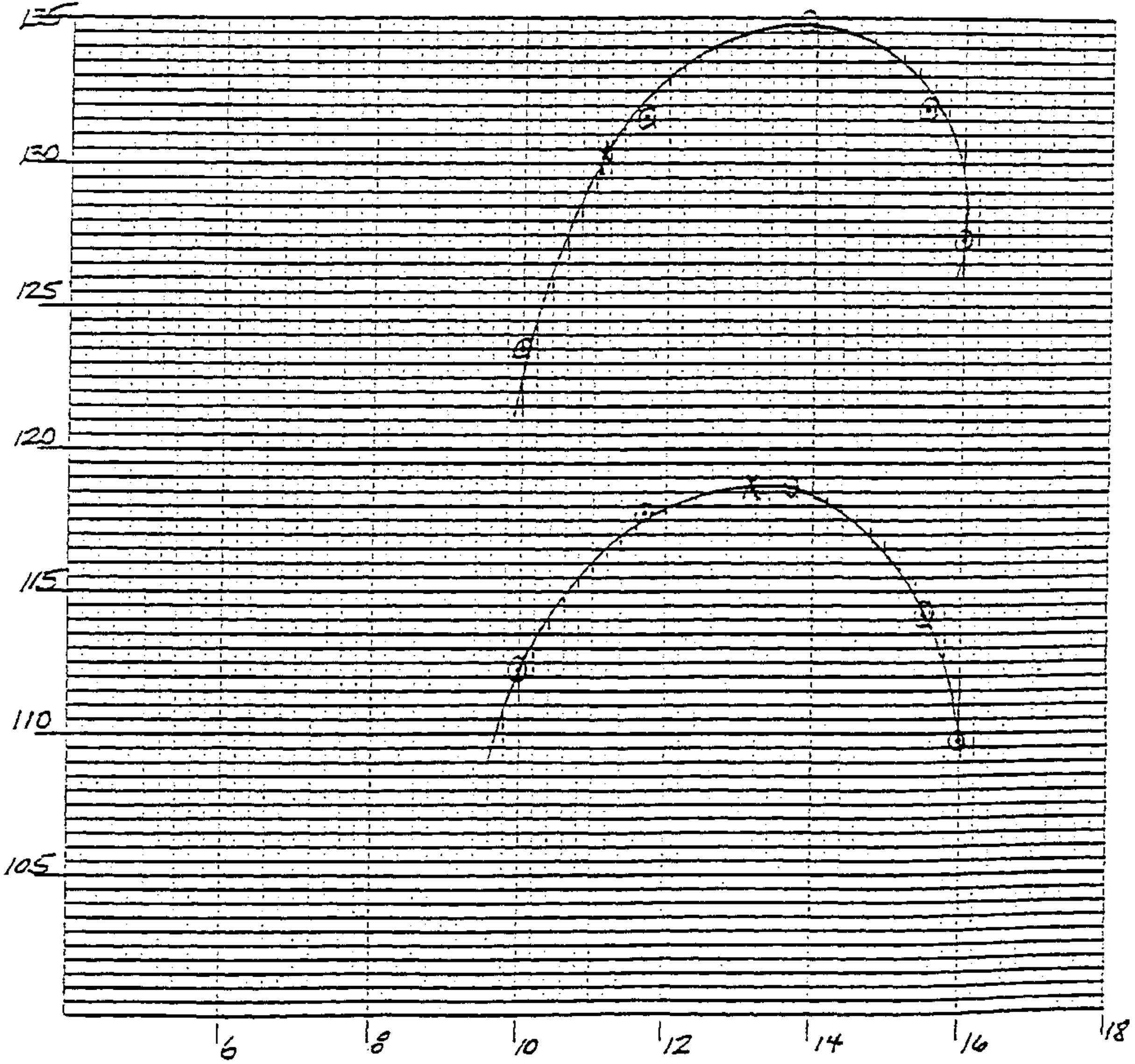

Figure 2

Sample ID 2204757
File No.

Density Sheet

DOT - 40
9-15

County Aurora, Ziebach

PCN/PROJECT B015 PH 0066(00)15

Field # 01

Tested By Tester, One

Date Tested 04/22/2015

Checked By Tester, Two

Source Borrow #6

Material Type Unclassified Excavation

Comment

Specimen Number	1	2	3	4	5	6	7
Weight of Can and Wet Material	164.7	192.7	142.0	121.7	133.2		
Weight of Can and Dry Material	151.0	174.2	127.0	107.2	117.0		
Weight Loss (Moisture) Speedy Reading	13.7	18.5	15.0	14.5	16.2	0.0	0.0
Weight of Can	14.0	16.0	17.5	13.9	15.8		
Weight of Dry Material	137.0	158.2	109.5	93.3	101.2		
Percent Moisture	10.0	11.7	13.7	15.5	16.0		

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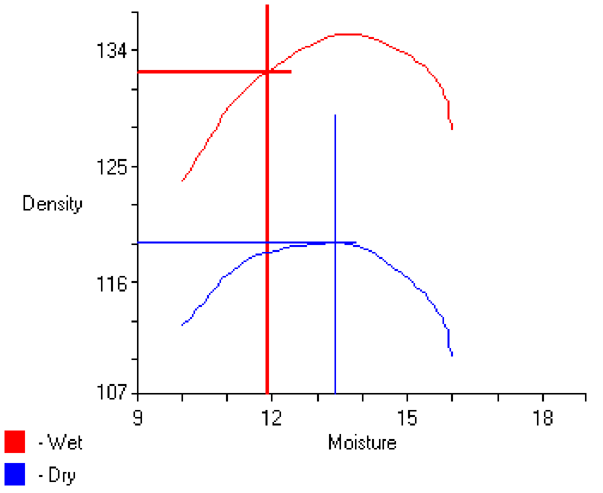
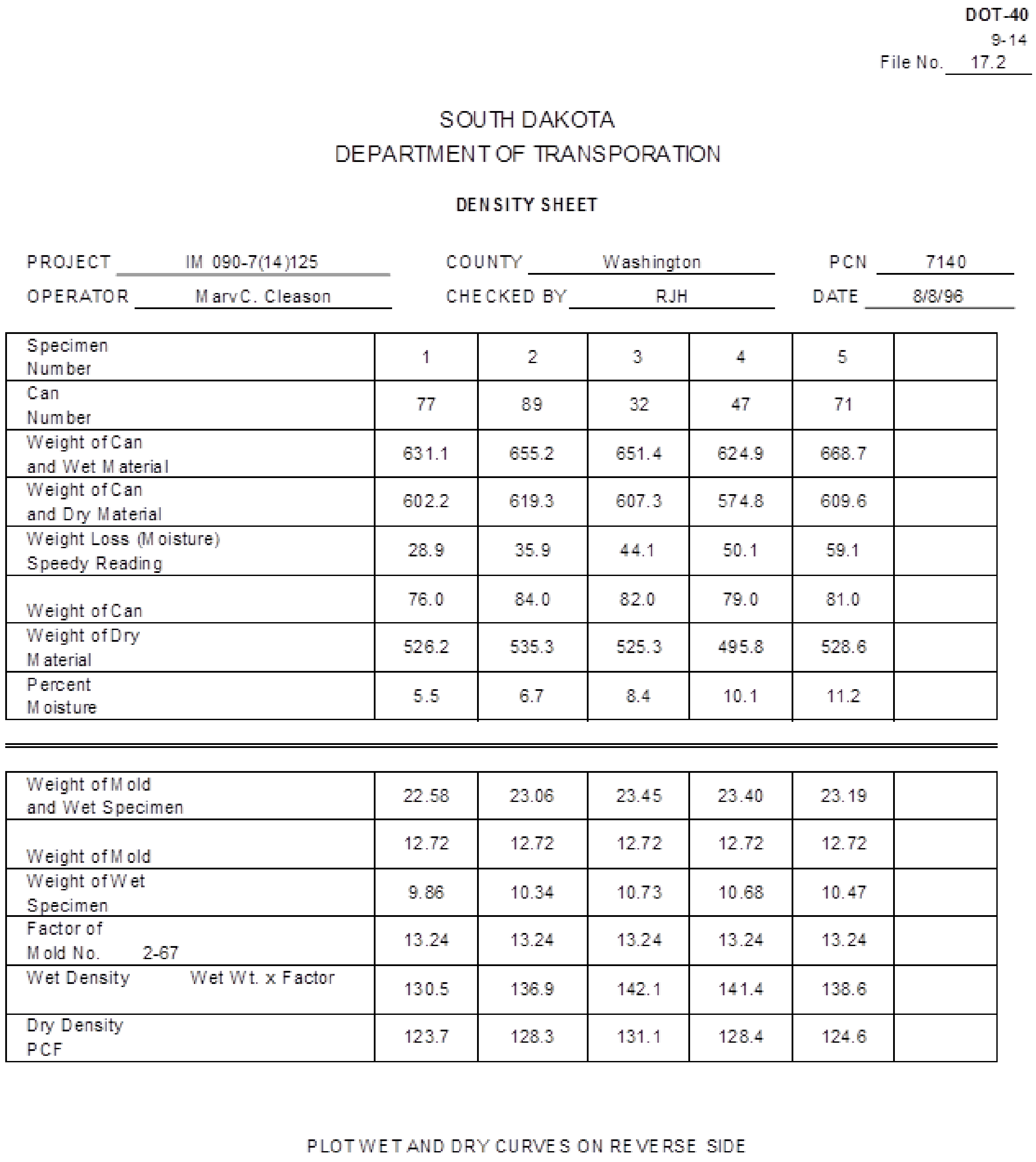
Weight of Mold and Specimen	13.83	14.10	14.21	14.11	13.96		
Weight of Mold	9.71	9.71	9.71	9.71	9.71	9.71	9.71
Weight of Wet Specimen	4.12	4.39	4.50	4.40	4.25		
Factor of Mold No. 2-90	29.98	29.98	29.98	29.98	29.98	29.98	29.98
Wet Density Wet Wt. x Factor	123.5	131.6	134.9	131.9	127.4		
Dry Density	112.3	117.8	118.6	114.2	109.8		



Wet Density: 132.0
Wet Moisture: 11.9
Dry Maximum Density: 118.7
Dry Optimum Moisture: 13.4
Four-Point Range: 115.7 - 121.7
Curve and Family: J

Figure 3

Back



DOT-40
9-14
File No. 17.2

SOUTH DAKOTA
DEPARTMENT OF TRANSPORATION

DENSITY SHEET

PROJECT IM 090-7(14)125 COUNTY Washington PCN 7140
OPERATOR Marv C. Cleason CHECKED BY RJH DATE 8/8/96

Specimen Number	1	2	3	4	5	
Can Number	77	89	32	47	71	
Weight of Can and Wet Material	631.1	655.2	651.4	624.9	668.7	
Weight of Can and Dry Material	602.2	619.3	607.3	574.8	609.6	
Weight Loss (Moisture) Speedy Reading	28.9	35.9	44.1	50.1	59.1	
Weight of Can	76.0	84.0	82.0	79.0	81.0	
Weight of Dry Material	526.2	535.3	525.3	495.8	528.6	
Percent Moisture	5.5	6.7	8.4	10.1	11.2	

Weight of Mold and Wet Specimen	22.58	23.06	23.45	23.40	23.19	
Weight of Mold	12.72	12.72	12.72	12.72	12.72	
Weight of Wet Specimen	9.86	10.34	10.73	10.68	10.47	
Factor of Mold No. 2-67	13.24	13.24	13.24	13.24	13.24	
Wet Density Wet Wt. x Factor	130.5	136.9	142.1	141.4	138.6	
Dry Density PCF	123.7	128.3	131.1	128.4	124.6	

PLOT WET AND DRY CURVES ON REVERSE SIDE

Figure 4

DOT-40
1-95

DENSITY SHEET
File # 17.2

COUNTY Washington PROJECT I96-4(14) 111 PCN 1423

FIELD NO. 6 LAB NO. H 92-46 DATE 8-8-96

SOURCE Plans Pit #2 TYPE OF MATERIAL Base Course

4-POINT DATA: OPTIMUM MOISTURE 8.6 MAXIMUM DENSITY 131.1

CURVE VALIDATION: FAMILY Ohio CURVE Little d MAX. DENSITY 133.0

GRANULAR MATERIAL 4-POINT RANGE 128.1 TO 134.1

(SEE REVERSE SIDE FOR CALCULATIONS)

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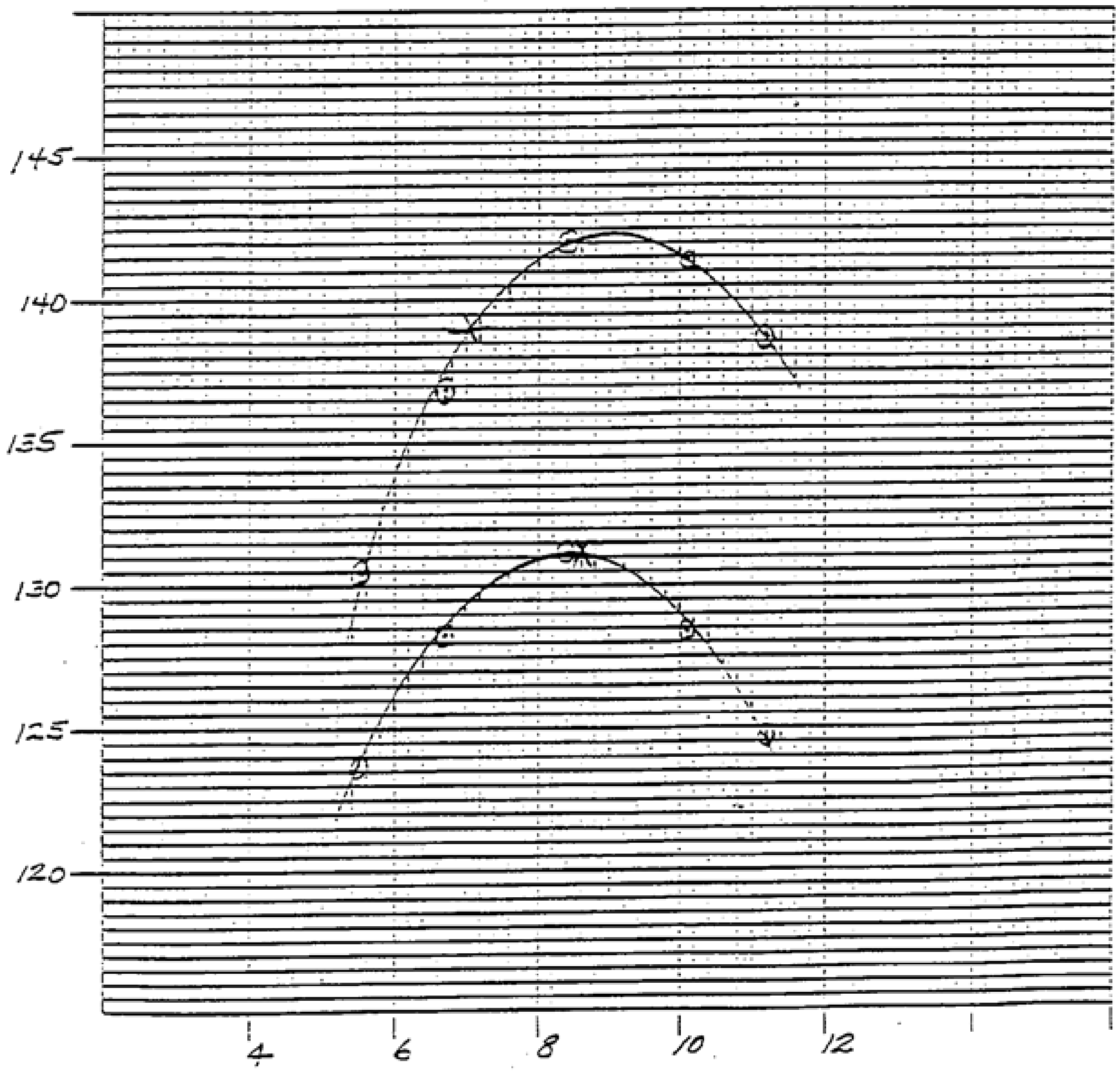
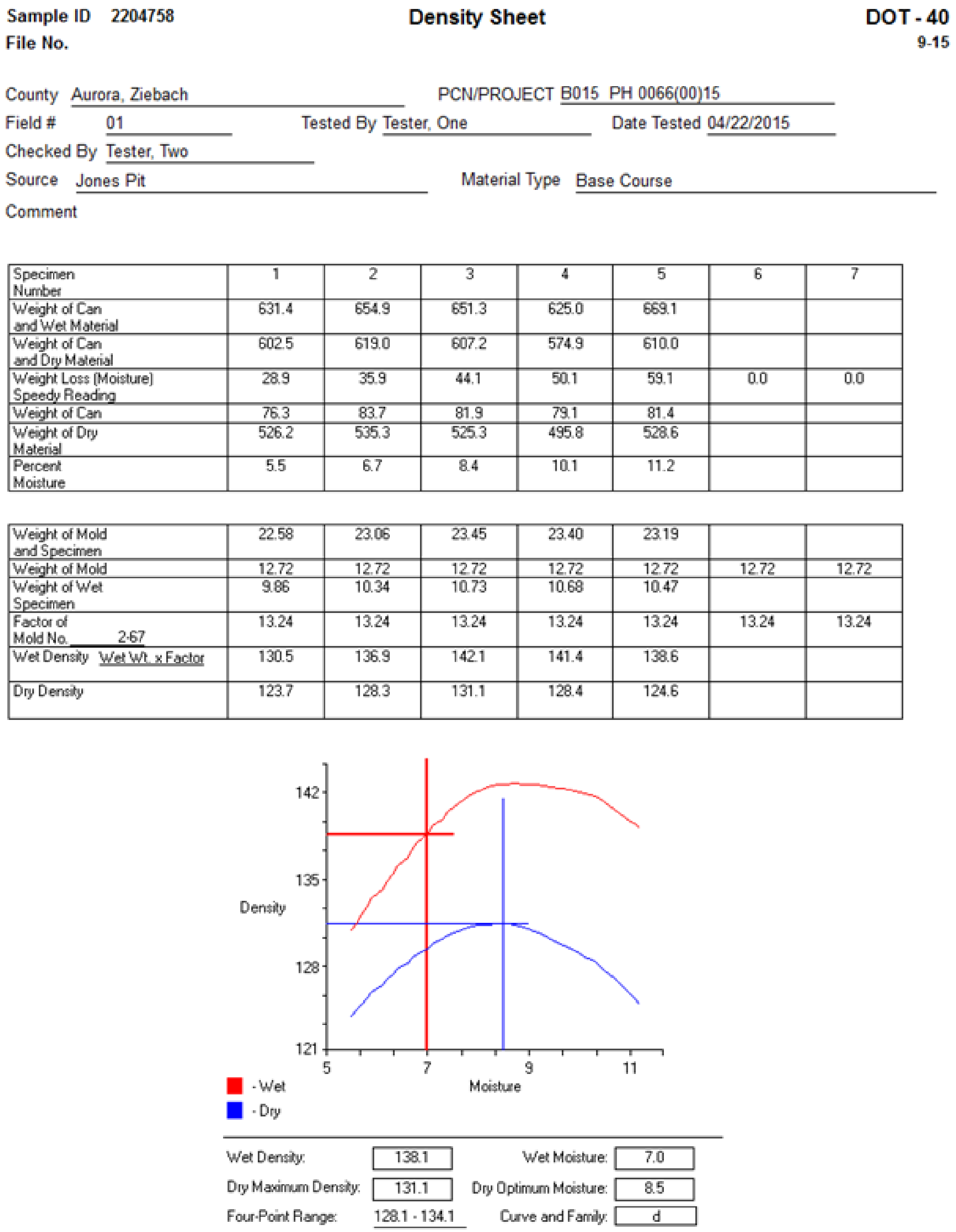


(Reverse side of DOT-40)

Figure 5



Sample ID 2204758
File No.

Density Sheet

DOT - 40
9-15

County Aurora, Ziebach
PCN/PROJECT B015 PH 0066(00)15
Field # 01
Tested By Tester, One
Date Tested 04/22/2015
Checked By Tester, Two
Source Jones Pit
Material Type Base Course
Comment

Specimen Number	1	2	3	4	5	6	7
Weight of Can and Wet Material	631.4	654.9	651.3	625.0	669.1		
Weight of Can and Dry Material	602.5	619.0	607.2	574.9	610.0		
Weight Loss (Moisture) Speedy Reading	28.9	35.9	44.1	50.1	59.1	0.0	0.0
Weight of Can	76.3	83.7	81.9	79.1	81.4		
Weight of Dry Material	526.2	535.3	525.3	495.8	528.6		
Percent Moisture	5.5	6.7	8.4	10.1	11.2		

Weight of Mold and Specimen	22.58	23.06	23.45	23.40	23.19		
Weight of Mold	12.72	12.72	12.72	12.72	12.72	12.72	12.72
Weight of Wet Specimen	9.86	10.34	10.73	10.68	10.47		
Factor of Mold No. 2-67	13.24	13.24	13.24	13.24	13.24	13.24	13.24
Wet Density Wet Wt. x Factor	130.5	136.9	142.1	141.4	138.6		
Dry Density	123.7	128.3	131.1	128.4	124.6		

🟥 - Wet
🟦 - Dry

Wet Density:	138.1	Wet Moisture:	7.0
Dry Maximum Density:	131.1	Dry Optimum Moisture:	8.5
Four-Point Range:	128.1 - 134.1	Curve and Family:	d

Figure 6

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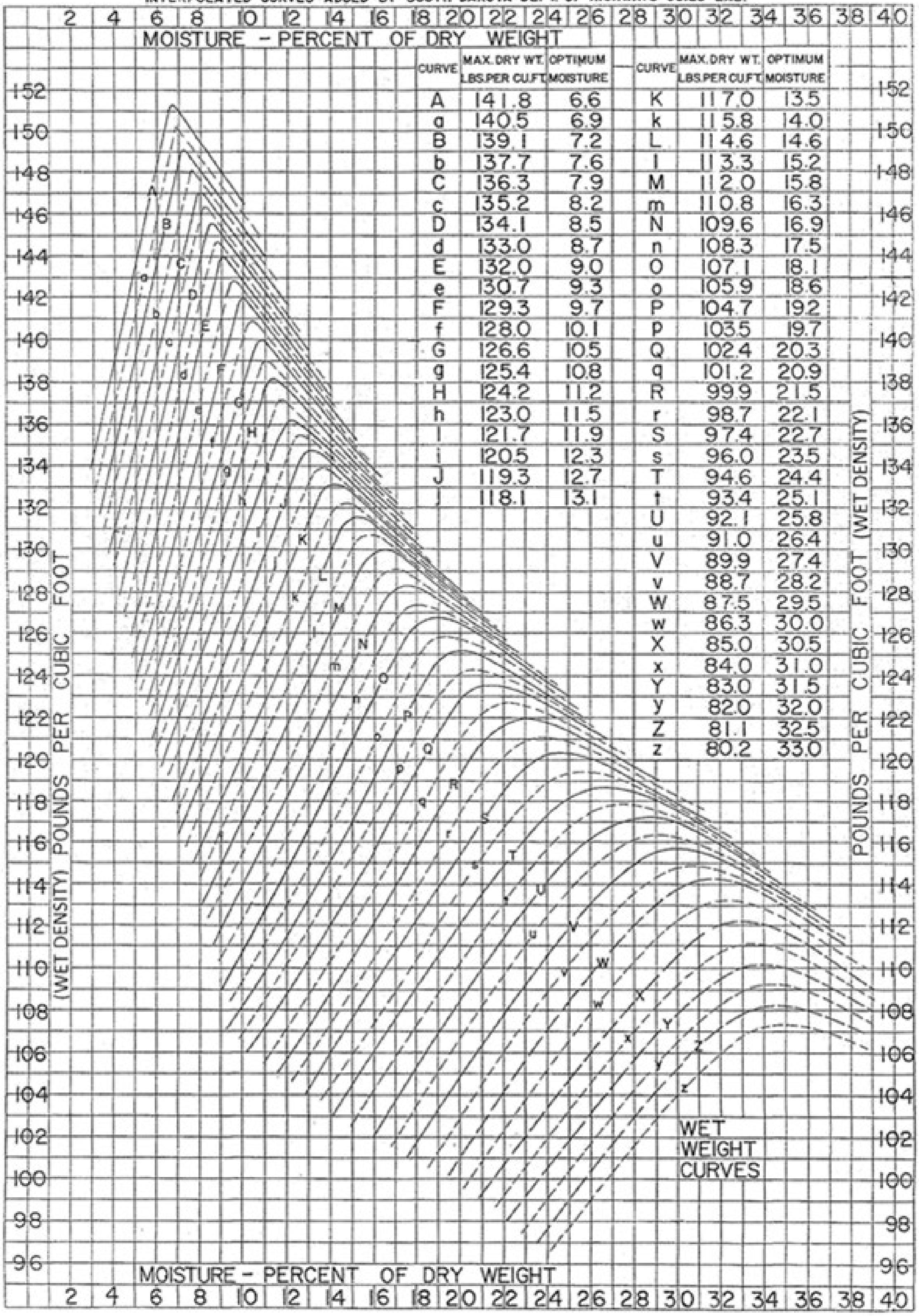
OHIO HWY. DEPT. TYPICAL MOISTURE DENSITY CURVES SET "C"
INTERPOLATED CURVES ADDED BY SOUTH DAKOTA DEPT. OF HIGHWAYS SOILS LAB.



CURVE	MAX. DRY WT. LBS.PER CU.FT.	OPTIMUM MOISTURE
A	141.8	6.6
a	140.5	6.9
B	139.1	7.2
b	137.7	7.6
C	136.3	7.9
c	135.2	8.2
D	134.1	8.5
d	133.0	8.7
E	132.0	9.0
e	130.7	9.3
F	129.3	9.7
f	128.0	10.1
G	126.6	10.5
g	125.4	10.8
H	124.2	11.2
h	123.0	11.5
I	121.7	11.9
i	120.5	12.3
J	119.3	12.7
j	118.1	13.1
K	117.0	13.5
k	115.8	14.0
L	114.6	14.6
l	113.3	15.2
M	112.0	15.8
m	110.8	16.3
N	109.6	16.9
n	108.3	17.5
O	107.1	18.1
o	105.9	18.6
P	104.7	19.2
p	103.5	19.7
Q	102.4	20.3
q	101.2	20.9
R	99.9	21.5
r	98.7	22.1
S	97.4	22.7
s	96.0	23.5
T	94.6	24.4
t	93.4	25.1
U	92.1	25.8
u	91.0	26.4
V	89.9	27.4
v	88.7	28.2
W	87.5	29.5
w	86.3	30.0
X	85.0	30.5
x	84.0	31.0
Y	83.0	31.5
y	82.0	32.0
Z	81.1	32.5
z	80.2	33.0

Figure 7

	MAX. DRY WT. LBS./CU.FT.	OPT. MOIST.		MAX. DRY WT. LBS./CU.FT.	OPT. MOIST.
1	85.0	33.4	11	79.9	38.4
2	84.5	33.9	12	79.4	38.9
3	84.1	34.3	13	79.0	39.4
4	83.5	34.8	14	78.5	40.0
5	83.0	35.3	15	77.9	40.6
6	82.5	35.9	16	77.4	40.9
7	81.9	36.4	17	76.9	41.4
8	81.4	36.9	18	76.4	41.9
9	81.0	37.3	19	76.0	42.4
10	80.5	37.8	20	75.5	42.9

FAMILY OF CURVES FOR LIGHT WEIGHT SOILS

When using this family of curves, the moisture content in the 1-point shall not be more than 2% below, or more than 1% above the optimum moisture

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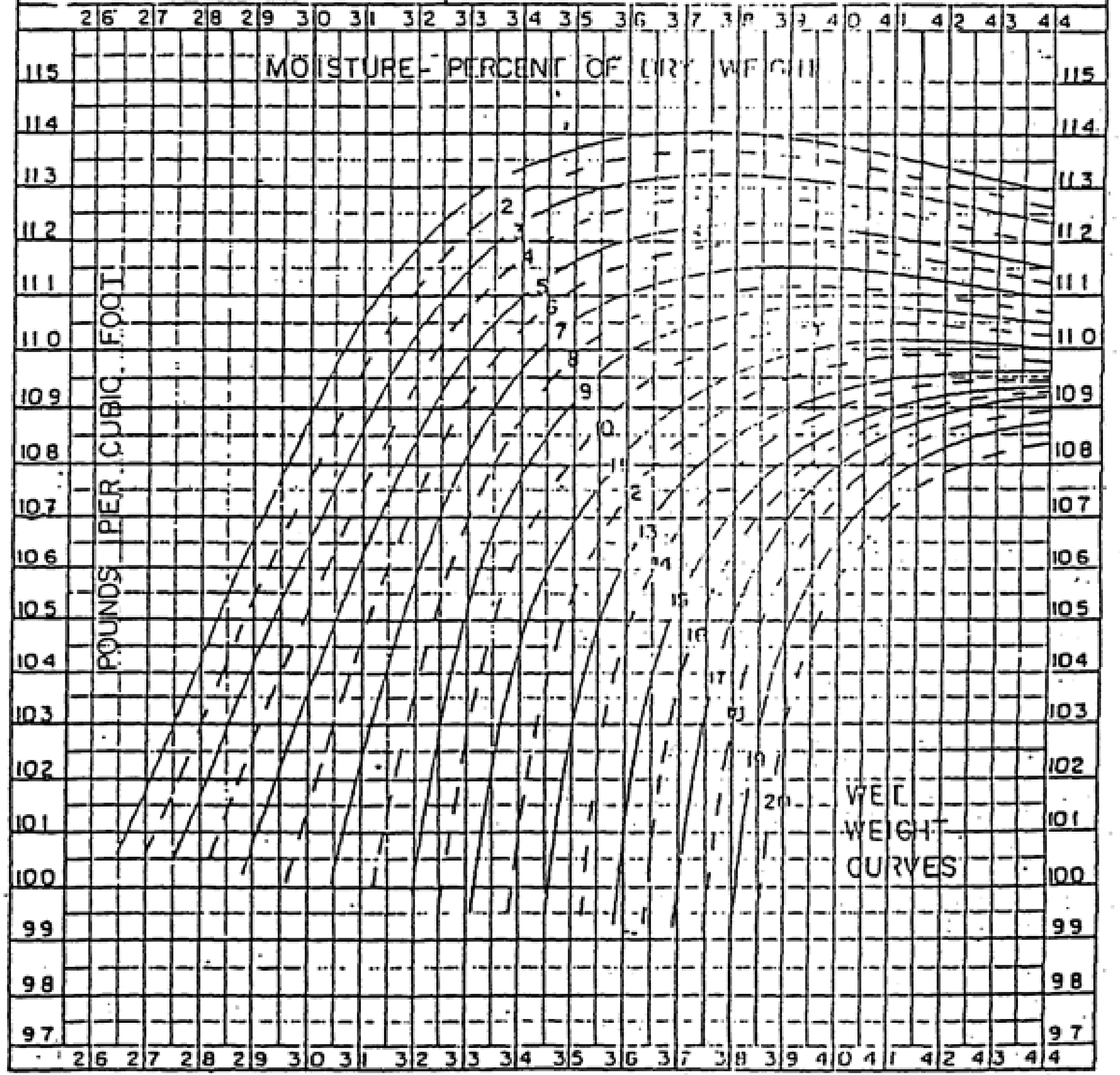

Figure 8

Density of Soils and/or Granular Material In-place by the Sand-Cone Method

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1. Scope:

This test is for determining the in-place density of soils and/or granular materials.

2. Apparatus:

2.1 Density apparatus consisting of a 6 1/2" diameter sand cone and a one gallon jar conforming to the requirements of AASHTO T 191.

2.2 Base plate conforming to the requirements of AASHTO T 191.

2.3 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.01 lb. An additional scale or balance that is readable to the nearest 0.1 gram will be needed for determining the moisture.

2.4 Oven capable of maintaining a temperature of 230° ± 9°F or other equipment according to SD 108.

Back

2.5 1/10th cubic foot standard measure.

2.6 Sand: Clean, dry and free flowing. It must not have a variation in bulk density greater than 1%. Sand retained between the #12 and #20, or #12 and #30 sieve sizes is most suitable. To prove suitability, several bulk density determinations must be made, using the same representative sample.

2.7 Sieves: 3/4", #4, #12, and a #20 or #30 sieves conforming to ASTM E11.

2.8 Miscellaneous: Small pick, hammer, chisels, spoons, pans or other suitable containers for drying moisture samples, buckets, plastic bags and paint brush.

3. Procedure:

3.1 Calibration of Density Apparatus

A. Determine the weight of sand required to fill the cone and base plate.

Pour the standard sand into the density apparatus through the cone with the valve open until the jar is full. The density apparatus should be gently tapped several times (With palm of hand) during filling to ensure that the maximum amount of sand will be available for the next test. Weigh the full density apparatus and record the weight to the nearest 0.01 lb.

Place the base plate on a clean, level, plane surface Such as the bottom of a 6" mold. Invert the density apparatus and seat the cone into the recess of the base plate. Open the valve to allow the sand to fill the cone and base plate. Avoid jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone and base plate. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of sand in the cone and base plate

B. Determine the Bulk Density of the Sand.

(1) Determine the weight of sand to fill the cone.

Pour the standard sand into the density apparatus through the cone with the valve open until the jar is full. The density apparatus should be gently tapped several times (With palm of hand) during filling to ensure that the maximum amount of sand will be available for the next test. Weigh the full density apparatus and record the weight to the nearest 0.01 lb.

Back

Invert the density apparatus and place the cone on a clean, level, plane. Open the valve to allow the sand to fill the cone. Avoid jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of sand in the cone.

(2) Determine the weight of sand to fill the cone and standard measure. Weigh the full density apparatus and record the weight to the nearest 0.01 lb. Center the density apparatus with the cone down and resting on the rim of the standard measure. Open the valve to allow the sand to fill the measure and cone. Avoid jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone and standard measure. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of the sand in the cone and standard measure.

NOTE: This step may be performed with the base plate sitting flush on the measure, in which case 3.1.B.(1) may be eliminated 23 and weight of the sand to fill the cone and base plate from 3.1.A. may be used.

(3) Determine Bulk Density of Sand.

Subtract the average weight of the sand in the cone from the average weight of the sand in the cone and standard measure. Multiply the result by the factor on the standard measure. The results will be the bulk density of the sand in pounds per cubic foot. Use DOT–87 worksheet to record the results.

NOTE: Vibration of the sand during any sand weight-volume determination may increase the bulk density of the sand and decrease the accuracy of the determination. After the sand is calibrated it should be stored in a reasonably air tight container to prevent changes in bulk density caused by a change in moisture content.

NOTE: The calibration of the density apparatus and base plate must be done following its use for 5 density tests or each time un-calibrated sand is added to the sand jar. Ensure that the sand has been thoroughly mixed or the sand comes from the same bag when using two jars.

Back

3.2 Density of In-Place Material.

A. Prior to traveling to the test site, weigh the full density apparatus and record the weight to the nearest 0.01 lb.

B. Prepare the surface of the location to be tested so that it is a level plane. Seat the base plate on the plane surface, ensuring that the edge of the hole of the base plate makes contact with the plane surface. Mark the outline of the base plate to check for movement during the test. It is recommended that the base plate be staked to the plane surface to prevent movement.

NOTE: In soils where leveling is not successful, the test may be conducted without the base plate. Mark the outline of the hole and dig test hole inside the mark. 23

C. Dig the test hole through the base plate, being very careful to avoid disturbing the soil that will bound the hole. Soils that are essentially granular require extreme care. Place all loosened soil in a container, being careful to avoid losing any material or moisture.

D. If the material being tested contains + #4 or + 3/4" rock refer to section 3.3 or 3.4 before proceeding with paragraph E below.

E. Seat the density apparatus in the recess of the base plate, open the valve and after the sand has stopped flowing, close the valve. Avoid jarring or vibrating the density apparatus while the sand is flowing. Weigh the density apparatus with the remaining sand to the nearest 0.01 lb.

F. Weigh the material that was removed from the test hole to the nearest 0.01 lb.

G. Mix the material thoroughly and secure a representative sample for moisture determination.

H. Weigh the material to the nearest 0.1 gram and dry it to a constant weight as per SD 108

I. Use the minimum test hole volumes and the minimum weight of the moisture content samples shown in table 1.

Table 1

Minimum Test Hole Volumes and Minimum Moisture Content Samples Based on Maximum Size of Particle

*Nominal Maximum Particle Size Sieve	Minimum Test Hole Volume ft³	Minimum Moisture Content Sample Grams
# 4	0.0250	100
½”	0.0500	500
¾”	0.0650	500
1”	0.0750	500
2”	0.1000	500

*Nominal maximum size particle is denoted by the smallest sieve opening listed above, through which 90% or more of the material will pass.

For particle size not listed in the table, use the next larger minimum sample size.

NOTE: The volume of the test hole will be computed to the nearest 0.0001 ft³ on the DOT-41.

3.3 When the material being tested is a soil material in which method 2 (4” mold) from SD 104 is to be used for the standard density and more than 10% rock is retained on the #4 sieve, make corrections as follows:

A. All + #4 rock must be removed from the material from the test hole.

B. Place the cone in the recess of the base plate and open the valve and release sufficient sand to cover the bottom of the hole, shut off the flow of sand and remove the density apparatus. Carefully place the rock retained on the #4 sieve in a single layer on the sand. Replace the cone in the recess of the base plate and continue the test. If a larger quantity of rock retained on the #4 sieve is encountered, place a layer of sand between the layers of rock.

Back

C. Weigh the material taken from the hole after the rock retained on the #4 sieve has been removed to the nearest .01 lb. and report the weight on the DOT-41.

D. Mix the material thoroughly and select a representative sample for a moisture test from the minus #4 material from the test hole in accordance with table 1. Weigh the material to the nearest 0.1 g and dry it to a constant weight as per SD 108.

3.4 When the material being tested is a granular material or soil material in which method 4 (6” mold) from SD 104 is to be used for the standard density, make corrections as follows:

A. All + 3/4" rock must be removed from the material from the test hole.

B. Place the cone over the hole and open the valve and release sufficient sand to cover the bottom of the hole, shut off the flow of sand and remove the density apparatus. Carefully place the rock retained on the 3/4” sieve in a single layer on the sand. Replace the density apparatus over the hole and continue the test. If a large quantity of rock is retained on the 3/4” sieve, place a layer of sand between the layers of rock.

Back

C. Weigh the minus 3/4” material from the hole and report the weight on the DOT-41 to the nearest 0.01 lb.

D. Mix the material thoroughly and select a representative sample for a moisture test from the minus 3/4" material from the test hole in accordance with table 1. Weigh the material to the nearest 0.1 gram and dry it to a constant weight as per SD 108.

3.5 Standard Density Determination (1-point)

A. Sample the material from or adjacent to the test hole. Perform the standard density as per SD 104, method 2 or method 4.

4. Report:

4.1 Calculations

A. The procedure for calculating the in-place density, standard density, and moisture are shown on the DOT-41.

See figure 1 for an example of a test on granular material and figure 2 for an example of a test on embankment soil.

B. The maximum dry density from the family of curves established by the 1-point determination is used to compute the percent of standard obtained for the test.

4.2 Report

A. Report the moisture content to the nearest 0.1 percentage point.

B. Report densities to the nearest 0.1 lb./ft³.

C. Report the percent of standard density obtained to the nearest whole percentage point.

5. References:

ASTM E11
AASHTO T 191
SD 104
SD 108
SD 110
DOT-41
DOT-87

Back

Sample ID 2204846
File No.

Density Report

DOT - 41
6-21

County Aurora, Ziebach
PCN/PROJECT B015 PH 0066(00)15
Station 113+39
Dist From CL 8' R
Width (Gravel) 40.00
Depth ____ (from top of Subgrade or Pipe)
Field # 06
Tested By Tester, One
Checked By Tester, Two
Date 06/21/2021

WORK AREA REPRESENTED (Circle what applies)

EMBANKMENT STA. TO STA. (per half mile, for each roadbed)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 5 ft.

BRIDGE END EMBANKMENT STA. TO STA.
1 per zone within plan limits 3 equal zones when backwall is less than 7ft. 4 equal zones when backwall is greater than 7ft.
Zone 1 Zone 2 Zone 3 Zone 4 Zone 5

BERM STA. TO STA. (100 ft. from Bridge End)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 3 ft.

PIPE
CROSS 24" or smaller undercut (1/2 way up) (0-2 ft. Above)
STORM 30" to 72" undercut (Lower 1/2) (Upper 1/2) (0-2 ft. Above)
INTERSECTION 72" or more undercut (Bottom 1/3) (Middle 1/3) (Top 1/3) (0-2 ft. Above)
After Minimum for size pipe installation ☐ 1 per 3 ft of backfill beginning at 2' above top of pipe

SUBBASE STA. TO STA. LIFT
[✓ BASE COURSE] STA. TO STA. 100+00 to 126+40 LIFT 2 of 3

Curve Type	Curve Used		Standard Density Maximum Density	Optimum Moisture		Granular Material 4-Point Range	SPECIFICATION	97%
Ohio	d	U.	133.0	8.7	%	128.1 - 134.1	% Obtained 100X(G/U)	100%

Balloon Method

B. Wt. Undried Matl. from Hole ____
C. Volumeter Reading in Hole ____
D. Initial Volumeter Reading ____
E. Volume of Test Hole (C-D) ____
F. Wet Density (B/E) ____
G. Dry Density F/(100+M{Field}) x 100 ____

Sand Method

A. Std. Sand PCF		96.4
B. Wt. Undried Matl. from Hole		11.98
C. Initial Wt. Sand		16.96
D. Final Wt. Sand	5.35	
Plus Cone Sand	3.66	9.01
E. Volume of Test Hole (C-D)/A		0.0825
F. Wet Density (B/E)		145.2
G. Dry Density F/(100+M{Field}) x 100		133.5

Nuclear Method

Meter No. ____
Test Mode ____
F. Wet Density from Gauge ____
+/-Corr. * ____ = ____
G. Dry Density F/(100+M{Field}) x 100 ____

1-Point Density Determination

O. Weight of Mold & Specimen		25.64
P. Weight of Mold		14.95
Q. Wet Wt. of Molded Specimen (O-P)		10.69
R. Factor of Mold No. Used in Test	2-36	13.29
S. Wet Density (QxR)		142.1
T. Dry Density S/(100+M [1-PT])x100		131.6

Moisture Determination

	1-Point	Field
H. Wt. of Wet Matl. and Container	523.1	829.9
I. Wt. of Dry Matl. and Container	484.3	762.7
J. Wt. of Moisture (H-I)	38.8	67.2
K. Wt. of Container		
L. Wt. of Dry Matl. (I-K)	484.3	762.7
M. Percent Moisture (Jx100)/L	8.0	8.8

Rock Determination

A. Total Sample Weight ____
B. Weight of Material Retained on 3/4" Sieve ____
C. Percent Retained On 3/4" Sieve (Bx100)/A ____

* Correction from DOT-39. If there is no correction or, if the correction has been applied to the meter show "NA".

Figure 1

Back

Back

Sample ID 2204843
File No.

Density Report

DOT - 41
6-21

County Aurora, Ziebach
PCN/PROJECT B015 PH 0066(00)15
Station 115+30
Dist From CL 7' R
Width (Gravel)
Depth 12' (from top of Subgrade or Pipe)
Field # E09
Tested By Tester, One
Checked By Tester, Two
Date 06/21/2021

WORK AREA REPRESENTED (Circle what applies)

[✓ EMBANKMENT] STA. TO STA. 104+00 to 130+00 (per half mile, for each roadbed)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) [✓ Zone 4 (5 ft. to bottom) 1 per 5 ft.]

BRIDGE END EMBANKMENT STA. TO STA.
1 per zone within plan limits — 3 equal zones when backwall is less than 7ft. — 4 equal zones when backwall is greater than 7ft.
Zone 1 Zone 2 Zone 3 Zone 4 Zone 5

BERM STA. TO STA. (100 ft. from Bridge End)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 3 ft.

PIPE
CROSS 24" or smaller undercut (1/2 way up) (0-2 ft. Above)
STORM 30" to 72" undercut (Lower 1/2) (Upper 1/2) (0-2 ft. Above)
INTERSECTION 72" or more undercut (Bottom 1/3) (Middle 1/3) (Top 1/3) (0-2 ft. Above)
After Minimum for size pipe installation ☐ 1 per 3 ft of backfill beginning at 2' above top of pipe

SUBBASE STA. TO STA. LIFT
BASE COURSE STA. TO STA. LIFT

Curve Type	Curve Used		Standard Density Maximum Density	Optimum Moisture		Granular Material 4-Point Range	SPECIFICATION	95%
Ohio	Q	U.	102.4	20.3	%	-	% Obtained 100X(G/U)	96%

Balloon Method

B. Wt. Undried Matl. from Hole
C. Volumeter Reading in Hole
D. Initial Volumeter Reading
E. Volume of Test Hole (C-D)
F. Wet Density (B/E)
G. Dry Density F/(100+M{Field}) x 100

Sand Method

A. Std. Sand PCF 96.4
B. Wt. Undried Matl. from Hole 3.91
C. Initial Wt. Sand 13.68
D. Final Wt. Sand 6.86
Plus Cone Sand 3.66 10.52
E. Volume of Test Hole (C-D)/A 0.0328
F. Wet Density (B/E) 119.2
G. Dry Density F/(100+M{Field}) x 100 98.4

Nuclear Method

Meter No.
Test Mode
F. Wet Density from Gauge
+/-Corr. * =
G. Dry Density F/(100+M{Field}) x 100

1-Point Density Determination

O. Weight of Mold & Specimen 13.27
P. Weight of Mold 9.22
Q. Wet Wt. of Molded Specimen (O-P) 4.05
R. Factor of Mold No. 4-73 Used in Test 30.12
S. Wet Density (QxR) 122.0
T. Dry Density S/(100+M [1-PT])x100 101.8

Moisture Determination

1-Point		Field
143.1	H. Wt. of Wet Matl. and Container	156.4
119.3	I. Wt. of Dry Matl. and Container	129.2
23.8	J. Wt. of Moisture (H-I)	27.2
	K. Wt. of Container	
119.3	L. Wt. of Dry Matl. (I-K)	129.2
19.9	M. Percent Moisture (Jx100)/L	21.1

Rock Determination

A. Total Sample Weight
B. Weight of Material Retained on 3/4" Sieve
C. Percent Retained On 3/4" Sieve (Bx100)/A

* Correction from DOT-39. If there is no correction or, if the correction has been applied to the meter show "NA".

Figure 2

Sample ID 2225659

DOT-87
3-19

Calibration of Sand Cone and Base Plate and Determination of Sand Bulk Density
SD 105 and SD 110

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Calibrated by: Tester, One Date: 09/08/2019

SAND CONE AND BASE PLATE: SD 105

A. Initial weight of sand, cone, and jar.	(1)	16.05	(2)	12.38	(3)	8.72	0.01 lb (1g)
B. Final weight of sand, cone, and jar.	(1)	12.38	(2)	8.72	(3)	5.06	0.01 lb (1g)
C. Weight of sand in cone and base plate. (A - B)	(1)	3.67	(2)	3.66	(3)	3.66	0.01 lb (1g)
D. Average weight of sand in cone and base plate.		3.66	0.01 lb (1g)				

SAND CONE AND MODIFIED BASE PLATE: SD 110

E. Initial weight of sand, cone, and jar.	(1)		(2)		(3)		0.01 lb (1g)
F. Final weight of sand, cone, and jar.	(1)		(2)		(3)		0.01 lb (1g)
G.Weight of sand in cone and modified base plate. (E - F)	(1)		(2)		(3)		0.01 lb (1g)
H. Average weight of sand in cone and modified base plate.			0.01 lb (1g)				

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SAND BULK DENSITY

I. Initial weight of sand, cone, and jar.	(1)	15.98	(2)	12.66	(3)	9.35	0.01 lb (1g)
J. Final weight of sand, cone, and jar.	(1)	12.66	(2)	9.35	(3)	6.03	0.01 lb (1g)
K. Weight of sand in cone. (I - J)	(1)	3.32	(2)	3.31	(3)	3.32	0.01 lb (1g)
L. Average weight of sand in cone.				3.32	0.01 lb (1g)		
M. Initial weight of sand, cone, and jar.	(1)	15.98	(2)	15.98	(3)	15.98	0.01 lb (1g)
N. Final weight of sand, cone, and jar.	(1)	3.03	(2)	3.04	(3)	3.03	0.01 lb (1g)
O. Weight of sand in cone and measure. (M - N)	(1)	12.95	(2)	12.94	(3)	12.95	0.01 lb (1g)
P. Average weight of sand in cone and measure.				12.95	0.01 lb (1g)		
Q. Average weight of sand in measure. (P - L)				9.63	0.01 lb (1g)		
R. Factor of Measure No. P-1881				10.01			
Sand Bulk Density (Q x R) =				96.4	0.1 lb/ft ^{3} (1 kg/m ^{3})		

Comments

Figure 3

Density of Soils In-place by the Rubber Balloon Method

---

1. Scope:

This test is for determining the density of soil in-place using a volumeter. This method is restricted to test hole volumes between 0.02500 and 0.05000 ft^3 and to bonded soil masses with a maximum particle size of ½".

2. Apparatus:

2.1 Volumeter conforming to the requirements of ASTM D2167.

NOTE: New volumeters will be calibrated and volumeters which have had the jar and scale replaced or pressure gauge repaired or replaced will be recalibrated, prior to use. Calibration will be performed by the Region Materials Engineer. Jars and scales are not interchangeable. The serial numbers must be identical.

2.2 Digging tools: Chisel, hammer, scoop or spoon, prospector's pick.

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2.3 Containers. Buckets with lids or plastic bags.

2.4 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.01 lb. and also one that is readable to the nearest 0.1 gram.

2.5 Drying equipment. An oven capable of maintaining a temperature of 230° ± 9°F or other equipment according to SD 108.

3. Procedure:

NOTE: References to base plate in this procedure apply only when the new type volumeters are being used.

3.1 Prepare the surface of the test area so that it is reasonably smooth and level (Free from loose material or holes). Place the volumeter and base plate on this surface and mark the outline of the base on the soil surface.

Take an initial reading using the same gauge pressure as was used during the calibration. Read the volume on the scale and record it on the worksheet.

3.2 Remove the volumeter from the test location and dig a hole centered within the scribed outline, or through the hole of the base plate. Exercise care so that soil around the top edge is not disturbed. Carefully place all the soil removed from the test hole in an airtight container for weight and moisture content determinations. Ensure the test hole volume is in accordance with SD 105, table 1.

3.3 Place the volumeter over the test hole or base plate in the same position used for the initial reading, and inflate the balloon in the hole. Using the same gauge pressure as was used for calibration, take and record the reading on the volume indicator. Release the pressure to deflate and retract the balloon from the hole. The difference between this reading and the initial reading is the test hole volume in ft.^{3}.

NOTE: The meter should be read to the nearest 0.00025.

3.4 Weigh the soil taken from the hole to the nearest 0.01 lb.

3.5 Mix the material thoroughly and select a representative sample for a moisture test, (SD 105, table 1). Weigh the material to the nearest 0.1 gram and dry it to a constant weight as per SD 108.

3.6 Standard Density Determination.

A. To determine standard density, take material from or adjacent to the test hole for SD 104, method 2 or method 4.

4. Report:

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4.1 Calculations.

A. The procedure for calculating the in-place density, standard density, and moisture are shown on the DOT-41, figure 1.

The maximum dry density from the family of curves established by the 1-point determination is used to compute the percent of standard obtained for the test.

4.2 Report.

A. Report the moisture content to the nearest 0.1 percentage point.

B. Report the wet and dry densities for the in-place and standard tests to the nearest 0.1 lb./ft^3.

C. Report the percent of standard density to the nearest whole percentage point.

5. References:

ASTM D2167
SD 104
SD 105
SD 108
DOT-41

Sample ID 2205173
File No.

Density Report

DOT - 41
6-21

County: Aurora, Ziebach
PCN/PROJECT: B015 PH 0066(00)15
Station: 268+50
Dist From CL: 17' R
Width (Gravel):
Depth: 0.5' (from top of Subgrade or Pipe)
Field #: E036
Tested By: Tester, One
Checked By: Tester, Two
Date: 06/21/2021

WORK AREA REPRESENTED (Circle what applies)

[✓ EMBANKMENT] STA. TO STA. 253+00 to 279+00 (per half mile, for each roadbed)
[✓ Zone 1 (0-1 ft.)] Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 5 ft.

BRIDGE END EMBANKMENT STA. TO STA.
1 per zone within plan limits 3 equal zones when backwall is less than 7ft. 4 equal zones when backwall is greater than 7ft.
Zone 1 Zone 2 Zone 3 Zone 4 Zone 5

BERM STA. TO STA. (100 ft. from Bridge End)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 3 ft.

PIPE
CROSS: 24" or smaller undercut (1/2 way up) (0-2 ft. Above)
STORM: 30" to 72" undercut (Lower 1/2) (Upper 1/2) (0-2 ft. Above)
INTERSECTION: 72" or more undercut (Bottom 1/3) (Middle 1/3) (Top 1/3) (0-2 ft. Above)
After Minimum for size pipe installation ☐ 1 per 3 ft of backfill beginning at 2' above top of pipe

SUBBASE STA. TO STA. LIFT
BASE COURSE STA. TO STA. LIFT

Curve Type	Curve Used	Standard Density Maximum Density	Standard Density Optimum Moisture	Granular Material 4-Point Range	SPECIFICATION 95%
Ohio	O	U. 107.1	18.1 %	-	% Obtained 100X(G/U) 95%

Balloon Method

B. Wt. Undried Matl. from Hole	3.56
C. Volumeter Reading in Hole	0.04050
D. Initial Volumeter Reading	0.01025
E. Volume of Test Hole (C-D)	0.03025
F. Wet Density (B/E)	117.7
G. Dry Density F/(100+M{Field}) x 100	101.3

Sand Method

A. Std. Sand PCF	
B. Wt. Undried Matl. from Hole	
C. Initial Wt. Sand	
D. Final Wt. Sand Plus Cone Sand	
E. Volume of Test Hole (C-D)/A	
F. Wet Density (B/E)	
G. Dry Density F/(100+M{Field}) x 100	

Nuclear Method

Meter No.
Test Mode
F. Wet Density from Gauge
+/-Corr. * =
G. Dry Density F/(100+M{Field}) x 100

1-Point Density Determination

O. Weight of Mold & Specimen		13.32
P. Weight of Mold		9.23
Q. Wet Wt. of Molded Specimen (O-P)		4.09
R. Factor of Mold No. Used in Test	2-35	30.01
S. Wet Density (QxR)		122.7
T. Dry Density S/(100+M [1-PT])x100		105.6

Moisture Determination

1-Point		Field
130.7	H. Wt. of Wet Matl. and Container	109.1
112.5	I. Wt. of Dry Matl. and Container	93.9
18.2	J. Wt. of Moisture (H-I)	15.2
	K. Wt. of Container	
112.5	L. Wt. of Dry Matl. (I-K)	93.9
16.2	M. Percent Moisture (Jx100)/L	16.2

Rock Determination

A. Total Sample Weight
B. Weight of Material Retained on 3/4" Sieve
C. Percent Retained On 3/4" Sieve (Bx100)/A

* Correction from DOT-39. If there is no correction or, if the correction has been applied to the meter show "NA".

Figure 1

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Procedure for Direct Shear Test of Soils Under Consolidated Drained Conditions

---

1. Scope:

This test is for determining the consolidated drained shear strength of a soil material in direct shear.

2. Apparatus:

2.1 Shall be in accordance with AASHTO T 236.

3. Procedure:

3.1 Shall be in accordance with AASHTO T 236 except:

A. Section 5.3 – Delete the section and replace with “Minimum specimen diameter for the circular specimens shall be 1.93 in. The diameter of the sampling tube shall be equal to the specimen diameter.”

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4. Report:

4.1 Report results as per AASHTO T 236.

5. References:

AASHTO T 236

Procedure for Moisture Content Determination for Soils and Aggregate

---

1. Scope:

This test is for determining the moisture content of soils and aggregates by drying on a stove or hot plate, drying in a convection or microwave oven, and the nuclear method of in-place moisture tests.

2. Apparatus:

2.1 Stove top or hot plate method.

A. Stove or hot plate.

B. Steel plate(s), approximately ¼" thick to place between the burner(s) and the sample pan.

C. Pan of sufficient size to contain the material and allow room for stirring without loss of material.

Back

D. Spoon or trowel for stirring the material during the drying process.

E. Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

F. Gloves.

2.2 Oven drying method.

A. Drying oven – Thermostatically controlled, preferably of the convection forced-draft type, capable of being heated continuously at a uniform temperature of 230º ± 9ºF throughout the drying chamber.
B. Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

C. Pan of sufficient size to contain the material and allow room for stirring without loss of material.

D. Stirring spoon or trowel.

E. Gloves.

2.3 Nuclear method – In-place moisture test.

A. A nuclear moisture/density gauge capable of determining moisture/densities by the direct transmission method and conforming to the requirements of AASHTO T 310.

B. A reference standard block for taking standard counts.

C. A drill rod, extraction tool and combination guide-scraper plate for preparing the test site and punching the hole for the source rod.

D. A manufacture's instruction manual for the nuclear gauge.

E. A nuclear gauge Information book, transportation documents book, nuclear badge, and metal storage box.

F. A hammer to drive the drill rod, and a shovel and other tools for site preparation.

2.4 Microwave oven method.

A. Microwave oven with vented chamber, variable power controls and output power rating of 1000 watts is adequate.

B. Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

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C. Containers (Must be suitable for microwave ovens-i.e., nonmetallic and resistant to sudden and extreme temperature change; porcelain, or glass).

D. Glove or holder for handling hot containers.

E. Spatulas, putty knives and glass rods.

3. Procedure:

3.1 Stove top or hot plate method.

A. Obtain a sample of wet material weighing a minimum of 100 grams for soils and a minimum of 500 grams for granular materials.

B. Weigh the material to the nearest 0.1 gram and dry it to a constant weight. Constant weight is achieved when two successive periods of drying indicate no change in the weight of the material. Check the first two samples tested on a project and an occasional sample thereafter for constant weight, to ensure that sufficient drying time is being allowed.

The sample usually has been dried to constant weight, when, using a cool metal spoon or spatula, the sample is briefly stirred and there is no evidence of moisture or material sticking to the metal of the stirring instrument.

C. Place the steel plate on the burner of the stove or gas hot plate. Steel plates are not required on electric hot plates. Place the pan holding the material on the steel plate.

D. Stir the material during drying to prevent the temperature of the sample from exceeding 230° ± 9°F.

E. If it is found that samples dried in an oven and those dried on top of the stove do not give test results that compare satisfactorily, use the oven dried method.

Cool until the container can be handled comfortably with bare hands and the operation of balance or sieves on which sample is placed are not affected by heat convection from material/pan.

3.2 Oven drying method.

A. Obtain a sample of wet material weighing a minimum of 100 g for soils and a minimum of 500 g for granular material. Weigh wet material and record to the nearest 0.1 g.

Back

B. Place in dry, clean pan and place in the oven maintained at 230° ± 9°. Stirring the sample periodically during drying accelerates the process.

C. Dry the material to a constant weight and weigh to the nearest 0.1 gram. Constant weight is achieved when two successive periods of drying indicate no change in the weight of the material. Check the first two samples tested on a project and occasional sample thereafter for constant weight, to ensure that sufficient drying time is established for material being tested and apparatus being used.

Cool until the container can be handled comfortably with bare hands and the operation of balance or sieves on which sample is placed are not affected by heat convection from material/pan.

3.3 Nuclear method – In-place moisture test.

A. Calibration and performing the standard count of the nuclear gauge shall be in accordance with SD 114, paragraph 3.1 and 3.2.

B. Select a location for the test where the gauge will be at least 2' away from any vertical projection, at least 10' away from any vehicle and at least 30' away from another nuclear gauge.

C. Remove material, as necessary, to reach the top of the compacted lift to be tested. Prepare a horizontal area, sufficient in size to accommodate the gauge, using the scraper plate supplied with the gauge, by planing to a smooth condition to obtain maximum contact between the gauge and the material being tested. Make sure the gauge sits solidly on the site without rocking.

D. The maximum depressions beneath the gauge shall not exceed 1/8”. Use native fines or fine sand to fill voids and level the excess with the scraper plate. The total areas thus filled with fines or sand should not exceed 10% of the bottom area of the gauge.

E. Place the guide scraper plate on the prepared test site and drive the drill rod with the extraction tool attached through the guide to a depth at least 2” below the depth of material to be measured. Remove the drill rod by pulling straight up and twisting the extraction tool, in order to avoid disturbing the hole.

F. Place the nuclear gauge over the test site and extend the source rod into the hole to the desired depth. Release the trigger at the desired depth and listen for the “Click” indicating that the source rod is properly locked into position on the index rod. Verify the depth shown on the display of the gauge agrees with the actual depth of the source rod. Slide the gauge so the surface of the source rod nearest the keypad is in contact with the edge of the hole.

Back

G. Take a one-minute reading to determine the % moisture and record this number. It is recommended that you take more than one reading and average the results. At the completion of the % moisture measurements, dig up the area beneath the gauge to collect the moisture specimen if a comparison is to be performed and visually check for large voids or inconsistent material which may give inaccurate results. If a large void or inconsistent material is encountered, disregard the test and move to a nearby location.

H. Correction determination: At least five tests must be performed using the nuclear gauge on mechanically compacted material and compared against oven dry moisture tests to compute a moisture correction. Take the moisture sample from the top of the lift to the depth of the source rod directly below the nuclear gauge and immediately place in an airtight container for moisture testing using the oven dry method. Use the DOT-39 to calculate the moisture correction. If an individual comparison is determined which is not within 2.0 % of the correction (Running average) calculated from the previous five individual comparisons, the results shall be considered suspect and additional checks should be run to determine if the material has changed.

I. After the moisture correction is determined, it is applied to future tests performed with the nuclear gauge. Each type of material shall have a different correction. Embankment material shall have a correction determination separate from surfacing material. Corrections are not interchangeable between nuclear gauges, and must be individually determined. If a change in project, change in material source, unusually high or low % moisture readings, considerable changes in sieve analysis, or visual change in material, additional checks should be completed and documented on a DOT-39.

The nuclear gauge moisture reading shall never be used for determination of in-place dry density.

J. Additional comparison checks against the oven dry method shall be performed at a minimum of at least once per 20 moisture tests. Results shall be documented on the DOT-39 worksheet and the correction (Running average) reevaluated for the five most recent in place moisture comparison tests performed.

K. If a discrepancy exists, contact the Region Materials Engineer.

3.4 Microwave oven moisture test method.

A. Determine the weight of a clean, dry container or dish, and record it on the applicable worksheet as "Wt. of container".

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B. Cut or break up the soil into small size aggregations to aid in obtaining quicker and more uniform drying of the specimen. Obtain a sample of wet material weighing a minimum of 100 grams for soils and a minimum of 500 grams for aggregates. Place the sample in the container, and immediately determine and record the weight to the nearest 0.1 gram.

C. Place the sample and container in a microwave oven and turn the oven on for 3 minutes. If experience with a particular soil type and specimen size indicates shorter or longer initial drying times can be used without overheating, the initial and subsequent drying times may be adjusted.

The 3-minute initial setting is for a minimum sample size of 100 grams. Smaller samples are not recommended when using the microwave oven because drying may be too rapid for proper control. Large samples may need to be split into segments and dried separately.

Most ovens have a variable power setting. For the majority of soils tested, a setting of "High" should be satisfactory; however, for some soils such a setting may be too severe. The proper setting can be determined only through the use of and experience with a particular oven for various soil types and sample sizes. The energy output of microwave ovens may decrease with age and usage; therefore, power settings and drying times should be established for each oven.

D. After the set time has elapsed, remove the container and soil from the oven, weigh the specimen as soon as the container may be handled safely to the nearest 0.1 gram and record the weight.

E. With a small spatula, knife, or short length of glass rod, carefully mix the soil, taking special precaution not to lose any soil.

F. Return the container and soil to the oven and reheat for 1 minute.

G. Repeat (D) through (F), until a constant weight has been achieved as per SD 108.

H. Use the final weight to calculate the moisture content. Obtain this value immediately after the heating cycle, as soon as the container may be handled safely.

Incremental heating, together with stirring, will minimize overheating and localized drying of the soil. The recommended time increments have been suitable for most specimens having particles smaller than a #4 sieve and with a sample of approximately 200 g; however, they may not be appropriate for all soils and ovens, and adjustment may be necessary.

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Cool until the container can be handled comfortably with bare hands and the operation of balance or sieves on which sample is placed are not affected by heat convection from material/pan.

Moisture content specimens should be discarded after testing and not used in any other tests due to particle breakdown, chemical changes or losses, melting, or losses of organic constituents.

4. Report:

4.1 Calculations for stove top or hot plate, oven drying, and microwave oven methods.

Calculate the percent of moisture for the drying on a stove or hot plate, oven drying and microwave oven methods as follows:

Moisture content =

$$\frac{\text{Weight wet material} - \text{weight dry material} \times 100}{\text{Weight dry material}}$$

4.2 Calculations for the nuclear method – In-place moisture test on DOT-39.

A = % moisture determined by oven dried method.

B = % moisture determined by the nuclear gauge.

C = A - B

D = Correction (Running average) of 5 most recent valid values of C in %

Moisture content = nuclear moisture + correction (Running average).

5. **References**:

AASHTO T 310
AASHTO T 265
SD 114
SD 311
DOT-35
DOT-39
DOT-41

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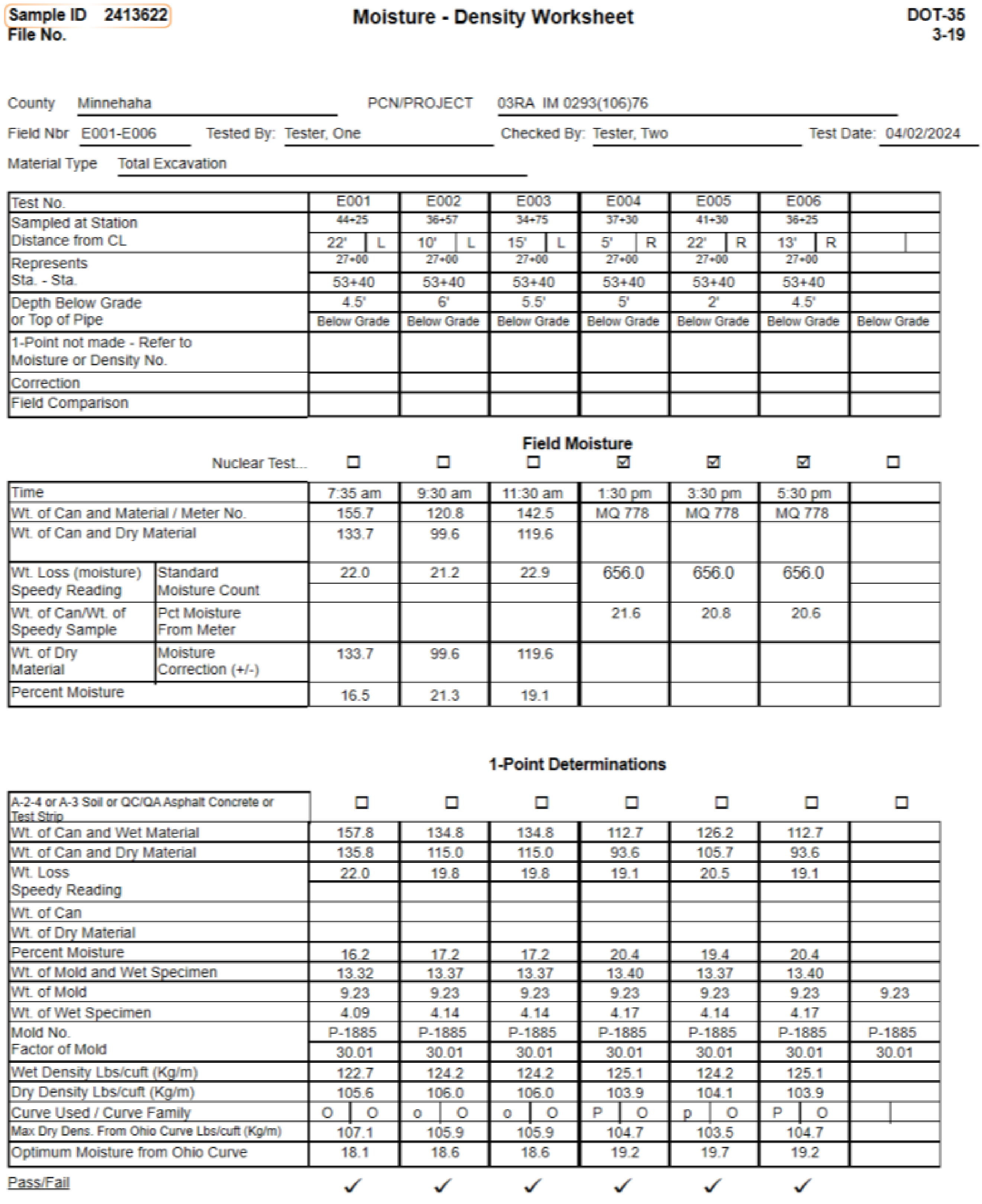

Sample ID **2413622**
File No.

Moisture - Density Worksheet

DOT-35
3-19

County Minnehaha PCN/PROJECT 03RA IM 0293(106)76

Field Nbr E001-E006 Tested By: Tester, One Checked By: Tester, Two Test Date: 04/02/2024

Material Type Total Excavation

Test No.	E001	E002	E003	E004	E005	E006	
Sampled at Station	44+25	36+57	34+75	37+30	41+30	36+25	
Distance from CL	22' L	10' L	15' L	5' R	22' R	13' R	
Represents	27+00	27+00	27+00	27+00	27+00	27+00	
Sta. - Sta.	53+40	53+40	53+40	53+40	53+40	53+40	
Depth Below Grade	4.5'	6'	5.5'	5'	2'	4.5'	
or Top of Pipe	Below Grade	Below Grade	Below Grade	Below Grade	Below Grade	Below Grade	Below Grade
1-Point not made - Refer to Moisture or Density No.							
Correction							
Field Comparison							

Field Moisture

Nuclear Test...		☐	☐	☐	☑	☑	☑	☐
Time		7:35 am	9:30 am	11:30 am	1:30 pm	3:30 pm	5:30 pm	
Wt. of Can and Material / Meter No.		155.7	120.8	142.5	MQ 778	MQ 778	MQ 778	
Wt. of Can and Dry Material		133.7	99.6	119.6				
Wt. Loss (moisture)	Standard Moisture Count	22.0	21.2	22.9	656.0	656.0	656.0	
Speedy Reading								
Wt. of Can/Wt. of Speedy Sample	Pct Moisture From Meter				21.6	20.8	20.6	
Wt. of Dry Material	Moisture Correction (+/-)	133.7	99.6	119.6				
Percent Moisture		16.5	21.3	19.1				

1-Point Determinations

A-2-4 or A-3 Soil or QC/QA Asphalt Concrete or Test Strip	☐	☐	☐	☐	☐	☐	☐
Wt. of Can and Wet Material	157.8	134.8	134.8	112.7	126.2	112.7	
Wt. of Can and Dry Material	135.8	115.0	115.0	93.6	105.7	93.6	
Wt. Loss	22.0	19.8	19.8	19.1	20.5	19.1	
Speedy Reading							
Wt. of Can							
Wt. of Dry Material							
Percent Moisture	16.2	17.2	17.2	20.4	19.4	20.4	
Wt. of Mold and Wet Specimen	13.32	13.37	13.37	13.40	13.37	13.40	
Wt. of Mold	9.23	9.23	9.23	9.23	9.23	9.23	9.23
Wt. of Wet Specimen	4.09	4.14	4.14	4.17	4.14	4.17	
Mold No.	P-1885	P-1885	P-1885	P-1885	P-1885	P-1885	P-1885
Factor of Mold	30.01	30.01	30.01	30.01	30.01	30.01	30.01
Wet Density Lbs/cuft (Kg/m)	122.7	124.2	124.2	125.1	124.2	125.1	
Dry Density Lbs/cuft (Kg/m)	105.6	106.0	106.0	103.9	104.1	103.9	
Curve Used / Curve Family	O O	o O	o O	P O	p O	P O	
Max Dry Dens. From Ohio Curve Lbs/cuft (Kg/m)	107.1	105.9	105.9	104.7	103.5	104.7	
Optimum Moisture from Ohio Curve	18.1	18.6	18.6	19.2	19.7	19.2	
Pass/Fail	✓	✓	✓	✓	✓	✓	

Figure 1

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Procedure for One-Dimensional Consolidation Properties of Soils

---

1. Scope:

This test is for determining the magnitude and rate of consolidation of soil when it is restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading.

2. Apparatus:

2.1 Shall be in accordance with AASHTO T 216 except:

A. Section 6.2.1 – Delete the section and replace with “Minimum specimen diameter – The minimum specimen diameter shall be 1.93 in.. The diameter of the sample in the tube shall be equal to the diameter of the consolidation test ring.”

B. Section 6.2.3 – Delete the first sentence and replace with “Minimum specimen diameter-to-height ratio – The minimum specimen diameter-to-height ratio shall be 1.93”.

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3. Procedure:

3.1 Shall be in accordance with AASHTO T 216.

4. Report:

4.1 Report results as per AASHTO T 216.

5. **References**:

AASHTO T 216

Density of Granular Material by Modified Sand-Cone Method for Thin Layers

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1. Scope:

This test is for determining in-place density of granular materials that have a total thickness of less than 4”. 24

2. Apparatus:

2.1 Density apparatus consisting of a 6 1/2" diameter sand cone and two 1 gallon jars conforming to the requirements of AASHTO T 191.

2.2 Modified base plate: The modified base plate is the same base plate used in SD 105 with a 10” diameter cone attached to the bottom. The height of the 10” diameter cone is approximately 3”.

2.3 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.01 lb. An additional scale or balance that is readable to the nearest 0.1 gram will be needed for determining the moisture.

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2.4 Oven capable of maintaining a temperature of 230° ± 9°F or other equipment according to SD 108.

2.5 1/10th cubic foot standard measure.

2.6 Sand: Clean, dry and free flowing. It must not have a variation in bulk density greater than 1%. Sand retained between the #12 and #20, or #12 and #30 sieve sizes is most suitable. To prove suitability, several bulk density determinations must be made, using the same representative sample.

2.7 Sieves: 3/4", #12, and a #20 or #30 sieves conforming to ASTM E11.

2.8 Miscellaneous: Small pick, hammer, chisels, spoons, pans or other suitable containers for drying moisture samples, buckets, plastic bags and paint brush.

3. Procedure:

3.1 Calibration of density apparatus

A. Determine the weight of sand required to fill the cone and modified base plate.

Pour the standard sand into the density apparatus through the cone with the valve open until the jar is full. The density apparatus should be gently tapped several times (With palm of hand) during filling to ensure that the maximum amount of sand will be available for the next test. Weigh the full density apparatus and record the weight to the nearest 0.01 lb.

Place the 10” cone of the modified base plate on a clean, level, plane surface (Such as a tabletop). Invert the density apparatus and seat the cone into the recess of the modified base plate. Open the valve to allow the sand to fill the cone and modified base plate. Avoid jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone and modified base plate. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of sand in the cone and modified base plate. Replace the sand removed in the cone and modified base plate weight determination and close the valve.

B. Determine the bulk density of the sand.

(1) Determine the weight of sand to fill the cone.

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Pour the standard sand into the density apparatus through the cone with the valve open until the jar is full. The density apparatus should be gently tapped several times (With palm of hand) during filling to ensure that the maximum amount of sand will be available for the next test. Weigh the full density apparatus and record the weight to the nearest 0.01 lb.

Invert the density apparatus and place the cone on a clean, level, plane surface (Such as a tabletop). Open the valve to allow the sand to fill the cone. Avoid jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of sand in the cone. Replace the sand removed in the cone weight determination and close the valve.

(2) Determine the weight of sand to fill the cone and standard measure.

Weigh the full density apparatus and record the weight to the nearest 0.01 lb. Center the density apparatus with the cone down and resting on the rim of the standard measure. Open the valve to allow the sand to fill the measure and cone. Avoid jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone and standard measure. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of the sand in the cone and standard measure. Replace the sand removed in the cone weight and standard measure determination and close the valve.

(3) Determine bulk density of sand.

Subtract the average weight of the sand in the cone from the average weight of the sand in the cone and standard measure. Multiply the result by the factor on the standard measure. The results will be the bulk density of the sand in pounds per cubic foot. Use DOT–87 worksheet to record the results.

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Vibration of the sand during any sand weight-volume determination may increase the bulk density of the sand and decrease the accuracy of the determination. After the sand is calibrated it should be stored in a reasonably airtight container to prevent changes in bulk density caused by a change in moisture content.

The calibration of the density apparatus and modified base plate must be done following its use for 5 density tests or each time un-calibrated sand is added to the sand jar. Ensure that the sand has been thoroughly mixed, or the sand comes from the same bag when using two jars.

3.2 Density of in-place material.

A. Prepare the surface of the location to be tested so that it is a level plane. Seat the 10” cone of the modified base plate on the plane surface, ensuring that the edge of the cone makes contact with the plane surface. Mark the outline of the cone to check for movement during the test.

B. Dig the test hole inside of the cone mark, being very careful to avoid disturbing the soil that will bound the hole. Soils that are essentially granular require extreme care. Place all loosened soil in a container, being careful to avoid losing any material or moisture.

C. After completion of the hole, screen the material over a 3/4“screen. Return – 3/4" material to the container.

D. Place the cone of the modified base plate inside of the cone mark. Seat the density apparatus in the recess of the modified base plate. Open the valve and release sufficient sand to cover the bottom of the hole, shut off the flow of sand and remove the density apparatus. Carefully place the rock retained on the 3/4” sieve in a single layer on the sand. If a large quantity of rock is retained on the 3/4” sieve, place a layer of sand between the layers of rock. Reseat the density apparatus and fill the hole until the sand is just below the modified base plate.

E. Remove the partially filled jar and remove the cone. Place the sand cone on the full jar. Reseat the density apparatus, open the valve and after the sand has stopped flowing, close the valve. Avoid jarring or vibrating the density apparatus while the sand is flowing. Weigh the density apparatus with the remaining sand and the partial jar to the nearest 0.01 lb.

F. Weigh the material that was removed from the test hole to the nearest 0.01 lb.

G. Mix the material thoroughly and secure a representative sample for moisture determination.

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H. Weigh the material to the nearest 0.1 gram and dry it to a constant weight as per SD 108.

I. Use the minimum test hole volumes and the minimum weight of the moisture content samples shown in table 1.

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Minimum Test Hole Volumes and Minimum Moisture
Content Samples Based on Maximum Size of Particle

*Nominal Maximum Particle Size Sieve	Minimum Test Hole Volume ft^3	Minimum Moisture Content Sample Grams
½”	0.0500	500
¾”	0.0650	500
1”	0.0750	500
2”	0.1000	500

*Nominal maximum size particle is denoted by the smallest sieve opening listed above, through which 90% or more of the material will pass.

For particle size not listed above, use the next larger minimum sample size.

The volume of the test hole will be computed to the nearest 0.0001 ft^3 on the DOT-41.

3.3 Standard density determination (1-point)

A. Sample the material from or adjacent to the test hole. Perform the standard density as per SD 104, method 4.

4. Report:

4.1 Calculations

A. The procedure for calculating the in-place density, standard density, and moisture content are shown on a DOT-41. (Figure 1 & 1A)

B. The maximum dry density from the family of curves established by the 1-point determination is used to compute the percent of standard obtained for the test.

4.2 Report

A. Report the moisture content to the nearest 0.1 percentage point.

B. Report the wet and dry densities for the in-place and standard test, to the nearest 0.1 lb./ft³.

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C. Report the percent of standard density obtained to the nearest whole percentage point.

5. References:

AASHTO T 191
ASTM E11
SD 104
SD 105
SD 108
DOT-41
DOT-87

Sample ID 2205193
File No.

Density Report

DOT - 41
6-21

County Aurora, Ziebach
PCN/PROJECT B015 PH 0066(00)15
Station 243+00
Dist From CL 11' R
Width (Gravel) 52.50
Depth ______ (from top of Subgrade or Pipe)
Field # abc123
Tested By Tester, One
Checked By Tester, Two
Date 06/21/2021

WORK AREA REPRESENTED (Circle what applies)

EMBANKMENT STA. TO STA. (per half mile, for each roadbed)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 5 ft.

BRIDGE END EMBANKMENT STA. TO STA.
1 per zone within plan limits 3 equal zones when backwall is less than 7ft. 4 equal zones when backwall is greater than 7ft.
Zone 1 Zone 2 Zone 3 Zone 4 Zone 5

BERM STA. TO STA. (100 ft. from Bridge End)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 3 ft.

	CROSS	24" or smaller	undercut	(1/2 way up)	(0-2 ft. Above)		
PIPE	STORM	30" to 72"	undercut	(Lower 1/2)	(Upper 1/2)	(0-2 ft. Above)	
	INTERSECTION	72" or more	undercut	(Bottom 1/3)	(Middle 1/3)	(Top 1/3)	(0-2 ft. Above)

After Minimum for size pipe installation ☐ 1 per 3 ft of backfill beginning at 2' above top of pipe

SUBBASE STA. TO STA. LIFT

[✓ BASE COURSE] STA. TO STA. 200+00 to 252+80 LIFT 3 of 3

Curve Type	Curve Used		Standard Density Maximum Density	Optimum Moisture		Granular Material 4-Point Range	SPECIFICATION	97%
Ohio	d	U.	133.0	8.7	%	128.1 - 134.1	% Obtained 100X(G/U)	97%

Balloon Method

B. Wt. Undried Matl. from Hole	
C. Volumeter Reading in Hole	
D. Initial Volumeter Reading	
E. Volume of Test Hole (C-D)	
F. Wet Density (B/E)	
G. Dry Density F/(100+M{Field}) x 100	

Sand Method

A. Std. Sand PCF		96.4
B. Wt. Undried Matl. from Hole		11.37
C. Initial Wt. Sand		30.90
D. Final Wt. Sand	10.69	
Plus Cone Sand	12.37	23.06
E. Volume of Test Hole (C-D)/A		0.0813
F. Wet Density (B/E)		139.9
G. Dry Density F/(100+M{Field}) x 100		128.6

Nuclear Method

Meter No. ______
Test Mode ______
F. Wet Density from Gauge ______
+/-Corr. * ______ = ______
G. Dry Density F/(100+M{Field}) x 100 ______

1-Point Density Determination

O. Weight of Mold & Specimen		25.64
P. Weight of Mold		14.95
Q. Wet Wt. of Molded Specimen (O-P)		10.69
R. Factor of Mold No. Used in Test	2-36	13.29
S. Wet Density (QxR)		142.1
T. Dry Density S/(100+M [1-PT])x100		131.6

Moisture Determination

1-Point		Field
523.1	H. Wt. of Wet Matl. and Container	829.9
484.3	I. Wt. of Dry Matl. and Container	762.7
38.8	J. Wt. of Moisture (H-I)	67.2
	K. Wt. of Container	
484.3	L. Wt. of Dry Matl. (I-K)	762.7
8.0	M. Percent Moisture (Jx100)/L	8.8

Rock Determination

A. Total Sample Weight ______
B. Weight of Material Retained on 3/4" Sieve ______
C. Percent Retained On 3/4" Sieve (Bx100)/A ______

* Correction from DOT-39. If there is no correction or, if the correction has been applied to the meter show "NA".

Figure 1

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Sample ID 2225660

DOT-87
3-19

Calibration of Sand Cone and Base Plate and Determination of Sand Bulk Density
SD 105 and SD 110

PROJECT PH 0066(00)15
COUNTY Aurora, Ziebach
PCN B015
Calibrated by: Tester, One
Date: 04/29/2019

SAND CONE AND BASE PLATE: SD 105

A. Initial weight of sand, cone, and jar.	(1)		(2)		(3)		0.01 lb (1g)
B. Final weight of sand, cone, and jar.	(1)		(2)		(3)		0.01 lb (1g)
C. Weight of sand in cone and base plate. (A - B)	(1)		(2)		(3)		0.01 lb (1g)
D. Average weight of sand in cone and base plate.				0.01 lb (1g)			

SAND CONE AND MODIFIED BASE PLATE: SD 110

E. Initial weight of sand, cone, and jar.	(1)	16.07	(2)	16.07	(3)	16.07	0.01 lb (1g)
F. Final weight of sand, cone, and jar.	(1)	3.70	(2)	3.70	(3)	3.71	0.01 lb (1g)
G.Weight of sand in cone and modified base plate. (E - F)	(1)	12.37	(2)	12.37	(3)	12.36	0.01 lb (1g)
H. Average weight of sand in cone and modified base plate.			12.37	0.01 lb (1g)			

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SAND BULK DENSITY

I. Initial weight of sand, cone, and jar.	(1)	15.98	(2)	12.66	(3)	9.35	0.01 lb (1g)
J. Final weight of sand, cone, and jar.	(1)	12.66	(2)	9.35	(3)	6.03	0.01 lb (1g)
K. Weight of sand in cone. (I - J)	(1)	3.32	(2)	3.31	(3)	3.32	0.01 lb (1g)
L. Average weight of sand in cone.				3.32	0.01 lb (1g)		
M. Initial weight of sand, cone, and jar.	(1)	15.98	(2)	15.98	(3)	15.98	0.01 lb (1g)
N. Final weight of sand, cone, and jar.	(1)	3.03	(2)	3.04	(3)	3.03	0.01 lb (1g)
O. Weight of sand in cone and measure. (M - N)	(1)	12.95	(2)	12.94	(3)	12.95	0.01 lb (1g)
P. Average weight of sand in cone and measure.				12.95	0.01 lb (1g)		
Q. Average weight of sand in measure. (P - L)				9.63	0.01 lb (1g)		
R. Factor of Measure No. P-1881				10.01			
Sand Bulk Density (Q x R) =				96.4	0.1 lb/ft^3 (1 kg/m^3)		

Comments

Figure 2

METHOD TO DETERMINE DURABLE MATERIAL RETAINED ON 3/4 INCH SIEVE

1. Scope:

This procedure is for determining the percentage by weight of durable material passing an 8 inch opening and retained on a 3/4 inch sieve.

2. Apparatus:

2.1 3/4” sieve conforming to AASHTO M 92.

2.2 Scale having a capacity of at approximately least 30 lbs, sensitive and readable to 0.01 lb.

2.3 Miscellaneous: shovel, bucket.

3. Procedure:

3.1 Field Sieve Analysis

A. Obtain a sample of material weighing approximately 30 lbs.

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B. Weigh the material, record to the nearest 0.1 lbs.

C. Sieve the sample over 3/4 inch sieve.

D. Weigh the material retained on the 3/4 inch sieve, record to the nearest 0.1 lbs.

3.2 Durability Check

A. Obtain a sample of material weighing approximately 30 lbs (may use material from 3.1).

B. Wash the material retained on the ¾” sieve.

C. Dry the material retained on the ¾ inch sieve.

D. Weigh the material retained on the 3/4 inch sieve (Wi), record to the nearest 0.1 lbs.

E. Place the sample in a pan and completely cover the sample with water.

F. Allow the material to soak for 24 hours.

G. Remove the material and dry.

H. Sieve the sample over 3/4 inch sieve.

I. Weigh the material retained on the 3/4 inch sieve (Wf), record to the nearest 0.1 lbs.

Note: Material is considered durable if it is 95% or more durable.

3.3 Moisture

A. Perform field moisture as per SD108 and 1-point determination as per SD104, Method 4.

4. Report:

4.1 Field Sieve Analysis

The percentage of materials retained on the ¾” sieve is calculated as follows: 24

$$\text{\% +3/4” material} = \frac{\text{wt. of material retained on ¾” sieve}}{\text{Total weight of material}} \times 100$$

Report the percentage to the nearest 0.1%. (DOT-41)

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4.2 Durability Check

The Material will be considered durable if the percentage of materials retained on the ¾” sieve is 5% or less.

$$\text{Durability} = \frac{\text{(Weight Final}(W_f) - \text{Weight Initial}(W_i)}{\text{Weight}(W_f)} \times 100$$

Report the durability percentage to the nearest 0.1%. (Miscellaneous. Test Document).

5. References:

None.

Blank

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Blank

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Determination of In-place Density of Soils and Aggregates by Nuclear Method

---

1. Scope:

This test is for determining density of soil and aggregate, including lime treated material, by the nuclear method.

2. Apparatus:

2.1 Nuclear moisture-density gauge capable of determining densities by the direct transmission method and conforming to the requirements of AASHTO T 310.

2.2 A reference standard block for taking standard counts.

2.3 A drill rod, extraction tool, and combination guide-scraper plate for preparing the test site and punching the hole for the source rod.

2.4 A manufacturer's instruction manual for the nuclear gauge.

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2.5 A nuclear gauge information book, transportation documents book, and nuclear badge.

2.6 A hammer to drive the drill rod, and a shovel and other tools for site preparation.

3. Procedure:

3.1 Calibration.

A. The Central Laboratory will calibrate nuclear gauges annually and each time repairs are made.

3.2 Standard counts.

A. Turn the gauge on and allow the gauge to warm up for at least 10 minutes.

B. Place the gauge on the reference standard block and take the standard count as recommended by the manufacturer.

C. Take at least one 4 minute standard count daily. This count should compare within 1% of the average of the 4 previous standard density counts and compare within 2% of the average of the 4 previous standard moisture counts for the gauge. If the standard count varies by more than these tolerances, do not accept the standard count. Check that all the manufacturer's guidelines have been followed and take another standard count.

NOTE: If the second count also fails, follow the manufacturer's recommendation for the particular model gauge for taking and recording 4 additional standard counts.

D. Record the results of the standard count in the gauge's logbook and on form DOT-41.

3.3 Site preparation.

A. Select a location for the test where the gauge will be at least 2' away from any vertical projection, at least 10' away from any vehicle and at least 30' away from another nuclear gauge.

B. Remove material, as necessary, to reach the top of the compacted lift to be tested. Prepare a horizontal area, sufficient in size to accommodate the gauge, using the scraper plate supplied with the gauge, by planing to a smooth condition to obtain maximum contact between the gauge and the material being tested. Make sure the gauge sits solidly on the site without rocking.

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C. The maximum depressions beneath the gauge will not exceed 1/8". Use native fines or fine sand to fill voids and level the excess with the scraper plate. The total areas thus filled with fines or sand should not exceed 10% of the bottom area of the gauge.

3.4 Wet density determination.

A. Place the guide-scraper plate on the prepared test site and drive the drill rod with the extraction tool attached through the guide to a depth at least 2" below the depth of the material to be measured. Remove the drill rod by pulling it straight up and twisting the extraction tool, to avoid disturbing the hole.

B. Place the nuclear gauge over the test site and extend the source rod into the hole to the desired depth. Release the trigger at the desired depth and listen for the "Click" indicating that the source rod is properly locked into position on the index rod. Verify the depth shown on the display of the gauge agrees with the actual depth of the source rod. Slide the gauge so the surface of the source rod nearest the keypad is in contact with the edge of the hole.

Take a one-minute reading to determine the wet density in lbs./ft^3 and record this number on the DOT-41 worksheet. It is recommended that you take more than one reading and average the results. At the completion of wet density measurements, dig up the area beneath the gauge to collect the moisture specimen and visually check for large voids or inconsistent material which may give inaccurate results. If a large void or inconsistent material is encountered, disregard the test and move to a nearby location. The moisture content used to determine the in place dry density must be collected from beneath the gauge.

3.5 Correction determination.

A. At least five tests must be performed using the nuclear gauge on mechanically compacted material and compared against SD 105 or SD 106 to compute a wet density correction (Figure 2) Use the DOT-39 to calculate the wet density correction. If an individual comparison is determined which is not within 3.0 lbs./ft^3 of the Correction (Running average) calculated from the previous five individual comparisons, the results will be considered suspect and additional checks should be run to determine if the material has changed.

After the wet density correction is determined, it is applied to future tests performed with the nuclear gauge. Each type of material will have a different correction. Embankment material will have a correction determination separate from surfacing material. Corrections are not interchangeable between nuclear gauges and must be individually determined. If a change in project, change in material source, unusually high or low density readings, considerable changes in sieve analysis, or visual change in material, additional checks should be completed and documented on a DOT-39.

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NOTE: The nuclear gauge moisture reading will never be used for determination of in-place dry density.

B. Additional comparison checks against SD 105 or SD 106. These tests will be performed at a minimum of at least once per 20 wet density tests. Results will be documented on the DOT-39 worksheet and the Correction (Running average) reevaluated for the five most recent wet density comparison tests performed. Results from Independent assurance tests may be used in determining the correction.

C. If a discrepancy exists, contact the Region Materials Engineer.

3.6 Standard density determination.

A. To determine standard density, take material from or adjacent to the test hole for SD 104, method 2 or method 4.

4. Report:

4.1 Calculations of wet density correction on DOT 39

A = Balloon or sand cone density in lb/ft^3.

B = Wet density in lbs./ft^3 determined by the nuclear gauge.

C = A – B

D = Correction (Running average) of 5 most recent values of C in lb/ft^3.

Wet Density = Nuclear wet density + correction

4.2 Report the percent of standard density to the nearest whole percentage point.

5. References:

AASHTO T 310
SD 105
SD 106
SD 108
DOT-39
DOT-41

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Sample ID 2205215
File No.

Density Report

DOT - 41
6-21

County Aurora, Ziebach
PCN/PROJECT B015 PH 0066(00)15
Station 28+91
Dist From CL 17' R
Width (Gravel)
Depth (from top of Subgrade or Pipe)
Field # test
Tested By Tester, One
Checked By Tester, Two
Date 06/21/2021

WORK AREA REPRESENTED (Circle what applies)

[✓ EMBANKMENT] STA. TO STA. 26+00 to 52+00 (per half mile, for each roadbed)

Zone 1 (0-1 ft.) [✓ Zone 2 (1-3 ft.)] Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 5 ft.

BRIDGE END EMBANKMENT STA. TO STA.

1 per zone within plan limits 3 equal zones when backwall is less than 7ft. 4 equal zones when backwall is greater than 7ft.

Zone 1 Zone 2 Zone 3 Zone 4 Zone 5

BERM STA. TO STA. (100 ft. from Bridge End)

Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 3 ft.

	CROSS	24" or smaller	undercut	(1/2 way up)	(0-2 ft. Above)		
PIPE	STORM	30" to 72"	undercut	(Lower 1/2)	(Upper 1/2)	(0-2 ft. Above)	
	INTERSECTION	72" or more	undercut	(Bottom 1/3)	(Middle 1/3)	(Top 1/3)	(0-2 ft. Above)

After Minimum for size pipe installation ☐ 1 per 3 ft of backfill beginning at 2' above top of pipe

SUBBASE STA. TO STA. LIFT

BASE COURSE STA. TO STA. LIFT

Curve Type	Curve Used		Standard Density Maximum Density	Optimum Moisture		Granular Material 4-Point Range	SPECIFICATION	95%
Ohio	O	U.	107.1	18.1	%	-	% Obtained 100X(G/U)	98%

Balloon Method

B. Wt. Undried Matl. from Hole
C. Volumeter Reading in Hole
D. Initial Volumeter Reading
E. Volume of Test Hole (C-D)
F. Wet Density (B/E)
G. Dry Density F/(100+M{Field}) x 100

Sand Method

A. Std. Sand PCF
B. Wt. Undried Matl. from Hole
C. Initial Wt. Sand
D. Final Wt. Sand Plus Cone Sand
E. Volume of Test Hole (C-D)/A
F. Wet Density (B/E)
G. Dry Density F/(100+M{Field}) x 100

Nuclear Method

Meter No. MQ 778
Test Mode 6" DIRECT TRANSMISSION
F. Wet Density from Gauge 120.80
+/-Corr. * 1.20 = 122.0
G. Dry Density F/(100+M{Field}) x 100 105.4

1-Point Density Determination

O. Weight of Mold & Specimen		13.32
P. Weight of Mold		9.23
Q. Wet Wt. of Molded Specimen (O-P)		4.09
R. Factor of Mold No. Used in Test	P-1885	30.01
S. Wet Density (QxR)		122.7
T. Dry Density S/(100+M [1-PT])x100		105.6

Moisture Determination

1-Point		Field
130.7	H. Wt. of Wet Matl. and Container	109.1
112.5	I. Wt. of Dry Matl. and Container	94.3
18.2	J. Wt. of Moisture (H-I)	14.8
	K. Wt. of Container	
112.5	L. Wt. of Dry Matl. (I-K)	94.3
16.2	M. Percent Moisture (Jx100)/L	15.7

Rock Determination

A. Total Sample Weight
B. Weight of Material Retained on 3/4" Sieve
C. Percent Retained On 3/4" Sieve (Bx100)/A

* Correction from DOT-39. If there is no correction or, if the correction has been applied to the meter show "NA".

Figure1

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Sample ID: 2205230

Determination of Corrections for Moisture and Density by the Nuclear Gauge

DOT-39
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Tested by Tester, One Checked by Tester, Two Test Date 04/28/2015
Nuclear Gauge No. MQ 778 Material Type Unclassified Excavation

Moisture (Percent)

Test No.	Date	Oven Dry	Nuclear Gauge	Individual Comparison Oven Dry - Nuclear	Correction (Running Avg.)
E001	06/03/2015	26.7	25.1	1.6	
E002	06/03/2015	23.9	22.1	1.8	
E003	06/03/2015	26.2	25.2	1.0	
E004	06/04/2015	12.4	10.9	1.5	
P002	06/04/2015	12.7	11.4	1.3	1.4
E025	06/08/2015	19.5	19.7	-0.2	1.1
E045	06/18/2015	18.3	16.8	1.5	1.0
E065	06/22/2015	18.7	17.5	1.2	1.1

Actual Moisture = Nuclear Moisture + Correction (Running Avg.)

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Wet Density (Lbs/CuFt)

Test No.	Date	Sand or Balloon Test	Nuclear Gauge	Individual Comparison Sand/Balloon - Nuclear	Correction (Running Avg.)
E001	06/03/2015	123.2	122.7	0.5	
E002	06/03/2015	122.4	121.3	1.1	
E003	06/03/2015	122.8	121.8	1.0	
E004	06/04/2015	126.2	123.5	2.7	
P002	06/04/2015	127.8	127.6	0.2	1.1
E025	06/08/2015	124.5	122.2	2.3	1.5
E045	06/18/2015	127.1	126.3	0.8	1.4
E065	06/22/2015	126.1	126.2	-0.1	1.2

Actual Wet Density = Nuclear Density + Correction (Running Avg.)

Figure 2

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Aggregate Section

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Method of Sampling Gravel, Stone, Sand, Filler, and Clay

1. Scope:

These methods are for obtaining samples from stockpiles, conveyor belts, windrows and spreader. Procedures for reducing samples to testing size are described in SD 213.

Other methods giving representative samples may be used, if approved by the Chief Materials and Surfacing Engineer.

2. Apparatus:

2.1 Not specified.

3. Procedure:

Sampling is as important as testing. Every precaution will be used to obtain samples that are representative of the material.

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3.1 Stockpile.

NOTE: Unless noted below, stockpile sampling is to be used for preliminary and quality samples.

A. Cone shaped stockpile.

Take care to avoid sampling segregated areas of the pile. Take approximately equal portions from the base, midpoint, and top of the pile. Before obtaining the sample at each sampling point, remove the aggregate to an approximate depth of 1 foot, and then obtain sample from the bottom of the hole. A board may be shoved into the pile just above the point of sampling to prevent segregation.

B. Flat topped stockpile.

Dig three or more shallow trenches on top of the stockpile approximately 10 feet long and 1 foot wide. The bottom of the trenches will be nearly level. Take equal portions from 3 equally spaced points along the bottom of each trench by pushing a shovel downward into the material and taking a shovelful from each point.

C. Stockpile (Loader method).

Sample the material from at least 3 different areas around the perimeter of the stockpile. Using a front-end loader, dig into pile and set aside a small pile of approximately 10 to 15 tons. Material will be removed from stockpile in same manner in which it will be removed for incorporation into project. The operator will roll the material from the loader bucket to reduce the amount of free fall. The additional buckets will be obtained and dumped in the same manner and placed uniformly over the preceding pile.

NOTE: When other methods of sampling can't be used, acceptance, independent assurance and other samples may be obtained during production at stockpile by sampling, the material from the area of the stockpile that is being incorporated into the project.

The small stockpile will then be struck off to approximately half of its original height by back dragging with the loader bucket. Take the required amount of material for the sample from 3 locations on the top exposed surface with a shovel taking care not to let material fall off the shovel.

3.2 Conveyor belt.

A. Stop the conveyor belt while obtaining the sample. Insert 2 templates conforming to the width and shape of the belt into the aggregate stream on the belt. Scoop all material between the templates into a suitable container using a brush to collect the fines on the belt. 23

If templates are not available, care must be taken to prevent material from the upper side of the belt from sliding or rolling onto the section being sampled. Sample the full width of the belt.

B. A special device capable of obtaining an entire cross section of the material as it is being discharged from the belt may be used. This device must consist of a pan of sufficient size to intercept the entire cross section of the discharge stream and hold the required quantity of material without overflowing. A set of rails or another suitable device must be included so that a representative sample of the entire stream can be obtained. Obtain at least three approximately equal increments and combine to form the field sample.

3.3 Windrows.

Sample the material in windrows by shoveling through small windrows or removing material to the midpoint of the cross section of large windrows. Waste the material removed in both procedures. Shave material from one face of the cross sectional area for the sample.

3.4 Spreader.

NOTE: Samples will be taken from a belt whenever physically possible.

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Sample the material from 3 to 5 locations immediately behind the spreader (before roller compaction). Take the required amount of material for the sample from the surface with a flat blade shovel taking care not to obtain material from the subgrade or lower lift.

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4. Report:

None required.

5. References:

SD 213

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Method of Test for Sieve Analysis

---

1. Scope:

This test is for determining sieve analysis of subbase, base course, mineral aggregate (Surface course materials), concrete aggregates, fillers, and similar materials.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Sieves. Standard square opening, conforming to ASTM E 11.

2.3 Drying oven capable of maintaining a temperature of 230° ± 9°F.

2.4 Pans, scoops, brushes, etc., for handling materials.

2.5 Unit weight bucket.

2.6 Mechanical sieve shaker.

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3. Procedure:

Surface Course Materials:

3.1 Obtain a sample in accordance with SD 201. The sample will be large enough to provide specimens for all required testing.

3.2 Reduce the sample to the size of the specimen needed for testing by splitting or quartering in accordance with SD 213.

3.3 Minimum sample size.

Nominal maximum size of particle is denoted by the smallest sieve opening listed below, through which 90% or more of the sample being tested will pass.

Nominal maximum size of particle	Minimum wt. of sample (Grams)
#4	500
3/8”	1000
1/2”	2500
3/4”	5000
1”	10000
1 1/2”	15000
2”	20000
2 1/2”	35000
3”	60000
3 1/2”	100000
4”	150000

3.4 The sample will be dried to a constant weight at a temperature of 230° ± 9°F or in accordance with SD 108. Frequent stirring will expedite the drying procedure.

Cool until the container can be handled comfortably with bare hands and the operation of balance or sieves on which sample is placed are not affected by heat convection from material/pan.

3.5 Determine loose weight, if required, in accordance with SD 205.

3.6 Weigh the sample and record the weight in the "Original dry sample weight" box of the DOT-3 worksheet to the nearest 0.1 gram.

3.7 Assemble a series of sieves that will furnish the information required by the specifications covering the material to be tested. Nest the sieves in order of decreasing size of opening from top to bottom and include a pan below the last sieve.

3.8 Pour the sample into the top sieve of the nest. Agitate the sieves by hand or on a mechanical shaker for a sufficient period of time, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving.

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The adequacy of sieving can be checked by the hand method. Hand sieving is done by using an individual sieve with a cover and pan while rotating and tapping the sieve approximately two times per second for one minute. The end point for sieving is when not more than 0.5% by weight will pass that sieve.

3.9 Remove any dirt adhering to the + #4 material. This can be accomplished by dumping the material from each individual sieve into a flat pan and rubbing it with a soft pine or rubber covered block. After the dirt has been removed, pour the contents of the pan back onto the sieves and complete the shaking.

An alternate method is to place the material retained on an individual sieve in a cement sample can. With the lid in place, agitate the aggregate using a circular motion. The material is then reintroduced to the sieve and sieved by hand.

3.10 Weigh the material retained on each sieve and the material in the pan to the nearest 0.1 gram and record the weights on the worksheet. Tabulate the total for these weights. The tabulated total should check within 0.3% of the "Original dry sample weight." If it does not, a backup sample will be tested.

3.11 In the coarse sieve series, the weight retained on a sieve in kg at the completion of sieving will not exceed the product of 2.5 times the sieve size opening in millimeters times the effective sieving area in m^2. In the fine sieve series (Openings smaller than #4) the weight retained on any sieve will not be greater than 4 $g/in.^2$ (See Chart 1 below). If any sieve is overloaded, make a notation on the gradation sheet and sieve the material retained on that sieve by hand in split portions until the adequacy of sieving requirement is met. Prevent the occurrence of any further overloading of sieves by using one of the following: insert an additional sieve with an opening size in between the overloaded sieve size and the next larger size in the sieve set, start with a smaller sample size to prevent the sieve from being overloaded, split the sample into two or more portions to sieve separately, or use a set of sieves having a larger frame size and providing greater sieving area. Sieve a sufficient amount of time so that the adequacy of sieving is met for all sieve sizes. Try approximately 10 minutes if using a mechanical sieve shaker and increase the time if the adequacy of sieving is not met for all sieve sizes.

Sieve opening size (Inches)	Maximum amount of material that may be retained in grams			
	8" dia. sieve	12" dia. sieve	13.8" x 13.8" sieve (14"x14" nominal)	14.6" x 22.8" sieve (16"x24" nominal)
4"	N/A	N/A	30,600	53,900
3 1/2"	N/A	15,100	27,600	48,500
3"	N/A	12,600	23,000	40,500
2 1/2"	N/A	10,600	19,300	34,000
2"	3,600	8,400	15,300	27,000
1 1/2"	2,700	6,300	11,500	20,200
1"	1,800	4,200	7,700	13,500
3/4"	1,400	3,200	5,800	10,200
5/8"	1,100	2,700	4,900	8,600
1/2"	890	2,100	3,800	6,700
3/8"	670	1,600	2,900	5,100
1/4"	450	1,100	1,900	3,400
#4	330	800	1,500	2,600
#6 thru #200	200	470	900	1,500

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Chart 1

3.12 Calculate the percentage of material retained on each sieve to the nearest 0.1% by dividing the weight of the retained material by the “Original dry sample weight” determined in 3.6.

3.13 Determine the accumulative percent passing each sieve by subtracting the retained percentage for the top sieve from 100.0 and continue subtracting the retained percentage for each sieve from the previous sieves accumulative passing percentage.

3.14 If the sample being tested requires a result for percentage of crushed particles, perform the test in accordance with SD 211 using a portion of the aggregate retained on the #4 sieve and above.

If the material being tested requires a result for total - #200, the material from that test can be used to perform the percentage of crushed particles test.

3.15 If the sample being tested requires a result for percentage of particles less than 1.95 specific gravity for the + #4 sieve material, perform the test in accordance with SD 214 using a portion of the aggregate retained on the #4 sieve and above.

3.16 Using the material from the pan below the #4 sieve, split out samples in accordance with SD 213 to conduct the balance of the required testing. The number and size of samples to be split out will depend on the type of material being tested. Most surface course materials will require a sample to complete the fine portion of the sieve analysis (500 gram min) and one for liquid limit/plastic limit/plasticity index. (500 gram min) If you are testing uncoated mineral aggregate for asphalt concrete, a third sample will have to be split out for a particles less than 1.95 specific gravity test.

3.17 Weigh the sample to be used for the fine portion of the sieve analysis to the nearest 0.1 gram and record the weight on the "Weight before washing" line on the worksheet.

3.18 Place the sample in a pan and add enough water to cover it. Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the #200 sieve from the coarser particles and bring the fine material into suspension. Pour the wash water containing the suspended and dissolved solids over a nest of 2 sieves. The lower sieve of the nest will be a #200 and the upper will be in a range of #8 to #16. Both of the sieves will conform to the requirements of ASTM E 11. Repeat the process of adding water, agitating the sample, and pouring the water over the nest of sieves until the wash water is clear.

3.19 Dry the washed aggregate to a constant weight in an oven at 230° ± 9°F, as per SD 108 and weigh to the nearest 0.1 gram. Record this weight on the "Weight after washing" line of the worksheet.

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Cool until the container can be handled comfortably with bare hands and the operation of balance or sieves on which sample is placed are not affected by heat convection from material/pan.

Subtract the weight of the sample after washing, from the weight of the sample before washing and record the result on the "Loss from washing (- #200)" line and on the "Pan wash" line below the #200 sieve on the sieve analysis.

3.20 Assemble a series of sieves that will furnish the information required by the specifications covering the material being tested. Nest the sieves in order of decreasing size of opening from top to bottom and include a pan below the last sieve.

3.21 Pour the aggregate into the top sieve of the nest, place the nest of sieves on a mechanical shaker and shake for a sufficient period of time (A minimum of 10 minutes). Adequacy of sieving can be checked as outlined in 3.8 above. The quantity of material retained on any sieve at the completion of the sieving operation will not exceed 4 grams per in^2 of sieve surface area. This amounts to 200 grams for an 8" diameter sieve.

3.22 Weigh the material retained on each sieve and in the pan and record the weights on the worksheet to the nearest 0.1 gram. Add the retained weights including the "Pan dry" and "Pan wash" quantities below the #200 sieve. Record this weight on the "Total" line at the bottom of the worksheet. This weight must be within 0.3% of the weight of the sample before washing. If it is not, a new sample will be tested.

Correct brush to use when cleaning sieves.

3/8" to #16 - steel #20 to #50 - brass #80 to > - paint

3.23 Complete the calculations for the fine sieves, beginning by dividing the initial sample weight derived in 3.17 above into the retained weights for each sieve and record the results on the worksheet to the nearest 0.1%. Next, multiply these retained percentages times the accumulative percentage passing the #4 sieve determined in 3.13 above and record the results on the worksheet again to the nearest 0.1%. Finally, determine the accumulative percentage passing each of these sieves by subtracting the retained percentage from the previous sieves accumulative passing percentage.

3.24 The percentage of material passing each sieve in the coarse and fines portion of the analysis may now be rounded and reported on the worksheet to the nearest whole number except the #200 sieve will be reported to the nearest 0.1%.

3.25 Prepare the sample of material split out earlier as outlined in SD 207 for liquid limit/plastic limit/plasticity index. testing.

3.26 Perform the liquid limit and plastic limit in accordance with SD 207, calculate the plasticity index, and report the results on the sieve analysis worksheet.

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3.27 If the sample being tested requires a result for percentage of particles less Than 1.95 specific gravity for the - #4 sieve material, perform the test on the 250 to 350 gram sample split out in 3.16 above in accordance with SD 208.

<u>Process for determining total - #200 materials in asphalt concrete (excludes Blade Laid and Class S):</u> 24

3.28 Following completion of the coarse sieve analysis combine all materials which were retained on #4 sieve and above and split out a sample for total - #200 testing in accordance with SD 213 which meets the requirements shown in the following table.

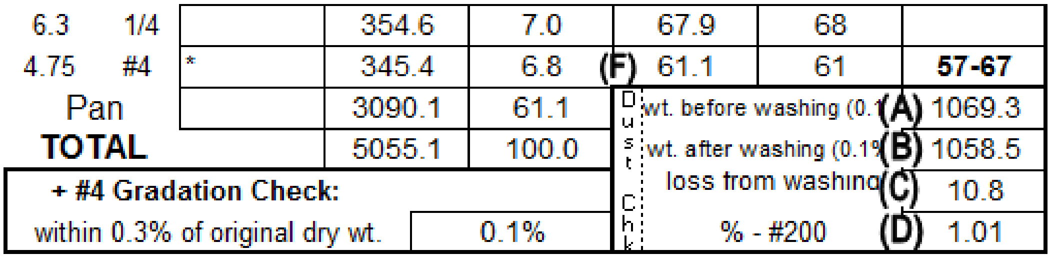
Nominal maximum size of particles	Minimum weight of sample, grams
#4	500
3/8"	500
1/2"	700
3/4"	1000
1"	1500

3.29 Weigh the sample to the nearest 0.1 g and record the weight as "Weight before washing" in the box labeled “(A)” below the coarse sieve area as shown on the enclosed example DOT-3 worksheet.

3.30 Place the sample in a pan and add enough water to cover it. Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the #200 sieve from the coarser particles and bring the fine material into suspension. Pour the wash water containing the suspended and dissolved solids over a nest of 2 sieves. The lower sieve of the nest will be a #200 and the upper will be in a range of #8 to #16. Both of the sieves will conform to the requirements of ASTM E 11. Repeat the process of adding water, agitating the sample, and pouring the water over the nest of sieves until the wash water is clear.

3.31 Following drying to a constant weight, weigh sample to nearest 0.1 g and record the weight as "Weight after wash" in the box labeled “(B)” below the coarse sieve area as shown on the enclosed example DOT-3 worksheet.

3.32 Calculate the percent passing the #200 Sieve (D) for the coarse aggregate by subtracting the "Weight after wash" (B) from the "weight before wash" (A) and dividing that result (C) by the "Weight before wash" (A). Multiply this result times 100. This is the percent - #200 for the coarse aggregate which must be recorded in the two boxes labeled “(D)” on the DOT-3 worksheet.



6.3	1/4		354.6	7.0	67.9	68	
4.75	#4	*	345.4	6.8	(F) 61.1	61	**57-67**
Pan			3090.1	61.1	Dust Chk	wt. before washing (0.1	(A) 1069.3
TOTAL			5055.1	100.0		wt. after washing (0.1%	(B) 1058.5
+ #4 Gradation Check:						loss from washing	(C) 10.8
within 0.3% of original dry wt.			0.1%			% - #200	(D) 1.01

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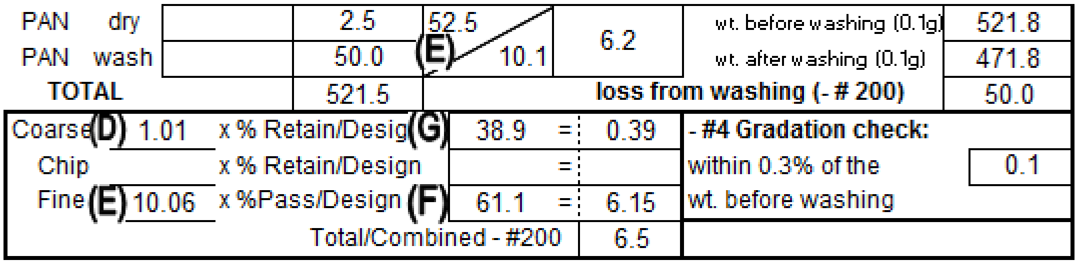
3.33 To complete the calculations for the total - #200 material, four pieces of information are needed in the - #200 box at the lower left corner of the DOT-3 worksheet. You have already provided one of these in step 3.32 above, ((D) which is the percent passing the #200 sieve on the coarse aggregate sample wash). The other three are: (E) The percent passing the #200 sieve on the fine sieve analysis (This includes the washed and sieved portion), (F) The percentage of material that passed the #4 sieve during the sieve analysis and (G) The percentage of material that was retained on the #4 Sieve. The amount of material retained on the #4 sieve (G) can be determined by subtracting the percent passing the #4 sieve (F) from 100.

3.34 Complete the calculations by multiplying the percent - #200 on the coarse sieve aggregate (D) times the percent of material retained on the #4 sieve (G) and multiply the percent - #200 on the fine sieves (E) times the percent of material that passed the #4 sieve (F) and divide each by 100. The result obtained when adding these 2 values is the "Total - #200 material" for this sample.

Example:

The coarse sieve analysis had 61.1% passing the #4 sieve. 100.0% minus 61.1% passing = 38.9% retained on the #4 sieve.

1.01% passed the #200 sieve in the coarse aggregate sample that was washed (D) and 10.06% passed the #200 sieve on the fine sieve analysis (E).



PAN dry		2.5	52.5 (E) 10.1	6.2	wt. before washing (0.1g)	521.8
PAN wash		50.0			wt. after washing (0.1g)	471.8
TOTAL		521.5	loss from washing (- # 200)			50.0

Coarse (D) 1.01	x % Retain/Desig (G)	38.9	=	0.39	- #4 Gradation check:	
Chip	x % Retain/Design		=		within 0.3% of the	0.1
Fine (E) 10.06	x %Pass/Design (F)	61.1	=	6.15	wt. before washing	
	Total/Combined - #200			6.5		

Calculations:

Retained #4 sieve $\frac{\text{(G) 38.9\% x (D) 1.01\% pass on coarse aggregate}}{100} = 0.39\%$

Passing #4 sieve $\frac{\text{(F) 61.1\% x (E) 10.06\% pass on fine sieve analysis}}{100} = 6.15\%$

0.39 + 6.15 = 6.54 or 6.5% total minus #200 for the sample.

Coarse Aggregate for Concrete:

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3.35 Obtain a sample in accordance with SD 201. The sample will be large enough to provide specimens for all required testing.

3.36 Reduce the sample to the size of the specimens needed for testing by splitting or quartering in accordance with SD 213. Two separate splits will be required; one split for sieve analysis and particles less than 1.95 specific gravity and one split to wash for material finer than #200 sieve.

3.37 For the minimum size of samples for the various tests required, see 3.3 above for the sieve analysis, SD 206 for material finer than #200 sieve, SD 214 for particles less than 1.95 specific gravity in coarse aggregate.

Coarse aggregate for lightweight concrete specimens will consist of 0.1 ft^3 or more of the material. 24

3.38 Perform the sieve analysis following the procedure outlined in 3.4, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, and 3.13 above. Coarse aggregate for concrete has a specification on the #8 sieve, so it will be necessary to add that sieve to the nest of sieves.

3.39 Using the samples split out in 3.36 above, perform the test for material finer than #200 sieve in accordance with SD 206, particles less than 1.95 specific gravity (frequency as per MSTR) in accordance with SD 214. Report the results of these tests on the worksheet in accordance with the guidelines provided by the applicable test procedure.

Fine Aggregate for Concrete:

3.40 Obtain a sample in accordance with SD 201. The sample will be large enough to provide specimens for all required testing.

3.41 Reduce the sample to the size of the specimens needed for testing by splitting or quartering in accordance with SD 213. The sample will require, a sieve analysis, inclusive of material finer than #200 sieve in accordance with SD 206, and particles less than 1.95 specific gravity in fine aggregate (frequency as per MSTR) in accordance with SD 208.

For other fine aggregates, the number of specimens needed will depend on the testing required for the sample as per specifications or plan notes.

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The sample split out for the sieve analysis, inclusive of material finer than #200 sieve, must contain a minimum of 500 grams while the sample for the less than 1.95 specific gravity in fine aggregate test must contain between 250 and 350 grams.

The minimum sample specimen weight for the sieve analysis, inclusive of material finer than #200 sieve, for lightweight fine aggregate will be as shown below:

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Wt. of aggregate (lbs./ft^3)	Min. weight of test specimen (grams)
5 to 15	50
15 to 25	100
25 to 35	150
35 to 45	200
45 to 55	250
55 to 65	300
65 to 75	350

3.42 Perform the sieve analysis, inclusive of material finer than #200 sieve, in accordance with procedure outlined in 3.17, 3.18, 3.19, 3.20, 3.21, and 3.22 above.

Fine aggregate for concrete has a specification on the 3/8” and #4 sieve, so it will be necessary to add these sieves to the nest of sieves.

3.43 Calculate the percentage of material retained on each sieve to the nearest 0.1% by dividing the weight of the retained material by the weight of the sample before washing. Material passing #200 should be calculated to 0.01% and rounded to 0.1%.

3.44 Determine the accumulative percent passing each sieve by subtracting the retained percentage for the top sieve from 100.0 and continue subtracting the retained percentage for each sieve from the previous sieves accumulative passing percentage.

3.45 The percentage of material passing each sieve may now be rounded and reported on the worksheet to the nearest whole number except the #200 sieve will be reported to the nearest 0.1%.

Process for determining Fineness Modulus (F.M.)

3.46 Samples of fine aggregate for concrete require a result for fineness modulus (F.M.). The sieves used for determination of F.M. are identified on the DOT-3 worksheet by an (*). Calculate the F.M. as follows:

A. Subtract the percentage passing (before rounding) the sieves designated by the (*) from 100.0 and record the result in the column titled F.M. After this has been accomplished on each sieve designated, total the results and divide by 100.

B. Report the result to the nearest 0.01%.

Example:

Sieve Size	Percent Passing	100.0 Minus Percent Passing
#4	99.8	0.2
#8	91.5	8.5
#16	67.8	32.2
#30	49.9	50.1
#50	21.5	78.5
#100	3.9	96.1
		Total 265.6

$$\text{Fineness modulus (F.M.)} = \frac{265.6}{100} = 2.656 \text{ or } 2.66$$

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Process for Determining Combined Percentage of Material Passing the #200 sieve

3.47 The specifications for aggregates used in concrete require the combined mixture of fine and coarse aggregate be such that not more than a certain percent of the combined materials pass the #200 sieve.

To calculate this combined percentage of material passing the #200 sieve, multiply the percent passing the #200 sieve on the fine and coarse aggregate times the percentage of the sand and rock used in the mix according to the design mix, divide each of the results by 100 and then add them together.

Example:

1.65% passing #200 sieve on coarse aggregate.
0.95% passing #200 sieve on fine aggregate.
Coarse aggregate is 64.4% of total aggregate used in the mix.
Fine aggregate is 35.6% of total aggregate used in the mix.

Coarse aggregate 1.65% x 64.4% / 100 = 1.06%
Fine aggregate 0.95% x 35.6% / 100 = 0.34%
Combined - #200 sieve = 1.40 or 1.4%.

The final percentage will be recorded to the nearest 0.1%.

3.48 Perform the test for particles less than 1.95 specific gravity in fine aggregates in accordance with SD 208 and report the results on the worksheet.

Class S, Microsurfacing, Asphalt Surface Treatments and Miscellaneous Fine Aggregate:

3.49 Obtain a sample in accordance with SD 201. The sample will be large enough to provide specimens for all required testing.

3.50 Reduce the sample to the size of the specimens needed for testing by splitting or quartering in accordance with SD 213. The number of specimens needed will depend on the testing required for the sample as per specifications or plan notes. 24

3.51 The minimum sample size for sieve analysis will be as outlined in 3.3 above. The minimum sample size for other tests will be as per designated test procedures.

3.52 If the sample being tested requires a result for flakiness index, perform the test in accordance with SD 203 using a portion of the aggregate retained on the #4 sieve and above.

3.53 If the sample being tested requires a result for percentage of crushed particles, perform the test in accordance with SD 211 using a portion of the aggregate retained on the #4 sieve and above.

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3.54 If liquid limit/plastic limit/plasticity index is required by specifications, a sample of - #4 will be obtained from a separate split. The sample split out for the liquid limit/plastic limit/plasticity index. must be of adequate size to produce at least 100 grams of - #40 sieve material.

3.55 The sample will be oven dried to a constant weight at a temperature of 230° ± 9°F or in accordance with SD 108.

3.56 Weigh the sample and record the weight in the “Weight before washing” line in the fine aggregate portion of the worksheet to the nearest 0.1 gram.

3.57 Perform wash as outlined in 3.18 above.

3.58 Dry the washed aggregate to a constant weight in an oven at 230° ± 9°F as per SD 108 and weight to the nearest 0.1 gram. Record this weight on the “Weight after washing” line in the fine aggregate portion of the worksheet to the nearest 0.1 gram.

3.59 Subtract the weight of the sample after washing, from the weight of the sample before washing and record the result on the “Loss from washing (- #200)” line and on the “Pan wash” line below the #200 sieve on the sieve analysis.

3.60 Assemble a series of sieves that will furnish the information required be the specifications covering the material being tested. The use of 12” diameter sieves is recommended to prevent sieve overloading.

3.61 Pour the aggregate into the top sieve of the nest, place the nest of sieves on a mechanical shaker and shake for a sufficient period of time (A minimum of 10 minutes). Adequacy of sieving can be checked as outlined in 3.8 above. The quantity of material retained on any sieve at the completion of the sieving operation will not exceed the amount listed in “Chart 1” of 3.11 above.

3.62 Weigh the material retained on each sieve and in the pan and record the weights on the worksheet to the nearest 0.1 gram. Add the retained weights including the “Pan Dry” and “Pan Wash” quantities below the #200 sieve. Record this weight on the “Total” line at the bottom of the worksheet. This weight must be within 0.3% of the weight of the sample before washing. If it is not, a new sample will be tested.

3.63 Calculate the percentage of material retained on each sieve to the nearest 0.1% by dividing the weight of the retained material by the weight of the sample before washing. Material passing #200 should be calculated to 0.01% and rounded to 0.1%.

3.64 Determine the accumulative percent passing each sieve by subtracting the retained percentage for the top sieve from 100.0 and continue subtracting the retained percentage for each sieve from the previous sieves accumulative passing percentage.

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3.65 The percentage of material passing each sieve may now be rounded and reported on the DOT-3 to the nearest whole number except the #200 sieve will be reported to the nearest 0.1%.

Granular Backfill and other Miscellaneous Aggregate:

3.66 Obtain a sample in accordance with SD 201. The sample will be large enough to provide specimens for all required testing.

3.67 Reduce the sample to the size of the specimens needed for testing by splitting or quartering in accordance with SD 213. The number of specimens needed will depend on the testing required for the sample as per specifications or plan notes. 24

3.68 The minimum sample size for sieve analysis will be as outlined in 3.3 above. The minimum sample size for other tests will be as per designated test procedures.

3.69 Perform the sieve analysis following the procedure outlined in 3.4 thru 3.15 above.

4. Report:

4.1 Test results will be reported on form DOT-3 or DOT-68 (These forms do not apply to the Central Lab). Use of the DOT-68 is limited to the following:

A. Concrete where 2 or more aggregate piles are being weighed during batching to meet a single gradation specification.

B. Asphalt for mineral aggregate samples on projects utilizing a batch type mixing plant.

4.2 Calculations for the DOT-68 are determined as follows:

A. Enter the "lbs./cu.yd." of rock and chip from the Mix Design on lines (H) and (I).

B. Divide the "lbs./cu.yd." of the rock and chip by the "Total" to obtain the "Total Agg. %" and multiply by 100 for lines (H) and (I).

Mix Batch Ticket,	lbs./cu. yd.;	Total Agg %	
1" rock	1374.00	77.6	**(H)**
Chip	396.0	22.4	**(I)**
		0	
		0	
Total	1770.0	100.0	

C. Split a separate sample of rock and chip for gradation and a separate sample of each for wash ensuring that you meet the minimum sample size as per 3.3 and SD 206.

D. Perform the gradation for each and calculate as per 3.12 – 3.13.

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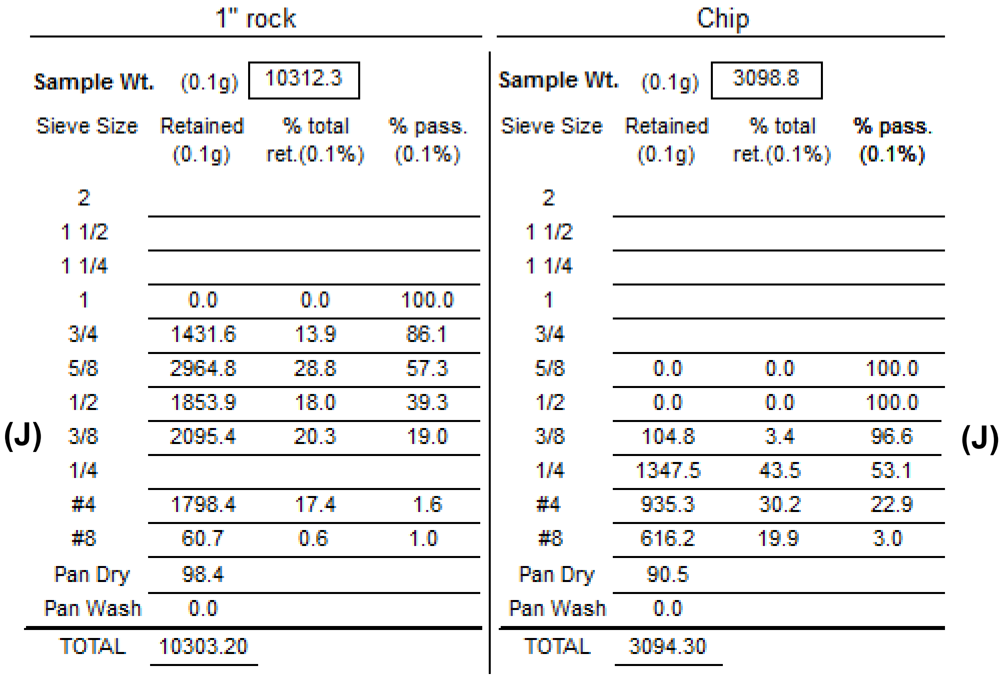


1" rock

Sample Wt. (0.1g) 10312.3

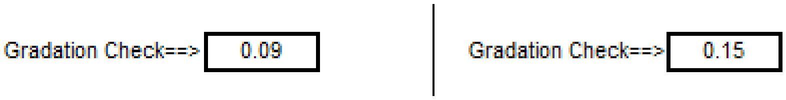
	Sieve Size	Retained (0.1g)	% total ret.(0.1%)	% pass. (0.1%)
	2			
	1 1/2			
	1 1/4			
	1	0.0	0.0	100.0
	3/4	1431.6	13.9	86.1
	5/8	2964.8	28.8	57.3
	1/2	1853.9	18.0	39.3
(J)	3/8	2095.4	20.3	19.0
	1/4			
	#4	1798.4	17.4	1.6
	#8	60.7	0.6	1.0
	Pan Dry	98.4		
	Pan Wash	0.0		
	TOTAL	10303.20		

Chip

Sample Wt. (0.1g) 3098.8

Sieve Size	Retained (0.1g)	% total ret.(0.1%)	**% pass. (0.1%)**	
2				
1 1/2				
1 1/4				
1				
3/4				
5/8	0.0	0.0	100.0	
1/2	0.0	0.0	100.0	
3/8	104.8	3.4	96.6	**(J)**
1/4	1347.5	43.5	53.1	
#4	935.3	30.2	22.9	
#8	616.2	19.9	3.0	
Pan Dry	90.5			
Pan Wash	0.0			
TOTAL	3094.30			

E. Calculate the "Gradation Check" as per 3.10.



Gradation Check==> 0.09

Gradation Check==> 0.15

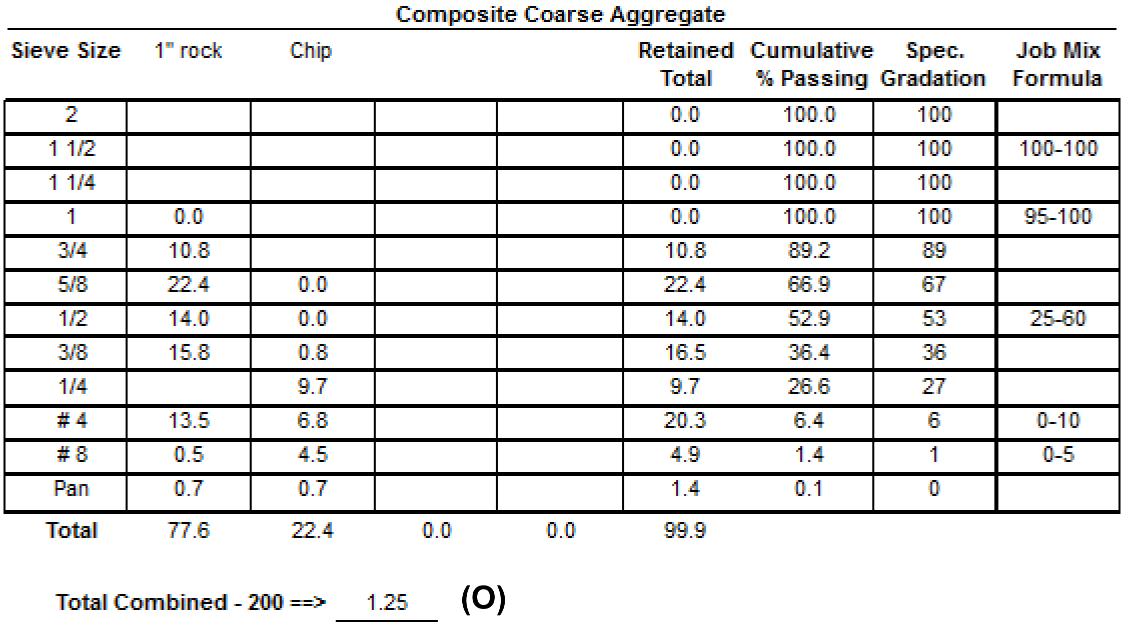
F. Perform the wash as per SD-206 and calculate lines (K) and (M).

G. Multiply line (K) by “Total Agg %”, line (H) divide by 100 and enter on line (L) for “Bin adj. -200”.

H. Multiply line (M) by “Total Agg %” line (I) divide by 100 and enter on line (N) for “Bin adj. -200”.

wt. before wash	3771.0		wt. before wash	2752.8	
wt. after wash	3728.2		wt. after wash	2707.1	
loss from wash	42.8		loss from wash	45.7	
% - #200 ==>	1.13	**(K)**	% - #200 ==>	1.66	**(M)**
Bin adj. - #200	0.877	**(L)**	Bin adj. - #200	0.372	**(N)**

I. Add lines (L) and (N) and enter on line (O) for “Total Combined -200” for the Coarse Aggregate.



Composite Coarse Aggregate

Sieve Size	1" rock	Chip			Retained Total	Cumulative % Passing	Spec. Gradation	Job Mix Formula
2					0.0	100.0	100	
1 1/2					0.0	100.0	100	100-100
1 1/4					0.0	100.0	100	
1	0.0				0.0	100.0	100	95-100
3/4	10.8				10.8	89.2	89	
5/8	22.4	0.0			22.4	66.9	67	
1/2	14.0	0.0			14.0	52.9	53	25-60
3/8	15.8	0.8			16.5	36.4	36	
1/4		9.7			9.7	26.6	27	
# 4	13.5	6.8			20.3	6.4	6	0-10
# 8	0.5	4.5			4.9	1.4	1	0-5
Pan	0.7	0.7			1.4	0.1	0	
Total	77.6	22.4	0.0	0.0	99.9			

Total Combined - 200 ==> 1.25 **(O)**

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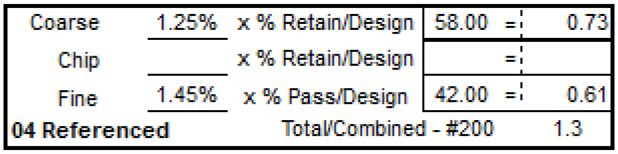
J. The value from line (O) will then be carried to line (P) to calculate the “Total/Combined -200” with the Fine Aggregate.

You must link the Fine Aggregate test with the Coarse Aggregate in MS&T for this calculation to occur.

K. You must enter the % of Fine Aggregate from the Mix Design on line (Q). Also enter the % of Coarse Aggregate from the Mix Design on line (P). The total of the column “% Retain/Design” must = 100.

L. Calculate the “Total/Combined - #200” as per 3.48



Coarse	1.25%	x % Retain/Design	58.00	=	0.73	**(P)**
Chip		x % Retain/Design		=		
Fine	1.45%	x % Pass/Design	42.00	=	0.61	**(Q)**
04 Referenced		Total/Combined - #200			1.3	

M. To calculate the Composite Coarse Aggregate “Retained Total” multiply the “% total ret.” from the respective sieve by the “Total Aggregate %” on the Mix Batch Ticket.

Example: (See line (J)) For 3/8 1” Rock multiply 20.3 x 0.776 = 15.75, round to 15.8, and 3/8 Chip multiply 3.4 x 0.224 = 0.76 round to 0.8,

You will round these numbers to report on the form but keep them at two decimal places to add in the next step.

Now add 15.75 + .76 = 16.51, round to 16.5, this is your “Retained Total” for 3/8.

N. Calculate the “Cumulative % Passing” as per 3.13.

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O. If the sample being tested requires a result for percentage of particles less than 1.95 specific gravity for the + #4 sieve material, perform the test in accordance with SD 214 using a portion of the aggregate retained on the #4 sieve and above.

5. References:

AASHTO T 27
ASTM E 11
SD 108
SD 201
SD 204
SD 206
SD 207
SD 208
SD 211
SD 213
SD 214
DOT-3
DOT-68
DOT-69

Sample ID 2203565

Sieve Analysis and P.I. Worksheet

DOT-3
3-19

File No.

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Charge to (if not above project)

Field No. 01 Date Sampled 03/10/2019 Date Tested 03/10/2019

Sampled By Brown, Benjamin Tested By Tester, One Checked By Tester, Two

Material Type Base Course Source

Lot No. Sublot No.

Weight Ticket Number or Station Lift of

[Wet Sample Weight (0.1g) **- Original Dry Sample Weight (0.1g]** 7,318.0] / dry weight x 100 = % moisture

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Sieve Size	Fineness Modulus	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
4 in.						
3 in.						
2 1/2 in.						
2 in.						
1 1/2 in.						
1 1/4 in.						
1 in.		0.0	0.0	100.0	100	100 - 100
3/4 in.		167.6	2.3	97.7	98	80 - 100
5/8 in.		240.6	3.3	94.4	94	
1/2 in.		351.7	4.8	89.6	90	68 - 91
3/8 in.	* 15.0	338.8	4.6	85.0	85	
1/4 in.		625.2	8.5	76.5	77	
#4	* 31.5	586.2	8.0	68.5	69	46 - 70
Pan		5008.1	68.4			
Total		7,318.2				

+ #4 Gradation Check

within 0.3% of original dry weight 0.00

Dust Check

wt. before washing (0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

Liquid Limit & Plastic Limit

		Liquid Limit	Plastic Limit
A. Can number		45	19
B. Weight of can + wet soil	(0.01g)	29.87	28.34
C. Weight of can + dry soil	(0.01g)	28.14	27.11
D. Weight of water (B - C)	(0.01g)	1.73	1.23
E. Weight of can	(0.01g)	19.92	20.17
F. Weight of dry soil (C - E)	(0.01g)	8.22	6.94
G. Liquid Limit (D / F x J x 100	(0.1g)	21.2	N.P. ☐
H. Plastic Limit (D / F x 100)	(0.1g)		17.7
I. Plasticity Index (G - H)	(0.1g)	3.5	

				Specification
Liquid Limit N.C. ☐	(G rounded)	21		0 - 25
Plasticity Index	(I rounded)	4		0 - 6

J. Correction # Blows 26

22=0.9846, 23=0.9899, 24=0.9952, 25=1.0000, 26=1.0050, 27=1.0100, 28=1.0138

weight - #40 181.4 / weight - #4 611.2 x % passing #4 = 20.3

(±3.0% VARIABLE of accumulative % passing (0.1%) on the #40)

Sieve Size	Fineness Modulus	Retained (.1g)	% total ret. (0.1g)	% total x % pass. #4	% passing (0.1g)	% passing (rounded)	Spec Req.
#6							
#8	* 46.3	136.5	21.6	14.8	53.7	54	34 - 58
#10		28.2	4.5	3.1	50.6	51	
#12							
#16	* 56.7	67.1	10.6	7.3	43.3	43	
#20		62.7	9.9	6.8	36.5	37	
#30	* 71.7	75.8	12.0	8.2	28.3	28	
#40		61.4	9.7	6.6	21.7	22	13 - 35
#50	* 84.3	55.6	8.8	6.0	15.7	16	
#80		34.4	5.4	3.7	12.0	12	
#100	* 88.5	4.8	0.8	0.5	11.5	12	
#200		10.6	1.7	1.2	10.3	10.3	3.0 - 12.0
Pan dry		1.7	95.1	10.3	wt before washing (0.1g)		631.9
Pan wash		93.4	15.0		wt after washing (0.1g)		538.5
Total	3.94	632.2			loss from washing(-#200)		93.4

Coarse % x % Retain/Design =

Fine 15.05 % x % Passing/Design =

Total/Combined -#200

- #4 Gradation Check

within 0.3% of original dry weight 0.05

Filler	0.00	Cr. Fines	0.00		0.00
Cr. Rock	0.00	Ma. Sand	0.00	Natural Sand	0.00
Na. Rock	0.00	Natural Fines	0.00	Add Rock	

Crushed Particles Test

Weight of crushed particles	447.0
Weight of total + #4 sample	1,015.9
Percent of crushed pieces	44
Specification 1 or more FF, min.	30 - 100

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	
Weight of lightweight particles	
Weight of - #4 material	
% lightweight particles	
Specification	

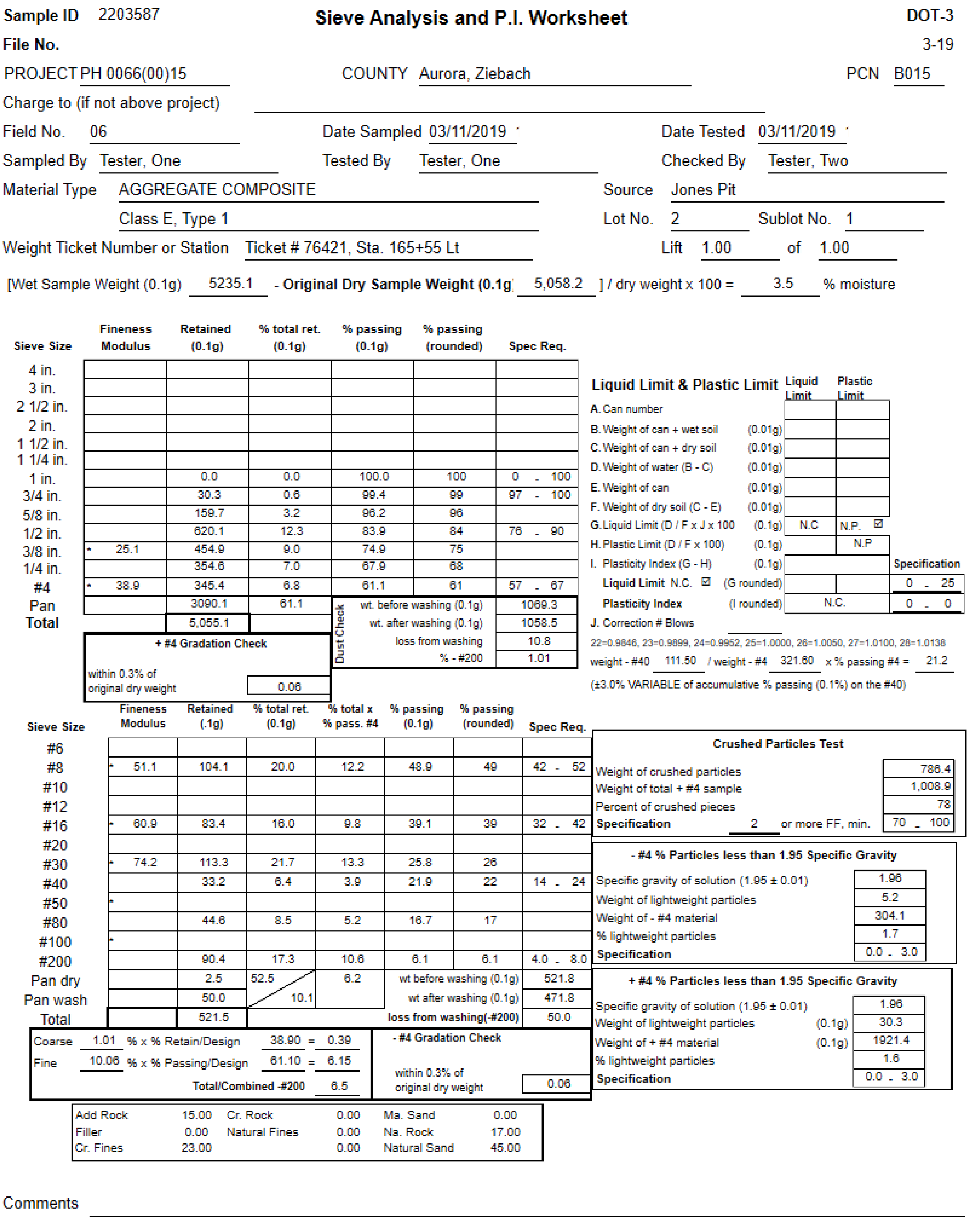
+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		
Weight of lightweight particles	(0.1g)	
Weight of + #4 material	(0.1g)	
% lightweight particles		
Specification		

Comments

Figure 1

Back



Sample ID 2203587

Sieve Analysis and P.I. Worksheet

DOT-3
3-19

File No.

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Charge to (if not above project)

Field No. 06 Date Sampled 03/11/2019 Date Tested 03/11/2019

Sampled By Tester, One Tested By Tester, One Checked By Tester, Two

Material Type AGGREGATE COMPOSITE Source Jones Pit

Class E, Type 1 Lot No. 2 Sublot No. 1

Weight Ticket Number or Station Ticket # 76421, Sta. 165+55 Lt Lift 1.00 of 1.00

[Wet Sample Weight (0.1g) 5235.1 - **Original Dry Sample Weight (0.1g)** 5,058.2] / dry weight x 100 = 3.5 % moisture

Sieve Size	Fineness Modulus	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
4 in.						
3 in.						
2 1/2 in.						
2 in.						
1 1/2 in.						
1 1/4 in.						
1 in.		0.0	0.0	100.0	100	0 - 100
3/4 in.		30.3	0.6	99.4	99	97 - 100
5/8 in.		159.7	3.2	96.2	96	
1/2 in.		620.1	12.3	83.9	84	76 - 90
3/8 in.	* 25.1	454.9	9.0	74.9	75	
1/4 in.		354.6	7.0	67.9	68	
#4	* 38.9	345.4	6.8	61.1	61	57 - 67
Pan		3090.1	61.1			
Total		5,055.1				

+ #4 Gradation Check

within 0.3% of original dry weight 0.06

Dust Check	
wt. before washing (0.1g)	1069.3
wt. after washing (0.1g)	1058.5
loss from washing	10.8
% - #200	1.01

Liquid Limit & Plastic Limit

		Liquid Limit	Plastic Limit	Specification
A. Can number				
B. Weight of can + wet soil	(0.01g)			
C. Weight of can + dry soil	(0.01g)			
D. Weight of water (B - C)	(0.01g)			
E. Weight of can	(0.01g)			
F. Weight of dry soil (C - E)	(0.01g)			
G. Liquid Limit (D / F x J x 100	(0.1g)	N.C	N.P. ☑	
H. Plastic Limit (D / F x 100)	(0.1g)		N.P	
I. Plasticity Index (G - H)	(0.1g)			
Liquid Limit N.C. ☑	(G rounded)			0 - 25
Plasticity Index	(I rounded)	N.C.		0 - 0

J. Correction # Blows

22=0.9846, 23=0.9899, 24=0.9952, 25=1.0000, 26=1.0050, 27=1.0100, 28=1.0138

weight - #40 111.50 / weight - #4 321.60 x % passing #4 = 21.2

(±3.0% VARIABLE of accumulative % passing (0.1%) on the #40)

Sieve Size	Fineness Modulus	Retained (.1g)	% total ret. (0.1g)	% total x % pass. #4	% passing (0.1g)	% passing (rounded)	Spec Req.
#6							
#8	* 51.1	104.1	20.0	12.2	48.9	49	42 - 52
#10							
#12							
#16	* 60.9	83.4	16.0	9.8	39.1	39	32 - 42
#20							
#30	* 74.2	113.3	21.7	13.3	25.8	26	
#40		33.2	6.4	3.9	21.9	22	14 - 24
#50	*						
#80		44.6	8.5	5.2	16.7	17	
#100	*						
#200		90.4	17.3	10.6	6.1	6.1	4.0 - 8.0
Pan dry		2.5	52.5	6.2			
Pan wash		50.0	10.1				
Total		521.5					

wt before washing (0.1g)	521.8
wt after washing (0.1g)	471.8
loss from washing(-#200)	50.0

Coarse 1.01 % x % Retain/Design 38.90 = 0.39
Fine 10.06 % x % Passing/Design 61.10 = 6.15
Total/Combined -#200 6.5

- #4 Gradation Check

within 0.3% of original dry weight 0.06

Crushed Particles Test

Weight of crushed particles	786.4
Weight of total + #4 sample	1,008.9
Percent of crushed pieces	78
Specification 2 or more FF, min.	70 - 100

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	1.96
Weight of lightweight particles	5.2
Weight of - #4 material	304.1
% lightweight particles	1.7
Specification	0.0 - 3.0

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		1.96
Weight of lightweight particles	(0.1g)	30.3
Weight of + #4 material	(0.1g)	1921.4
% lightweight particles		1.6
Specification		0.0 - 3.0

Add Rock	15.00	Cr. Rock	0.00	Ma. Sand	0.00
Filler	0.00	Natural Fines	0.00	Na. Rock	17.00
Cr. Fines	23.00		0.00	Natural Sand	45.00

Comments

Figure 2

Page 1 of 1

Sample ID 2203609
File No.

Gyratory Aggregate Worksheet

DOT-69
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Field No. QC04 Date Sampled 03/12/2019 Date Tested 03/12/2019

Sampled By Tester, One Tested By Tester, One Checked By Tester, Two

Material Type AGGREGATE COMPOSITE Source Jones Pit

Class Q2 Lot No. 1 Sublot No. 4

Weight Ticket Number or Station # 50855, Sta. 625+15 Lift 1 of 1

% moist. = (wet wt. 8616.4 - dry wt.) / dry wt. x 100 = 3.9

Original Dry Sample Wt. (.1g) 8,289.9

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Sieve Size mm	in	**Retained (0.1g)**	**%total ret.(0.1%)**	**%pass. (0.1%)**	**%pass. (rounded)**	**Spec Req.**
100	4					
75	3					
62.5	2 1/2					
50	2					
37.5	1 1/2					
31.5	1 1/4					
25	1					
19	3/4	0.0	0.0	100.0	100	100 - 100
16	5/8	7.3	0.1	99.9	100	
12.5	1/2	501.4	6.0	93.9	94	89 - 100
9.5	3/8	890.3	10.7	83.2	83	79 - 93
6.25	1/4	990.4	11.9	71.3	71	
4.75	#4	787.3	9.5	61.8	62	
Pan		5116.7	61.7			
Total		8293.4				

+ #4 Graduation Check:
within 0.3% of orig dry wt. 0.04

Dupl Chk	
wt. before washing(0.1g)	709.30
wt. after washing(0.1g)	707.10
loss from washing	2.2
% - #200	0.31

Sand Equiv. Test	Sand Rdg.	Clay Rdg.	S.E.
Reading #1	3.10	6.60	47
Reading #2	3.10	6.50	48

Sand Equivalent Tests Results	48	42 - 100
Fine Aggregate Angularity Test Results	41.8	41.0 - 100.0
Flat and Elongated Particles Test Results	0.0	-

Sieve Size mm	#	**Retained (0.1g)**	**%total ret.(0.1%)**	**%total x %pass. #4**	**%pass. (0.1%)**	**%pass. (rounded)**	**Spec Req.**
3.35	6						
2.36	8	187.7	29.8	18.4	43.4	43	41 - 51
2.00	10						
1.70	12						
1.18	16	137.2	21.8	13.5	29.9	30	
0.850	20						
0.600	30	112.0	17.8	11.0	18.9	19	
0.425	40	54.3	8.6	5.3	13.6	14	
0.300	50	42.7	6.8	4.2	9.4	9	
0.180	80						
0.150	100	35.0	5.6	3.5	5.9	6	
0.075	200	10.5	1.7	1.1	4.8	4.8	2.9 - 6.9
Pan	dry	4.8	49.2	4.8	wt before washing (0.1g)		629.8
Pan	wash	44.40	7.8		wt after washing (0.1g)		585.4
Total		628.60			**loss from washing(-#200)**		44.4

Coarse	0.31	% x % Retain/Design	38.20	=	0.12
Fine	7.81	% x % Retain/Design	61.80	=	4.83
		Total/Combined - #200			5.0

- #4 Gradation check:
within 0.3% of the wt before washing 0.2

Natural Sand	0.00	Na. Rock	31.00	Natural Fines	25.00
Natural Sand	0.00	Natural Fines	0.00	Osch Nat Fines	16.00
Cr.Fines	28.00				

+ #4 % Particles less than 1.95 SP. GR.

Specific gravity of solution	(1.95 ± 0.01)	1.95
wt. of lightweight particles	(0.1 g)	19.1
weight of + #4 material	(0.1 g)	1824.9
% lightweight particles		1.0
SPECIFICATION		0.0 - 3.0

- #4 % Particles less than 1.95 SP. GR.

Specific gravity of solution	(1.95 ± 0.01)	1.95
wt. of lightweight particles	(0.1 g)	3.2
weight of - #4 material	(0.1 g)	302.4
% lightweight particles		1.1
SPECIFICATION		0.0 - 3.0

Crushed Particles Test

weight of crushed particles	651.7
weight of total + #4 sample	729.3
percent of crushed particles	89
SPECIFICATION 2 or more FF, min	65 - 100

Figure 3

Weight of measure and glass plate		327.1
Weight of measure, glass plate & water		426.8
M = net mass of water		99.7
Water Temperature / Density	77 F	997.03
V = volume of cylinder, mL		100.0

Dry - #4 bulk specific gravity (Gsb)	2.563		
Volume of cylinder, mL(V)	100.0		
Weight of cylinder, g (A)	183.0		
Wt of cylinder + aggregate, g (B)	332.5	332.2	
Wt. aggregate, g (F=B-A)	149.5	149.2	Average
Uncompacted voids, (nearest 0.1%) U=((V-(F/Gsb))/V) x 100	41.7	41.8	41.8

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Sieve Size		Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/ Elongated Particles	Percent Flat/ Elongated Individual Sieve	Percent Flat/ Elongated Weighted Average
mm	in					
50.0	2					
37.5	1 1/2					
25.0	1					
19.0	3/4					
12.5	1/2					
9.5	3/8					
4.75	#4					

Total sample wt. 0.0

Percent flat and enlongated particles 0.0

in the total sample (weighted average) rounded 0

Comments 12" sieves used

Figure 3A

Sample ID 2203613

Sieve Analysis and P.I. Worksheet

DOT-3
3-19

File No.

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Charge to (if not above project)

Field No. 03 Date Sampled 03/12/2019 Date Tested 03/12/2019

Sampled By Tester, One Tested By Tester, One Checked By Tester, Two

Material Type COARSE AGGREGATE
A-45, Bridge

Source Hills Materials, Rapid City Quarry

Lot No. Sublot No.

Weight Ticket Number or Station Lift of

Back

[Wet Sample Weight (0.1g) - **Original Dry Sample Weight (0.1g)** 10,414.8] / dry weight x 100 =

Sieve Size	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
4 in.					
3 in.					
2 1/2 in.					
2 in.					
1 1/2 in.	0.0	0.0	100.0	100	100 - 100
1 1/4 in.					
1 in.	286.0	2.7	97.3	97	95 - 100
3/4 in.	1,720.7	16.5	80.8	81	
5/8 in.	1,098.7	10.5	70.3	70	
1/2 in.	1,407.0	13.5	56.8	57	25 - 60
3/8 in.	1,620.8	15.6	41.2	41	
1/4 in.	2,492.5	23.9	17.3	17	
#4	908.0	8.7	8.6	9	0 - 10
Pan					
Total					

Dush Check

wt. before washing (0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

+ #4 Gradation Check

within 0.3% of original dry weight 0.18

Sieve Size	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
#6			8.6	9	
#8	644.7	6.2	2.4	2	0 - 5
#10					
#12					
#16					
#20					
#30					
#40					
#50					
#80					
#100					
#200					
Pan dry	217.9	217.9 2.1		wt before washing (0.1g)	3627.3
Pan wash	0.0			wt after washing (0.1g)	3567.5
Total	10396.3			loss from washing(-#200)	59.8

Coarse	1.65	% x % Retain/Design	64.40	=	1.06
Fine	0.95	% x % Passing/Design	35.60	=	0.34
03 Referenced		Total/Combined -#200			1.4

- #4 Gradation Check

within 0.3% of original dry weight

Sieve Size	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/ Elongated Particles	% Flat/ Elongated Individual Sieve	% Flat/ Elongated Weighted Average
2 in.					
1 1/2 in.					
1 in.					
3/4 in.					
1/2 in.					
3/8 in.					
#4					
Total	0.0				0.0
				(rounded)	0
				Specification	0.0 - 10.0

Crushed Particles Test

Weight of crushed particles	
Weight of total + #4 sample	
Percent of crushed pieces	
Specification ______ or more FF, min.	-

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	
Weight of lightweight particles	
Weight of - #4 material	
% lightweight particles	
Specification	-

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		1.96
Weight of lightweight particles	(0.1g)	0.1
Weight of + #4 material	(0.1g)	1857.0
% lightweight particles		0.0
Specification		0.0 - 1.0

Comments 13.8" x 13.8" sieves were used. The 1/4 sieve was overloaded. 1/4 sieve was split in half and sieved by hand.

Figure 4

Sample ID 2203622	**Screen Analysis and P.I. Worksheet**	**DOT-3**
File No.		3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Charge to (if not above project)

Field No. 03 Date Sampled 03/12/2019 Date Tested 03/12/2019

Sampled By Tester, One Tested By Tester, One Checked By Tester, Two

Material Type FINE AGGREGATE Source Birdsall S & G Wasta

A-45 Bridge Lot No. Sublot No.

Weight Ticket Number or Station Lift of

[Wet Sample Weight (0.1g) **- Original Dry Sample Weight (0.1g**] / dry weight x 100 = % moisture

Sieve Size	**Fineness Modulus**	**Retained (0.1g)**	**% total ret. (0.1g)**	**% passing (0.1g)**	**% passing (rounded)**	**Spec Req.**
4 in.						
3 in.						
2 1/2 in.						
2 in.						
1 1/2 in.						
1 1/4 in.						
1 in.						
3/4 in.						
5/8 in.						
1/2 in.						
3/8 in.	* 0.0	0.0	0.0	100.0	100	100 - 100
1/4 in.						
#4	* 0.2	1.2	0.2	99.8	100	95 - 100
Pan						
Total						

Dust Check	
wt. before washing (0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

+ #4 Gradation Check

within 0.3% of original dry weight

Sieve Size	**Fineness Modulus**	**Retained (.1g)**	**% total ret. (0.1g)**	**% total x % pass. #4**	**% passing (0.1g)**	**% passing (rounded)**	**Spec Req.**
#6							
#8	* 8.5	52.3	8.3		91.5	92	
#10							
#12							
#16	* 32.2	149.0	23.7		67.8	68	45 - 85
#20							
#30	* 50.1	112.8	17.9		49.9	50	
#40		79.4	12.6		37.3	37	
#50	* 78.5	99.3	15.8		21.5	22	10 - 30
#80							
#100	* 96.1	110.6	17.6		3.9	4	2 - 10
#200		18.4	2.9		1.0	1.0	
Pan dry		0.9	6.0		wt before washing (0.1g)		629.4
Pan wash		5.1	1.0		wt after washing (0.1g)		624.3
Total	2.66	629.0			loss from washing(-#200)		5.1

Coarse	1.65	% x % Retain/Design	64.40	=	1.06
Fine	0.95	% x % Passing/Design	35.60	=	0.34
03 Referenced		**Total/Combined -#200**			1.4

- #4 Gradation Check

within 0.3% of original dry weight 0.1

Crushed Particles Test

Weight of crushed particles	
Weight of total + #4 sample	
Percent of crushed pieces	
Specification ______ or more FF, min.	-

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		1.95
Weight of lightweight particles	(0.1g)	1.6
Weight of - #4 material	(0.1g)	274.3
% lightweight particles		0.6
Specification		0 - 1

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		
Weight of lightweight particles	(0.1g)	
Weight of + #4 material	(0.1g)	
% lightweight particles		
Specification		-

Comments

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Figure 5

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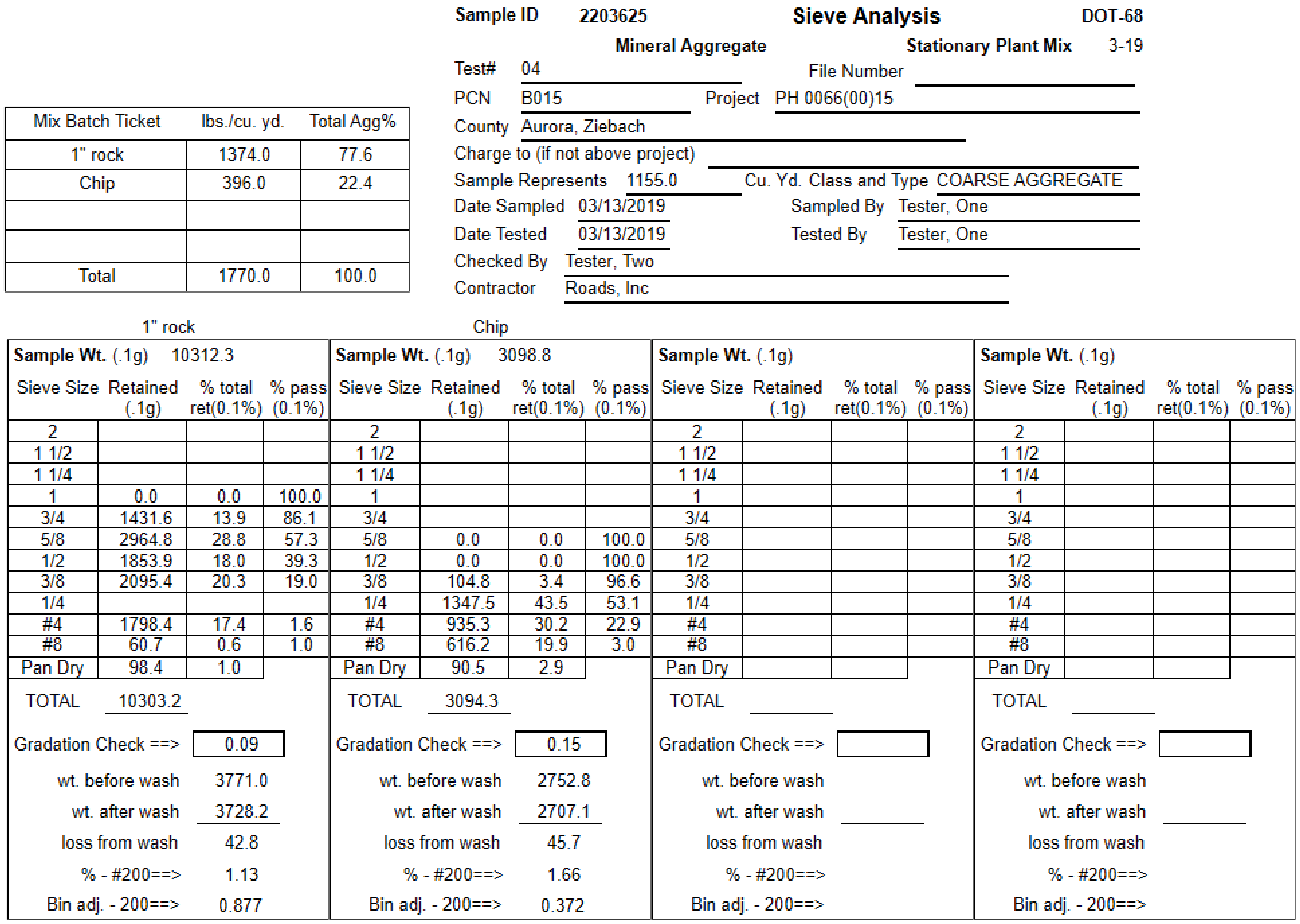

Sample ID 2203625 **Sieve Analysis** **DOT-68**

Mineral Aggregate **Stationary Plant Mix** 3-19

Test# 04 File Number

PCN B015 Project PH 0066(00)15

County Aurora, Ziebach

Charge to (if not above project)

Sample Represents 1155.0 Cu. Yd. Class and Type COARSE AGGREGATE

Date Sampled 03/13/2019 Sampled By Tester, One

Date Tested 03/13/2019 Tested By Tester, One

Checked By Tester, Two

Contractor Roads, Inc

Mix Batch Ticket	lbs./cu. yd.	Total Agg%
1" rock	1374.0	77.6
Chip	396.0	22.4
Total	1770.0	100.0

1" rock

Sample Wt. (.1g) 10312.3

Sieve Size	Retained (.1g)	% total ret(0.1%)	% pass (0.1%)
2			
1 1/2			
1 1/4			
1	0.0	0.0	100.0
3/4	1431.6	13.9	86.1
5/8	2964.8	28.8	57.3
1/2	1853.9	18.0	39.3
3/8	2095.4	20.3	19.0
1/4			
#4	1798.4	17.4	1.6
#8	60.7	0.6	1.0
Pan Dry	98.4	1.0	

TOTAL 10303.2

Gradation Check ==> 0.09

wt. before wash 3771.0

wt. after wash 3728.2

loss from wash 42.8

% - #200==> 1.13

Bin adj. - 200==> 0.877

Chip

Sample Wt. (.1g) 3098.8

Sieve Size	Retained (.1g)	% total ret(0.1%)	% pass (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8	0.0	0.0	100.0
1/2	0.0	0.0	100.0
3/8	104.8	3.4	96.6
1/4	1347.5	43.5	53.1
#4	935.3	30.2	22.9
#8	616.2	19.9	3.0
Pan Dry	90.5	2.9	

TOTAL 3094.3

Gradation Check ==> 0.15

wt. before wash 2752.8

wt. after wash 2707.1

loss from wash 45.7

% - #200==> 1.66

Bin adj. - 200==> 0.372

Sample Wt. (.1g)

Sieve Size	Retained (.1g)	% total ret(0.1%)	% pass (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8			
1/2			
3/8			
1/4			
#4			
#8			
Pan Dry			

TOTAL

Gradation Check ==>

wt. before wash

wt. after wash

loss from wash

% - #200==>

Bin adj. - 200==>

Sample Wt. (.1g)

Sieve Size	Retained (.1g)	% total ret(0.1%)	% pass (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8			
1/2			
3/8			
1/4			
#4			
#8			
Pan Dry			

TOTAL

Gradation Check ==>

wt. before wash

wt. after wash

loss from wash

% - #200==>

Bin adj. - 200==>

Figure 6

Back

Composite Coarse Aggregate

Sieve Size	1" rock	Chip			Retained Total	Cumulative Passing	Specification Gradation	Job Mix Formula
2					0.0	100.0	100	
1 1/2					0.0	100.0	100	100 - 100
1 1/4					0.0	100.0	100	
1	0.0				0.0	100.0	100	95 - 100
3/4	10.8				10.8	89.2	89	
5/8	22.3	0.0			22.3	66.9	67	
1/2	14.0	0.0			14.0	52.9	53	25 - 60
3/8	15.8	0.8			16.6	36.3	36	
1/4		9.7			9.7	26.6	27	
#4	13.5	6.8			20.3	6.3	6	0 - 10
#8	0.5	4.5			5.0	1.3	1	0 - 5
Pan	0.8	0.6			1.4	0.0	0	
Total	77.7	22.4			100.1			

Total Combined - #200 ==> **1.25**

Coarse	______	% x % Retain/Design	58.00	=	______
Fine	______	% x % Pass/Design	42.00	=	______
04 Referenced		**Total/Combined - #200**			

+ #4 % Particles less than 1.95 SP. GR.		1" rock	Chip
Specific gravity of solution	(1.95 ± 0.01)	1.96	1.95
wt. of lightweight particles	(0.1g)	25.0	11.0
weight of + #4 material	(0.1g)	1500.0	1430.0
% lightweight particles		1.7	0.8
Bin Adj. % lightweight particles		1.3	0.2
Composite % lightweight particles		**1.5**	
SPECIFICATION		0.0 - 1.0	

Figure 6A

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	Sieve Size mm	Sieve Size inches	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
Rock Size	50.0	2					
1" rock	37.5	1 1/2					
% of Rock	25.0	1	0.0				
77.6	19.0	3/4	1,431.6	1431.6	0.9	0.1	
	12.5	1/2	4,818.7	809.3	6.7	0.8	0.4
	9.5	3/8	2,095.4	228.5	4.6	2.0	0.4
	4.75	#4	1,798.4	96.7	0.9	0.9	0.2

Total sample wt. 10,144.1

Percent flat and enlongated particles in: 1.0

Percent flat and elongated particles in Total Rock: 0.8

	Sieve Size mm	Sieve Size inches	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
Rock Size	50.0	2					
Chip	37.5	1 1/2					
% of Rock	25.0	1					
22.4	19.0	3/4					
	12.5	1/2	0.0	0.0	0.0		
	9.5	3/8	104.8	75.0	0.0		
	4.75	#4	2,282.8	40.8	1.1	2.7	2.6

Total sample wt. 2,387.6

Percent flat and enlongated particles in: 2.6

Percent flat and elongated particles in Total Rock: 0.6

	Sieve Size mm	Sieve Size inches	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
Rock Size	50.0	2					
	37.5	1 1/2					
% of Rock	25.0	1					
	19.0	3/4					
	12.5	1/2					
	9.5	3/8					
	4.75	#4					

Total sample wt. ______

Percent flat and enlongated particles in:

Percent flat and elongated particles in Total Rock:

Combined Percent Flat and Elongated Particles for Total Rock: **1.4**

Rounded: 1

Comments ______________________________

Figure 6B

Sample ID 2203643

Screen Analysis and P.I. Worksheet

DOT-3
3-19

File No.

PROJECT PH 0066(00)15
COUNTY Aurora, Ziebach
PCN B015
Charge to (if not above project)
Field No. 04
Date Sampled 03/16/2019
Date Tested 03/16/2019
Sampled By Tester, One
Tested By Tester, One
Checked By Tester, Two
Material Type FINE AGGREGATE
1155.0 cuyd, RT. 2805.0
Source Pete Lein & Sons, Wasta
Lot No.
Sublot No.
Weight Ticket Number or Station Belt
Lift
of

[Wet Sample Weight (0.1g) ______ - **Original Dry Sample Weight (0.1g** ______] / dry weight x 100 = ______ % moisture

Back

Sieve Size	**Fineness Modulus**	**Retained (0.1g)**	**% total ret. (0.1g)**	**% passing (0.1g)**	**% passing (rounded)**	**Spec Req.**
4 in.						
3 in.						
2 1/2 in.						
2 in.						
1 1/2 in.						
1 1/4 in.						
1 in.						
3/4 in.						
5/8 in.						
1/2 in.						
3/8 in.	* 0.0	0.0	0.0	100.0	100	100 - 100
1/4 in.						
#4	* 0.1	0.8	0.1	99.9	100	95 - 100
Pan						
Total						

+ #4 Gradation Check

within 0.3% of original dry weight ______

Dust Check

wt. before washing (0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

Crushed Particles Test

Weight of crushed particles	
Weight of total + #4 sample	
Percent of crushed pieces	
Specification ______ or more FF, min.	-

Sieve Size	**Fineness Modulus**	**Retained (.1g)**	**% total ret. (0.1g)**	**% total x % pass. #4**	**% passing (0.1g)**	**% passing (rounded)**	**Spec Req.**
#6							
#8	* 5.4	31.0	5.3		94.6	95	
#10							
#12							
#16	* 27.3	128.2	21.9		72.7	73	45 - 85
#20		96.5	16.5		56.2	56	
#30	* 62.0	106.7	18.2		38.0	38	
#40		89.1	15.2		22.8	23	
#50	* 87.2	58.7	10.0		12.8	13	10 - 30
#80		49.0	8.4		4.4	4	
#100	* 96.8	6.9	1.2		3.2	3	2 - 10
#200		10.6	1.8		1.4	1.4	
Pan dry		0.8	8.5		wt before washing (0.1g)		585.7
Pan wash		7.7	1.5		wt after washing (0.1g)		578.0
Total	2.79	**586.0**			**loss from washing(-#200)**		7.7

Coarse	1.36	% x % Retain/Design	58.00	=	0.79
Fine	1.45	% x % Passing/Design	42.00	=	0.61
04 Referenced		Total/Combined -#200			1.4

- #4 Gradation Check

within 0.3% of original dry weight 0.1

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		1.95
Weight of lightweight particles	(0.1g)	0.0
Weight of - #4 material	(0.1g)	298.4
% lightweight particles		0.0
Specification		0 - 1

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		
Weight of lightweight particles	(0.1g)	
Weight of + #4 material	(0.1g)	
% lightweight particles		
Specification		-

Comments ______

Figure 7

Sample ID 2203623

Sieve Analysis and P.I. Worksheet

DOT-3
3-19

File No.

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Charge to (if not above project)

Field No. 01 Date Sampled 03/13/2019 Date Tested 03/13/2019

Sampled By Tester, One Tested By Tester, One Checked By Tester, Two

Material Type Type 2A Cover Aggregate Source Spencer Quarry

Taken @ 180.3 tons Lot No. Sublot No.

Weight Ticket Number or Station # 194, Sta 866+00 Lift of

[Wet Sample Weight (0.1g) ____ - **Original Dry Sample Weight (0.1g)** ____] / dry weight x 100 = ____ % moisture

Sieve Size	Fineness Modulus	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
4 in.						
3 in.						
2 1/2 in.						
2 in.						
1 1/2 in.						
1 1/4 in.						
1 in.						
3/4 in.						
5/8 in.						
1/2 in.						
3/8 in.	0.0	0.0	0.0	100.0	100	100 - 100
1/4 in.		235.5	19.2	80.8	81	
#4	47.6	349.1	28.4	52.4	52	0 - 70
Pan						
Total						

Dust Check

wt. before washing (0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

+ #4 Gradation Check

within 0.3% of original dry weight ____

Liquid Limit & Plastic Limit

		Liquid Limit	Plastic Limit	
A. Can number				
B. Weight of can + wet soil	(0.01g)			
C. Weight of can + dry soil	(0.01g)			
D. Weight of water (B - C)	(0.01g)			
E. Weight of can	(0.01g)			
F. Weight of dry soil (C - E)	(0.01g)			
G. Liquid Limit (D / F x J x 100	(0.1g)	N.A.	N.P. ☐	
H. Plastic Limit (D / F x 100)	(0.1g)		N.A.	
I. Plasticity Index (G - H)	(0.1g)			Specification
Liquid Limit N.C. ☐	(G rounded)			-
Plasticity Index	(I rounded)	N.A.		0 - 3

J. Correction # Blows ____

22=0.9846, 23=0.9899, 24=0.9952, 25=1.0000, 26=1.0050, 27=1.0100, 28=1.0138

weight - #40 ____ / weight - #4 ____ x % passing #4 = ____

(±3.0% VARIABLE of accumulative % passing (0.1%) on the #40)

Sieve Size	Fineness Modulus	Retained (.1g)	% total ret. (0.1g)	% total x % pass. #4	% passing (0.1g)	% passing (rounded)	Spec Req.
#6							
#8	89.8	518.3	42.2	22.1	10.2	10	0 - 28
#10		44.6	3.6	1.9	6.6	7	
#12							
#16							
#20							
#30							
#40		66.0	5.4	2.8	1.2	1	0 - 4
#50							
#80							
#100							
#200		12.2	1.0	0.5	0.2	0.2	0.0 - 3.0
Pan dry		1.1	4.7	0.2	wt before washing (0.1g)		1228.5
Pan wash		3.6	0.2		wt after washing (0.1g)		1224.9
Total		1230.4			loss from washing(-#200)		3.6

Coarse ____ % x % Retain/Design ____ = ____
Fine 0.38 % x % Passing/Design ____ = ____
Total/Combined -#200 ____

- #4 Gradation Check

within 0.3% of original dry weight 0.15

Natural Fines	0.00	Ma. Sand	0.00	Filler	0.00
Natural Sand	0.00	Add Rock	0.00	Na. Rock	0.00
	0.00	Cr. Rock	0.00	Cr. Fines	

Crushed Particles Test

Weight of crushed particles	582.6
Weight of total + #4 sample	582.6
Percent of crushed pieces	100
Specification 2 or more FF, min.	50 - 100

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	
Weight of lightweight particles	
Weight of - #4 material	
% lightweight particles	
Specification	

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	
Weight of lightweight particles (0.1g)	
Weight of + #4 material (0.1g)	
% lightweight particles	
Specification	

Comments 12" sieves were used. The #8 was split in two and shaken by hand. As per foot note #2, plasticy index was wavied as not more than 4.0% of the material passed the #40 sieve.

Figure 8

Page 1 of 1

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Method of Test for Flakiness Index

---

1. Scope:

This test is for determining the flakiness index of aggregates used in asphalt surface treatments.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 A metal plate approximately 0.0625 inches thick with slots of the following dimensions: 0.525” x 2.36”, 0.375” x 1.97”, 0.263” x 1.57”, 0.184” x 1.18” and 0.131” x 0.79”. Tolerances in the width dimension will be ± 0.005” and tolerances in the length will be ± 0.10”

2.3 Pans, scoops, brushes, etc. for handling the materials.

3. Procedure:

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Flakiness Index:

NOTE: The following procedure is prepared based on the assumption the flakiness index test is performed utilizing the aggregate retained on the applicable sieves during a sieve analysis test performed in accordance with the provisions of SD 202.

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3.1 Copy the weights of the materials retained on the 3/4”, 1/2”, 3/8”, 1/4” and #4 sieve from the DOT-3 into the appropriate box in column A of the DOT-61.

3.2 Aggregate retained on each sieve will be tested particle by particle for its ability to pass through the appropriate elongated opening on the plate. The size of the slots required for each fraction is given in table 1 below.

NOTE: If the material retained on any one of the sieves comprises less than 4% of the total weight of the sample, that material will be omitted from the flakiness index test. If a 5/8” sieve is used in the sieving, the material retained on that sieve will be combined with the material retained on the 1/2” sieve for this testing.

Table 1
Slot Size for Each Aggregate Fraction

Range of aggregate size		Width of slotted sieve opening (Inches)
Material passing	Material retained	
1”	3/4"	0.525
3/4"	1/2"	0.375
1/2"	3/8”	0.263
3/8”	1/4"	0.184
1/4"	#4	0.131

3.3 Following the testing of the aggregate particle by particle over the appropriate elongated opening on the plate, weigh the material that was retained and record the weight in column C for each fraction. Also weigh the material that passed through the slot for each fraction and record the weight in column D of the worksheet. Add the materials weights in columns C & D and record the result in column E. All weights will be recorded to the nearest 0.1 grams.

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3.4 Total the weight of the materials in columns C & D and record the result in the “Total” block for each column at the bottom of the worksheet. The total for columns C & D combined should equal the total of column E. The total of column E will be within 0.3% of the total in column A.

Example (Figure 2):

$$\left(\frac{\text{Total Column (A) - Total Column (E)}}{\text{Total Column (A)}}\right) \text{ X } 100 = \left(\frac{584.6 - 582.9}{584.6}\right) \text{ X } 100 = \mathbf{0.3\%}$$

3.5 Calculate the flakiness index by dividing the total in column D (Total weight of the materials passing the elongated slots) by the total in column E (Total weight of the material) and multiplying the result by 100. Report the result to the nearest whole percentage.

Flakiness Index =

$$\frac{\text{Total of column (D)}}{\text{Total of column (E)}} = \_\_\_\_\_\_\_ \text{x } 100 = \_\_\_\_\_\_\_ \%$$

4. Report:

4.1 Test results will be reported on form DOT-61.

5. References:

SD 202
DOT-3
DOT-61

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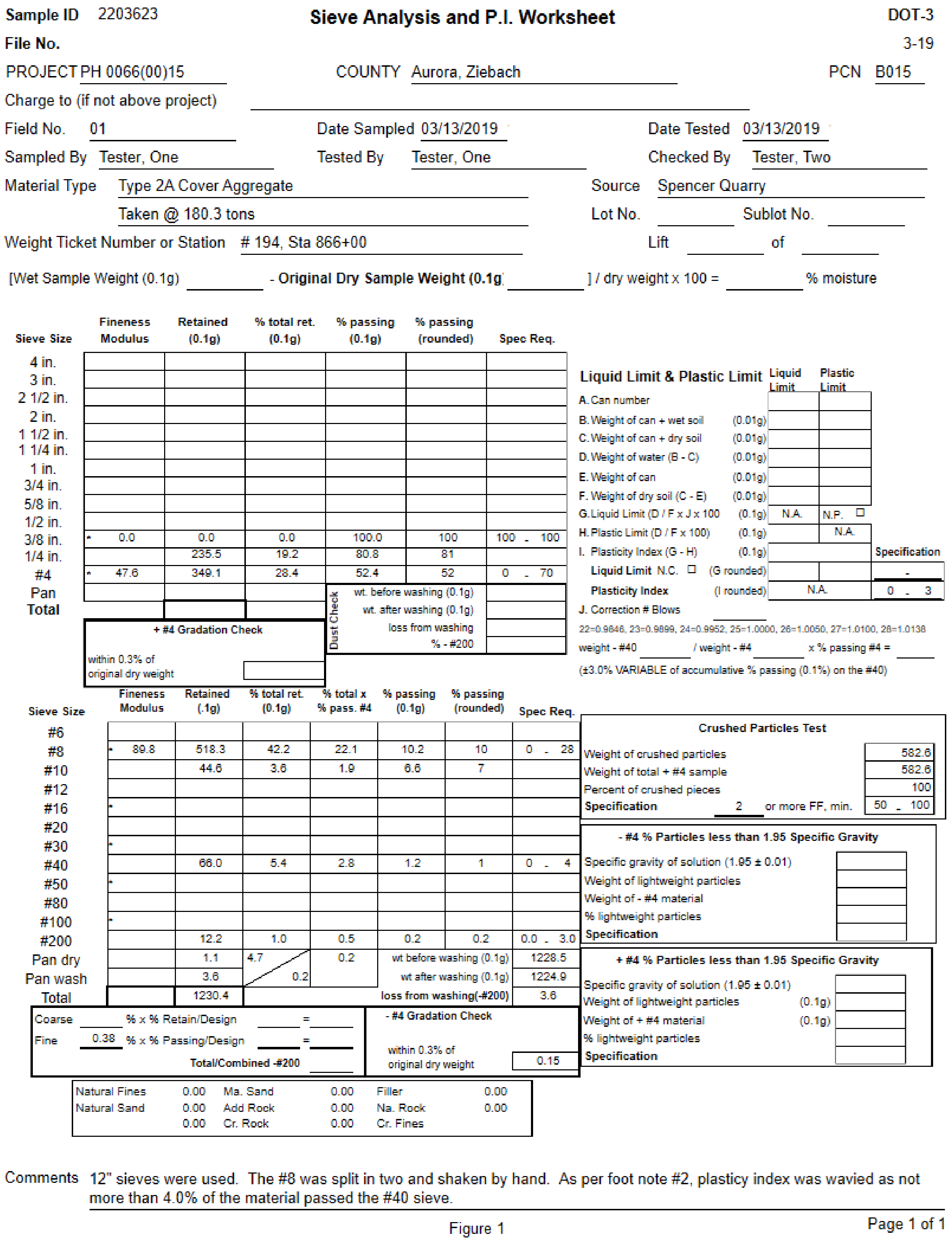


Sample ID 2203623

Sieve Analysis and P.I. Worksheet

DOT-3
3-19

File No.

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Charge to (if not above project)

Field No. 01 Date Sampled 03/13/2019 Date Tested 03/13/2019

Sampled By Tester, One Tested By Tester, One Checked By Tester, Two

Material Type Type 2A Cover Aggregate Source Spencer Quarry

Taken @ 180.3 tons Lot No. Sublot No.

Weight Ticket Number or Station # 194, Sta 866+00 Lift of

[Wet Sample Weight (0.1g) - **Original Dry Sample Weight (0.1g)**] / dry weight x 100 = % moisture

Sieve Size	Fineness Modulus	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
4 in.						
3 in.						
2 1/2 in.						
2 in.						
1 1/2 in.						
1 1/4 in.						
1 in.						
3/4 in.						
5/8 in.						
1/2 in.						
3/8 in.	0.0	0.0	0.0	100.0	100	100 - 100
1/4 in.		235.5	19.2	80.8	81	
#4	47.6	349.1	28.4	52.4	52	0 - 70
Pan						
Total						

+ #4 Gradation Check
within 0.3% of original dry weight

Dust Check	
wt. before washing (0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

Liquid Limit & Plastic Limit

		Liquid Limit	Plastic Limit
A. Can number			
B. Weight of can + wet soil	(0.01g)		
C. Weight of can + dry soil	(0.01g)		
D. Weight of water (B - C)	(0.01g)		
E. Weight of can	(0.01g)		
F. Weight of dry soil (C - E)	(0.01g)		
G. Liquid Limit (D / F x J x 100	(0.1g)	N.A.	N.P. ☐
H. Plastic Limit (D / F x 100)	(0.1g)		N.A.
I. Plasticity Index (G - H)	(0.1g)		

				Specification
Liquid Limit N.C. ☐	(G rounded)			-
Plasticity Index	(I rounded)	N.A.		0 - 3

J. Correction # Blows

22=0.9846, 23=0.9899, 24=0.9952, 25=1.0000, 26=1.0050, 27=1.0100, 28=1.0138

weight - #40 / weight - #4 x % passing #4 =

(±3.0% VARIABLE of accumulative % passing (0.1%) on the #40)

Sieve Size	Fineness Modulus	Retained (.1g)	% total ret. (0.1g)	% total x % pass. #4	% passing (0.1g)	% passing (rounded)	Spec Req.
#6							
#8	89.8	518.3	42.2	22.1	10.2	10	0 - 28
#10		44.6	3.6	1.9	6.6	7	
#12							
#16							
#20							
#30							
#40		66.0	5.4	2.8	1.2	1	0 - 4
#50							
#80							
#100							
#200		12.2	1.0	0.5	0.2	0.2	0.0 - 3.0
Pan dry		1.1	4.7	0.2	wt before washing (0.1g)		1228.5
Pan wash		3.6	0.2		wt after washing (0.1g)		1224.9
Total		1230.4			loss from washing(-#200)		3.6

Coarse % x % Retain/Design =
Fine 0.38 % x % Passing/Design =
Total/Combined -#200

- #4 Gradation Check
within 0.3% of original dry weight 0.15

Natural Fines	0.00	Ma. Sand	0.00	Filler	0.00
Natural Sand	0.00	Add Rock	0.00	Na. Rock	0.00
	0.00	Cr. Rock	0.00	Cr. Fines	

Crushed Particles Test

Weight of crushed particles	582.6
Weight of total + #4 sample	582.6
Percent of crushed pieces	100
Specification 2 or more FF, min.	50 - 100

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	
Weight of lightweight particles	
Weight of - #4 material	
% lightweight particles	
Specification	

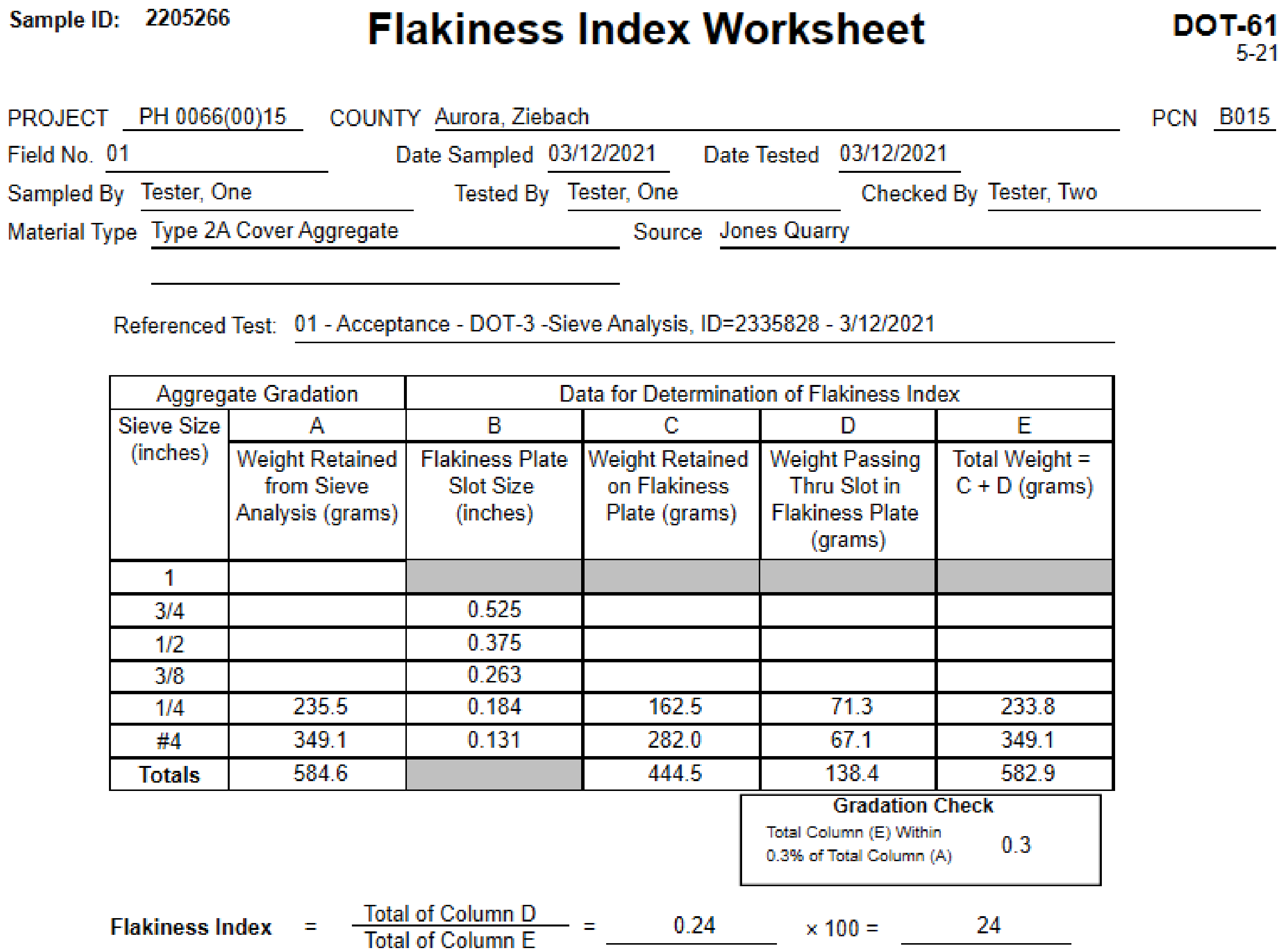
+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	
Weight of lightweight particles (0.1g)	
Weight of + #4 material (0.1g)	
% lightweight particles	
Specification	

Comments 12" sieves were used. The #8 was split in two and shaken by hand. As per foot note #2, plasticy index was wavied as not more than 4.0% of the material passed the #40 sieve.

Page 1 of 1

Figure 1



Sample ID: 2205266

Flakiness Index Worksheet

DOT-61
5-21

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Field No. 01 Date Sampled 03/12/2021 Date Tested 03/12/2021

Sampled By Tester, One Tested By Tester, One Checked By Tester, Two

Material Type Type 2A Cover Aggregate Source Jones Quarry

Referenced Test: 01 - Acceptance - DOT-3 -Sieve Analysis, ID=2335828 - 3/12/2021

Aggregate Gradation		Data for Determination of Flakiness Index			
Sieve Size (inches)	A	B	C	D	E
	Weight Retained from Sieve Analysis (grams)	Flakiness Plate Slot Size (inches)	Weight Retained on Flakiness Plate (grams)	Weight Passing Thru Slot in Flakiness Plate (grams)	Total Weight = C + D (grams)
1					
3/4		0.525			
1/2		0.375			
3/8		0.263			
1/4	235.5	0.184	162.5	71.3	233.8
#4	349.1	0.131	282.0	67.1	349.1
Totals	584.6		444.5	138.4	582.9

Gradation Check
Total Column (E) Within 0.3% of Total Column (A) 0.3

Flakiness Index = $\frac{\text{Total of Column D}}{\text{Total of Column E}}$ = 0.24 × 100 = 24

Figure 2

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Method of Test for Abrasion of Small-Size Coarse Aggregate by use of the Los Angeles Machine

1. Scope:

This standard practice describes the procedure for determining the resistance of coarse aggregate to abrasion using the Los Angeles testing machine.

2. Apparatus:

2.1 Los Angeles testing machine meeting requirements of AASHTO T 96.

2.2 Sieves. All sieves conforming to the requirements of ASTM E11. 18

2.3 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.4 Abrasive charge, steel spheres meeting the requirements of AASHTO T 96.

Depending upon the grading of the test sample as described in table 1, the abrasive charge shall be as follows:

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Grading	Number of Spheres	Mass of Charge (g)
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15

3. Procedure:

3.1 Obtain field sample in accordance with SD 201 and reduce the sample to test size by using SD 213. Oven dry the sample at 230 ± 9°F.

3.2 Assemble a series of sieves that will furnish the information required by the specifications covering the material to be tested. Nest the sieves in order of decreasing size of opening from top to bottom and include a pan below the last sieve.

3.3 Pour the sample into the top sieve of the nest. Agitate the sieves by hand or on a mechanical shaker for a sufficient period of time.

3.4 Remove any dirt adhering to the + #4 material. This can be accomplished by dumping the material from each individual sieve into a flat pan and rubbing it with a soft pine or rubber covered block. After the dirt has been removed, pour the contents of the pan back onto the sieves and complete the shaking.

An alternate method of removing dirt is to place the material retained on an individual sieve in an enclosed container. Agitate the aggregate in the container by hand using a circular motion. The material is then reintroduced to the sieve and sieved by hand.

3.5 Separate the test specimen into individual size fractions and recombine to the grading in table 1, most nearly corresponding to the gradation of the aggregate sample.

Table 1: Grading's for test specimens

Sieve size		Mass for each grading (g)			
Passing	Retained on	A	B	C	D
1 ½"	1"	1250 ± 25			
1"	3/4"	1250 ± 25			
3/4"	1/2"	1250 ± 10	2500 ± 10		
1/2"	3/8"	1250 ± 10	2500 ± 10		
3/8"	1/4"			2500 ± 10	
1/4"	#4			2500 ± 10	
#4	#8				5000 ± 10
Total		5000 ± 10	5000 ± 10	5000 ± 10	5000 ± 10

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3.6 Record the mass of the sample before testing to the nearest 1 g.

3.7 Place the test specimen and abrasive charge in the Los Angeles testing machine and rotate the machine at a speed of 30 to 33 rpm for 500 revolutions.

3.8 After the testing machine has completed the required amount of revolutions, discharge the material from the machine and perform a preliminary separation of the test specimen on the #4 sieve. Sieve the finer portion on a #12 sieve.

3.9 Record the mass of the material retained above the #12 sieve to the nearest 1 g.

4. Report:

4.1 Calculate the “Percent wear” as follows:

$$\text{Percent wear} = \frac{(A - B)}{A} \times 100$$

Where:

A = Mass of original sample to the nearest 1 g.

B = Mass of final sample retained above the #12 sieve to the nearest 1 g.

4.2 Report the grading designation of the test specimen from table 1 and the percent wear to the nearest 1% by mass.

5. References:

AASHTO T 96
ASTM E11 18
ASTM C 131
SD 201
SD 202
SD 213

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Method of Test for Unit Weight and Voids in Aggregate

1. Scope:

This test covers the determination of unit weight and the percent of voids in fine, coarse or mixed aggregates.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 lb.

2.2 Tamping rod: A round, straight steel rod, 5/8” in diameter and approximately 24” in length, having one end rounded to a hemispherical tip of the same diameter of the rod.

2.3 Measure: A cylindrical metal measure. It shall be watertight, with the top and bottom true and even, and sufficiently rigid to retain its form under rough usage. The top rim shall be parallel to the bottom within 0.5 degrees. The capacity of the measure shall conform to the limits of Table 1.

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Table 1

Nominal maximum size of aggregate	Capacity of measure
Inches	ft³
½	1/10
1	1/3
1 ½	½
3	1
4	2 ½
5	3 ½

2.4 Drying oven capable of maintaining a temperature of 230° ± 9°F.

2.5 Straightedge, scoop, or shovel.

3. Procedure:

3.1 Obtain samples in accordance with SD 201.

3.2 Dry the sample to a constant weight in an oven or in accordance with SD 108.

3.3 Calibrate the measure.

A. Weigh the measure and glass cover plate and record to the nearest 0.1 lb.

B. Weigh the water, plate and measure and record to the nearest 0.1 lb.

C. Calculate the volume of the measure.

$$\text{Volume ft}^3 = (B - A) / D$$

D. Measure the temperature of the water to the nearest 1° F and determine its density from Table 2. Interpolate, if necessary.

Table 2

Temperature F°	lb./ft^3
60	62.366
65	62.336
70	62.301
75	62.261
80	62.216
85	62.166

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E. Calculate the factor for the measure to the nearest 0.01 by dividing the unit weight of the water by the weight required to fill the measure. Factor = D / (B - A)

3.4 Compacted weight determination.

A. Rodding: This procedure is applicable to aggregates having a maximum size of 1 ½" or less.

(1) Fill the measure 1/3 full and level the surface. Rod the aggregate with 25 strokes. The strokes shall be distributed uniformly. The measure shall be filled 2/3 full and again level and rod as before. Fill the measure to overflowing and repeat the rodding. Level the surface of the aggregate with the fingers and straightedge. Any slight projections of the larger pieces of the coarse aggregate should approximately balance the larger voids in the surface below the top of the measure.

(2) When rodding the first layer, do not allow the rod to forcibly strike the bottom of the measure. When rodding

the remaining layers, use only enough force to cause tamping rod to penetrate the previous layer.

(3) Weigh the aggregates required to fill the measure to the nearest 0.1 lb. Multiply this weight by the factor of the unit.

B. Jigging: This procedure is applicable to aggregates having a maximum size greater than 1 1/2” and not exceeding 4”.

(1) Fill the measure in 3 approximately equal layers, compacting each layer by placing the measure on a firm base, raising the opposite sides alternately about 2” and allowing the measure to drop, hitting with a sharp, slapping blow. Compact each layer by dropping the measure 25 times on each side. Level the surface of the aggregate with the fingers and a straightedge. Any slight projections of the larger pieces of the coarse aggregate should approximately balance the larger voids in the surface below the top of the measure.

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(2) Weigh the aggregate required to fill the measure to the nearest 0.1 lb. Multiply this weight by the factor of the unit.

3.5 Loose weight determination.

A. Shoveling: This procedure is applicable to aggregates having a maximum size of 4” or less.

(1) Fill the measure to overflowing by means of a shovel, discharging the aggregate from a height not to exceed 2” above the measure. Exercise care to prevent segregation. Level the surface of the aggregate with the fingers and a straightedge. Any slight projections of the larger pieces of the coarse aggregate should approximately balance the larger voids in the surface below the top of the measure.

(2) Weigh the aggregate required to fill the measure to the nearest 0.1 lb. Multiply this weight by the factor of the measure.

4. Report:

4.1 Record the unit weight to the nearest pound.

4.2 Calculate the void content in aggregate using the unit weight measured by rodding, jigging, or the shoveling procedure.

Voids, % = (A x W) – B / (A x W) x 100

A = Bulk specific gravity of the aggregate as determined in accordance with SD 209 or SD 210

B = Unit weight of the aggregates

W = Unit weight of the water

4.3 Report the results to the nearest 0.1%.

Back

5. References:

AASHTO T19
SD 108
SD 201
SD 209
SD 210

SD 206

Method of Test for Amount of Material Finer than #200 Sieve

---

1. Scope:

This test covers the determination of the amount of material finer than a #200 sieve.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Sieves. A nest of two sieves with the lower being a #200 sieve and the upper being a sieve with openings in the range of #8 to #16, both conforming to the requirements of ASTM E11. 18

2.3 Container. A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of material or water.

2.4 Drying oven capable of maintaining a temperature of 230° ± 9°F.

Back

3. Procedure:

3.1 Obtain samples in accordance with SD 201.

3.2 The size of the specimen shall conform to the following:

NOTE: Nominal maximum size of particle is denoted by the smallest sieve opening listed below, through which 90% or more of the sample being tested will pass.

Nominal maximum size of particles	Minimum weight of sample, grams
#4	500
3/8”	1000
1/2”	2000
3/4”	2500
1”	3500
1 1/2” & above	5000

3.3 Dry the sample to a constant weight in an oven at 230° ± 9°F or in accordance with SD 108. Weigh the material to the nearest 0.1 gram.

3.4 Place the sample in the container and add enough water to cover it. Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the #200 sieve from the coarser particles, and to bring the fine material into suspension. Pour the wash water containing the suspended and dissolved solids over the nest of sieves. Repeat the operation until the wash water is clear.

NOTE: Plain water should be used as noted above unless the finer material that is adhering to the larger particles can't be removed readily with plain water because of some clay coatings or when aggregates have been extracted from bituminous mixtures. In these cases the fine materials will be separated more readily when using a wetting agent such as Aerosol OT, Alconox, or liquid dishwashing detergents. Only use enough wetting agent so that a small amount of suds is obtained.

3.5 Dry the washed aggregate to a constant weight (As defined in section 3.3 above) in an oven at 230° ± 9°F or in accordance with SD 108.

NOTE: If the material being tested also requires testing in accordance with SD 216 and/or SD 218, material from this test may be used to eliminate the need for additional testing specimens.

4. Report:

4.1 Calculate the amount of material passing a #200 sieve by washing as follows:

$$\frac{(\text{Original dry weight - weight after washing})}{\text{Original dry weight}} \times 100 = \text{\% of material finer than \#200 sieve}$$

Back

4.2 Percentages shall be reported to the whole number or decimal required by the specification.

5. References:

ASTM E11
SD 108 | 18
SD 201
SD 216
SD 218
DOT-3

Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index

---

1. Scope:

This test is for determining the liquid limit, plastic limit, and the plasticity index of soils and granular materials. Referee tests will be performed in accordance with AASHTO T 89 and AASHTO T 90.

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

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

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

The word “Soil” in these tests shall mean the - #40 sieve material.

2. Apparatus:

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2.1 Balance having a capacity of at least 100 grams sensitive and readable to .01 gram.

2.2 Containers. Containers, such as metal cans with lids, which will prevent loss of moisture prior to and during weighing.

2.3 Drying oven. Ovens, hot plates or other suitable devices for drying the samples at 230°F ± 9°F.

2.4 Evaporating dish. A porcelain dish used for mixing the soil and water.

2.5 Liquid limit device conforming to specifications as described in AASHTO T 89.

2.6 Grooving tool. A combined grooving tool and gauge as described in AASHTO T 89.

2.7 Gauge. 10mm x 25mm x 50mm (Optional).

2.8 Plastic wash bottle with jet opening for adding water to the soil.

2.9 Pulverizing apparatus shall be a mortar and rubber covered pestle or a mechanical device consisting of a mortar of suitable size and shape and a power-driven, rubber covered muller for breaking up soil particles without reducing individual grain size.

2.10 Splitter. Mechanical splitter capable of reducing the size of sample. (SD 213).

2.11 Sieves. Sieves shall conform to ASTM E11.

2.12 Spatula. A spatula having a flexible steel blade approximately 3” in length and 3/4” in width.

2.13 Spoon. An appropriate size spoon for mixing and transferring the dry soil.

2.14 Surface for rolling. A ground glass plate or a piece of smooth paper laying on a smooth, horizontal surface.

3. Procedure:

For Disturbed Soil Samples

3.1 Obtain a field sample in accordance with SD 201.

Obtain an approximate 500 gram dry sample of - #4 sieve material that is of adequate size to produce at least 100 grams of - #40 sieve material.

3.2 Sieve the material on a #40 sieve.

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3.3 Pulverize the material retained on the #40 sieve using the mortar and rubber covered pestle or the power driven muller. If the sample contains brittle particles, the pulverizing operation shall be done carefully and with just enough pressure to free the finer material that adheres to the coarser particles.

For Aggregate Samples

3.4 Obtain an approximate 500 gram sample of -#4 material from SD 202.

Begin by weighing the sample to the nearest 0.1 gram and record it as “Wt. - #4” on the worksheet. Place the material on a #40 sieve with a pan below the sieve and agitate them for a period of time. (The use of a relief sieve, #20 or #30, is encouraged above the #40 to prevent overloading.) Place the material retained on the sieves into a pulverizing mechanism (Which shall consist of a mortar and rubber covered pestle or a power driven muller) and carefully pulverize the material.

Alternately sieve and pulverize the material until not more than 1% will pass the #40 sieve during 1 minute of sieving.

Weigh the material in the pan to the nearest 0.1 gram and record it as “Wt. - #40” on the worksheet. Calculate the percentage of the sample which passed through the sieve by dividing the “Wt. - #40” by the “Wt. - #4” and then multiplying this percentage by the accumulative percent passing the #4 sieve in the sieve analysis. Compare this percentage to the accumulative percentage of material that passed the #40 sieve in the sieve analysis. These should compare within ±3.0%. If the difference is more than 3.0% above the sieve analysis percentage, a new sample should be prepared and sieved, if it is more than 3.0% below the percentage passing in the sieve analysis, more pulverizing and sieving is required and the results recalculated.

NOTE: The variation should not be more than 3.0%.

3.5 Liquid Limit

Adjust the cup of the liquid limit device to a 10 mm drop. Place a piece of masking tape across the wear spot on the bottom of the cup parallel with the axis of the cup hanger pivot. The tape must bisect the center of the wear spot, leaving the front half of the wear spot (away from the cup hanger pivot) exposed. From the front of the liquid limit device, slide the gauge under the cup until it comes in contact with the tape. Check the adjustment by turning the crank at 2 revolutions per second while holding gauge in position against the tape and cup. The adjustment is correct if a ringing or clicking sound is heard without the cup rising from the gauge.

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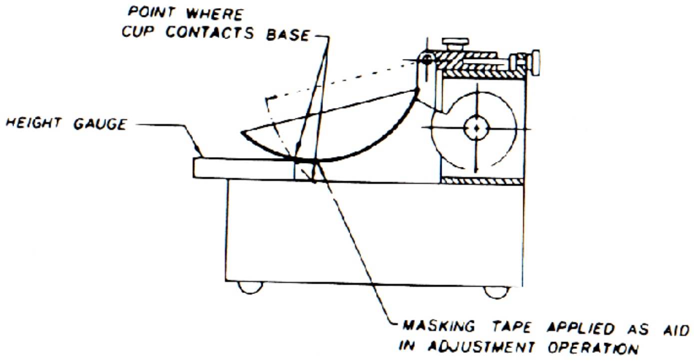

Calibration for Height of Drop

Figure 1

3.6 Mix the sample of - #40 material thoroughly and transfer approximately 50 to 100 grams to the evaporating dish. If not enough material is produced from steps 3.3 or 3.4, repeat steps 3.3 or 3.4 until enough material is produced. Add 15 to 20 mL of water by alternately and repeatedly stirring, kneading and chopping with a spatula, allowing time for moisture to soak into the soil. (Allow 5 to 10 minutes, with the longer time used for material slow to absorb water.) Make further additions of water in increments of 1 to 3 mL. Mix each increment of water thoroughly as previously described before adding another increment. Once testing has begun, no additional dry soil shall be added to the moistened soil. The cup of the liquid limit device shall not be used for mixing.

When sufficient water has been thoroughly mixed with the soil to form a uniform mass of stiff consistency, place an adequate quantity of this mixture in the cup above the spot where the cup rests on the base. Squeeze and spread this mixture with the spatula to level and at the same time trimmed to a depth of approximately 10 mm at the point of maximum thickness. Use as few strokes of the spatula as possible, taking care to prevent entrapment of air bubbles within the mass.

Divide the soil in the cup of the mechanical device with a firm stroke of the grooving tool, along the diameter through the centerline of the cam follower, forming a clean sharp groove of the proper dimensions (Figure 2). To avoid tearing the sides of the groove or slipping of the soil cake within the cup, up to 6 strokes (From front to back or back to front, counting as 1 stroke) shall be permitted.

NOTE: At this point, spilled portions of moistened soil shall be wiped from the edges of the cup and base of the machine to ensure a clean surface on which the cup will fall.

Lift and drop the cup containing the soil by turning the crank at a rate of two revolutions per second until the sides of the groove come in contact at the bottom of the groove for a distance of 1/2”, (Figure 3). Do not hold the base of the machine with the hand while turning the crank.

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NOTE: Some soils tend to slide on the surface of the cup instead of flowing. If this occurs, remove the material from the cup, add more water, remix and repeat the test. If the soil continues to slide on the cup at a lesser number of blows than 25, the material shall be considered non-controllable (N.C.) and a note should be made that the liquid limit could not be determined.

Restrict the accepted number of blows for groove closure to between 22 and 28 blows. Record the number of blows for the accepted closure. Remove a slice of soil (8 grams minimum) approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to and including that portion of the groove where the closure took place, and place it in a container. Promptly weigh and record to the nearest 0.01 g, the weight of the can and wet soil. Dry to a constant weight as per SD 108.

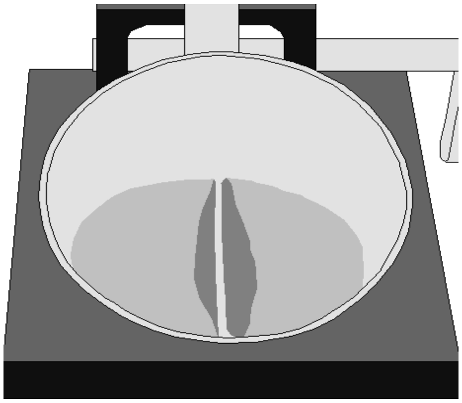

Figure 2
(Soil cake grooved for the test)

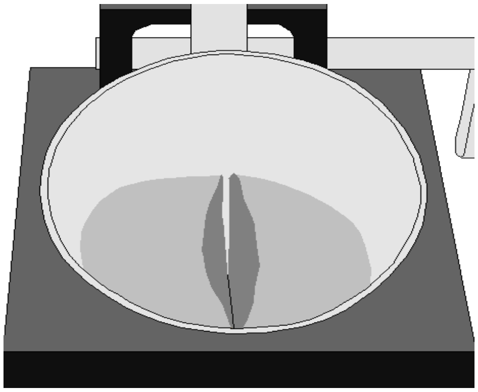

Figure 3
(Soil cake after normal test)

3.7 Plastic limit.

Take a sample weighing a minimum of 8 grams from the wet material in the evaporating dish used for the liquid limit test. Take the sample at any stage of the mixing process when the material becomes plastic enough to be shaped without excessively sticking to the fingers when squeezed. Set this sample aside until the liquid limit test has been completed.

Select a 1.5 to 2.0 gram portion from the 8 gram sample and squeeze and form this into an ellipsoidal-shaped mass. Roll this mass between the fingers and the ground-glass plate or a piece of smooth paper (do not use paper towels) laying on a smooth horizontal surface with just sufficient pressure to roll the mass into a uniform thread approximately 1/8” in diameter throughout its length (Figure 4). When the diameter of the thread reaches 1/8”, break it into 6 or 8 pieces, squeeze the pieces together into a uniform mass roughly ellipsoidal in shape and re-roll. The rate of rolling shall be between 80 and 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position.

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NOTE: If 1/8” cannot be attained after repeated rolldown attempts, sample is considered non-plastic (NP).

Continue this alternate rolling to a thread, gathering together, kneading and re-rolling until the thread crumbles under the pressure required for rolling (Figure 5).

The crumbling may occur when the thread has a diameter greater than 1/8”. This shall be a satisfactory end point, provided the soil has been previously rolled into a 1/8” diameter thread.

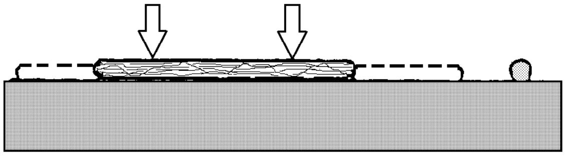

Figure 4

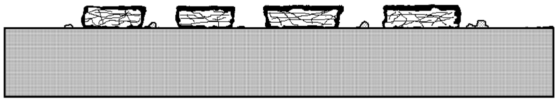

Figure 5

3.8 Gather all the crumbled soil together and place it in a tared container for weighing. This requires an additional sample to be taken and the steps in paragraph 3.7 followed again. Be sure the lid is on the container to prevent evaporation while the additional material is prepared.

Weigh and record the weight of the container and wet soil to the nearest 0.01 gram. Dry the sample to a constant weight as per SD 108.

4. Report:

4.1 Calculation of the liquid limit.

A. Calculate the moisture content to the nearest 0.1% of the oven-dried weight as follows:

$$\% \text{ moisture} = \frac{\text{Weight of water}}{\text{Weight of oven-dried material}} \times 100$$

B. Convert the percent of moisture to the Liquid Limit using the following conversion factors.

# of blows	x factor	# of blows	x factor
22 =	0.9846	26 =	1.0050
23 =	0.9899	27 =	1.0100
24 =	0.9952	28 =	1.0138
25 =	**1.0000**		

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C. Record the liquid limit to the nearest 0.1% on the worksheet.

4.2 Calculation of the plastic limit.

A. Calculate the plastic limit as follows:

$$\text{Plastic limit} = \frac{\text{Weight of water}}{\text{Weight of oven-dried material}} \times 100$$

B. Record the plastic limit to the nearest 0.1% on the worksheet.

4.3 Calculation of the plasticity index.

A. Calculate the plasticity index as follows:

Plasticity index = liquid limit – plastic limit

B. Record the plasticity index to the nearest 0.1% on the worksheet.

4.4 Report the liquid limit and plasticity index to the whole number or decimal required by the specifications.

5. References:

AASHTO T 89
AASHTO T 90
ASTM E11
SD 108
SD 202
SD 213
DOT-3

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Sample ID 2203565

Sieve Analysis and P.I. Worksheet

DOT-3
3-19

File No.

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Charge to (if not above project)

Field No. 01 Date Sampled 03/10/2019 Date Tested 03/10/2019

Sampled By Brown, Benjamin Tested By Tester, One Checked By Tester, Two

Material Type Base Course Source

Lot No. Sublot No.

Weight Ticket Number or Station Lift of

[Wet Sample Weight (0.1g) ______ - **Original Dry Sample Weight (0.1g)** 7,318.0] / dry weight x 100 = ______ % moisture

Sieve Size	Fineness Modulus	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
4 in.						
3 in.						
2 1/2 in.						
2 in.						
1 1/2 in.						
1 1/4 in.						
1 in.		0.0	0.0	100.0	100	100 - 100
3/4 in.		167.6	2.3	97.7	98	80 - 100
5/8 in.		240.6	3.3	94.4	94	
1/2 in.		351.7	4.8	89.6	90	68 - 91
3/8 in.	* 15.0	338.8	4.6	85.0	85	
1/4 in.		625.2	8.5	76.5	77	
#4	* 31.5	586.2	8.0	68.5	69	46 - 70
Pan		5008.1	68.4			
Total		7,318.2				

+ #4 Gradation Check

within 0.3% of original dry weight 0.00

Dust Check

wt. before washing (0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

Liquid Limit & Plastic Limit

		Liquid Limit	Plastic Limit	Specification
A. Can number		45	19	
B. Weight of can + wet soil	(0.01g)	29.87	28.34	
C. Weight of can + dry soil	(0.01g)	28.14	27.11	
D. Weight of water (B - C)	(0.01g)	1.73	1.23	
E. Weight of can	(0.01g)	19.92	20.17	
F. Weight of dry soil (C - E)	(0.01g)	8.22	6.94	
G. Liquid Limit (D / F x J x 100	(0.1g)	21.2	N.P. ☐	
H. Plastic Limit (D / F x 100)	(0.1g)		17.7	
I. Plasticity Index (G - H)	(0.1g)	3.5		
Liquid Limit N.C. ☐	(G rounded)	21		0 - 25
Plasticity Index	(I rounded)	4		0 - 6

J. Correction # Blows 26

22=0.9846, 23=0.9899, 24=0.9952, 25=1.0000, 26=1.0050, 27=1.0100, 28=1.0138

weight - #40 181.4 / weight - #4 611.2 x % passing #4 = 20.3

(±3.0% VARIABLE of accumulative % passing (0.1%) on the #40)

Sieve Size	Fineness Modulus	Retained (.1g)	% total ret. (0.1g)	% total x % pass. #4	% passing (0.1g)	% passing (rounded)	Spec Req.
#6							
#8	* 46.3	136.5	21.6	14.8	53.7	54	34 - 58
#10		28.2	4.5	3.1	50.6	51	
#12							
#16	* 56.7	67.1	10.6	7.3	43.3	43	
#20		62.7	9.9	6.8	36.5	37	
#30	* 71.7	75.8	12.0	8.2	28.3	28	
#40		61.4	9.7	6.6	21.7	22	13 - 35
#50	* 84.3	55.6	8.8	6.0	15.7	16	
#80		34.4	5.4	3.7	12.0	12	
#100	* 88.5	4.8	0.8	0.5	11.5	12	
#200		10.6	1.7	1.2	10.3	10.3	3.0 - 12.0
Pan dry		1.7	95.1	10.3	wt before washing (0.1g)		631.9
Pan wash		93.4	15.0		wt after washing (0.1g)		538.5
Total	3.94	632.2			loss from washing(-#200)		93.4

Coarse ______ % x % Retain/Design ______ = ______

Fine 15.05 % x % Passing/Design ______ = ______

Total/Combined -#200 ______

- #4 Gradation Check

within 0.3% of original dry weight 0.05

Filler	0.00	Cr. Fines	0.00		0.00
Cr. Rock	0.00	Ma. Sand	0.00	Natural Sand	0.00
Na. Rock	0.00	Natural Fines	0.00	Add Rock	

Crushed Particles Test

Weight of crushed particles	447.0
Weight of total + #4 sample	1,015.9
Percent of crushed pieces	44
Specification 1 or more FF, min.	30 - 100

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	
Weight of lightweight particles	
Weight of - #4 material	
% lightweight particles	
Specification	

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		
Weight of lightweight particles	(0.1g)	
Weight of + #4 material	(0.1g)	
% lightweight particles		
Specification		

Comments

Figure 6

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SD 208

Method of Test for Percentage of Particles of Less Than 1.95 Specific Gravity in Fine Aggregates

---

1. Scope:

This test is for determining the percentage of lightweight particles in fine aggregate.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Sieves. A #30 sieve conforming to the requirements of ASTM E11.

2.3 Strainer. A piece of #30 sieve cloth, conforming to ASTM E11, of suitable size and shape for separating the floating pieces from the heavy liquid.

2.4 Beakers and graduate. Two 1000 mL glass beakers and one glass graduate of at least 250 mL capacity.

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2.5 Containers suitable for drying the aggregate sample.

2.6 Hydrometer for measuring the specific gravity of the liquid, readable to 0.01.

2.7 Zinc chloride solution having a specific gravity of 1.95 ± 0.01.

2.8 Drying oven capable of maintaining a temperature of 230° ± 9°F.

3. Procedure:

3.1 Using the graduate and hydrometer, check the specific gravity of the zinc chloride solution and record on the worksheet to the nearest 0.01.

3.2 Obtain a 250 to 350 g sample in accordance with SD 201. The sample will consist of material passing the #4 sieve unless it is a concrete fine aggregate sample. For concrete fine aggregates, the sample will consist of the full portion of material including any plus #4 material that may be present.

Dry in an oven at 230° ± 9°F to a constant weight as per SD 108. Weigh the material to the nearest 0.1 gram. 24

Material previously washed in a testing procedure may not be used for this test.

3.3 Screen the material on a #30 sieve and save the retained portion for the test.

3.4 Place approximately 600 mL of the solution in a glass beaker. The material is poured into the solution and at the same time stir the solution with a spoon. Continue stirring to ensure that all of the material is in suspension. Allow the material to settle until there is a defined cleavage plane between the rising and settling material.

3.5 Decant the solution over the strainer into a glass beaker. Continue decanting until the settled material appears near the lip of the beaker.

3.6 Pour the solution back into the settled material at the same time stirring with a spoon to bring all material into suspension. Decant the solution as described in paragraph 3.5.

3.7 Thoroughly wash the material retained on the strainer to remove all zinc chloride. Dry the material to a constant weight in an oven at 230° ± 9°F. Weigh the material to the nearest 0.1 gram.

4. Report:

4.1 The approximate percentage of lightweight particles is calculated in the following manner:

$$\%\ \text{lightweight particles} = \frac{\text{wt. of decanted particles}}{\text{wt. of original dry sample}} \times 100$$

Back

4.2 Report the percentage of lightweight particles to the nearest 0.1%.

5. References:

ASTM E11
SD 108
SD 201
DOT-3
DOT-69

Method of Test for Specific Gravity and Absorption of Fine Aggregate

---

1. Scope:

This test is for determining the bulk specific gravity and absorption of fine aggregate.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Flask. A volumetric flask having a capacity of 500 mL with a known tare weight.

2.3 Mold. A metal, cone shaped mold with the following dimensions: top, 1 ½”; bottom, 3 ½”; height, 2 ⅞”.

2.4 Tamper. A metal tamping rod weighing 12 oz. and having a flat circular tamping face 1” in diameter.

Back

2.5 Drying oven capable of maintaining a temperature of 230° ± 9°F.

2.6 Funnel. A small funnel to introduce the fine aggregate into the flask.

3. Procedure:

3.1 Obtain a sample of at least 1000g in accordance with SD 201.

3.2 Dry the sample in an oven at 230° ± 9°F to a constant weight as per SD 108. Weigh the material to the nearest 0.1 gram.

3.3 Allow the sample to cool to a comfortable handling temperature, cover with water, either by immersion or by the addition of at least 6% moisture to the fine aggregate, and permit to stand for 15 to 19 hours. | 18

3.4 Decant excess water with care to avoid loss of fines, spread on a flat non-absorbent surface exposed to a gently moving current of warm air, and stir frequently to secure homogenous drying. Continue until the test specimen approaches a free flowing condition.

3.5 Test the material to determine if surface moisture is present with the cone and tamper. Hold the mold firmly on a smooth non-absorbent surface with the large diameter down. Place a portion of the partially dried fine aggregate loosely in mold by filling it to overflowing and heaping additional material above the top of the mold by holding it with cupped fingers of the hand holding the mold.

Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper. The height of each drop shall be about 1/4” above the surface elevation of the fine aggregate. Distribute the drops over the entire surface of the fine aggregate.

Remove the loose sand from the base of the mold and lift it vertically. If surface moisture is still present, the fine aggregate will retain the shape of the mold. When the fine aggregate slumps slightly, it indicates that it has reached a surface dry condition. (It is intended that the first trial of the cone test be made with some surface water in the specimen. If the first test indicates that moisture is not present on the surface, mix a few milliliters of water with the fine aggregate; allow to stand covered for approximately 30 minutes, then proceed with the cone test.)

3.6 Immediately weigh a 500.0 g sample of the surface dry material and place it in the flask. Add water at 73.4° ± 3°F to the material and roll the flask to eliminate air bubbles. After all air bubbles have been removed, place the flask in a constant temperature bath at 73.4° ± 3°F for 1 hour.

Fill the flask with water to the 500 mL mark and weigh the flask, water and fine aggregate to the nearest gram.

Back

Remove the fine aggregate from the flask and dry to a constant weight. Weigh the dry aggregate to the nearest 0.1 gram. In lieu of drying the material from the flask, a second 500.0 gram of surface dry sample may be used to determine the dry weight.

4. Report:

4.1 Bulk specific gravity:

Calculate the bulk specific gravity, 73.4°/73.4°F, as follows:

$$\text{Bulk Sp. Gr.} = A \;/\; (B + S - C)$$

Where:

A = Mass of oven-dry specimen in air, g;

B = Mass of pycnometer filled with water, g;

C = Mass of pycnometer with specimen and water to calibration mark, g;

S = Mass of saturated surface-dry specimen, g;

A. Bulk specific gravity (Saturated surface-dry basis).

Calculate the bulk specific gravity, 73.4°/73.4°F, on the basis of mass of saturated surface-dry aggregate as follows:

$$\text{Bulk Sp. Gr. (saturated surface-dry basis)} = S / (B + S - C)$$

B. Apparent specific gravity.

Calculate the apparent specific gravity, 73.4°/73.4°F, as follows:

Apparent Sp. Gr. = A / (B + A - C)

C. Absorption.

Calculate the percentage of absorption, as defined in ASTM C125, as follows:

Absorption, percent = ((S - A) / A) X 100

4.2 Report the concrete specific gravity to the nearest 0.01 and the absorption to the nearest 0.1%. Report the asphalt specific gravity to 0.001 and absorption to the nearest 0.1%.

5. References:

AASHTO T 84
ASTM C 125
SD 108
SD 201

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Method of Test for Specific Gravity and Absorption of Coarse Aggregate

---

1. Scope:

This test is for determining the bulk specific gravity and the absorption of coarse aggregate.

The bulk specific gravity, saturated surface dry test is the method used for the determination of the weight per ft³ of riprap.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Wire basket. A wire basket, large enough to hold the coarse aggregate sample, with #6 mesh or smaller openings.

2.3 Water tank. A pail or tank into which the sample is suspended in water at 73.4° ± 3°F for weighing.

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2.4 Sieves. A #4 sieve conforming to ASTM E11. 18

2.5 Drying oven capable of maintaining a temperature of 230° ± 9°F.

3. Procedure:

3.1 Coarse aggregate.

A. Obtain a sample in accordance with SD 201. The minimum sample specimen weight shall be as shown in the following table.

Nominal maximum size, in	Minimum mass of test sample, lb.
1/2	4.4
¾	6.6
1	8.8
1 ½	11
2	18
2 ½	26
3	40
3 ½	55
4	88
4 ½	110
5	165
6	276

B. Screen and wash the sample on the #4 sieve.

C. Immerse the + #4 sieve material in water for 15 to 19 hours.

D. Remove the specimen from the water and roll in an absorbent cloth until all visible films of water are removed from the particles.

E. Weigh and record the weight of the material to the nearest 0.1 gram.

F. Place the specimen in the wire basket and weigh and record the weight to the nearest 0.1 g of the material suspended in water at 73.4°F ± 3°F.

G. Dry the material to a constant weight and weigh to the nearest 0.1 gram.

3.2 Riprap.

A. Select a representative sample in accordance with the table shown in 3.1 A. (If small pieces are not available, select a larger piece that can be broken down in the laboratory).

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B. Wash the specimen to remove dust and then immerse it in water for 15 to 19 hours.

C. Continue with paragraph 3.1. D. thru 3.1 G.

4. Report:

4.1 Bulk specific gravity.

Calculate the bulk specific gravity, 73.4/73.4°F as follows:

Bulk Sp. Gr. = A/(B-C)

Where:

A = Mass of oven-dry test sample in air, g,

B = Mass of saturated-surface-dry test sample in air, g, and

C = Mass of saturated test sample in water, g.

4.2 Bulk specific gravity (Saturated-surface-dry).

Calculate the bulk specific gravity, 73.4/73.4°F, on the basis of mass of saturated-surface-dry aggregate as follows:

Bulk sp. gr. (Saturated-surface-dry) = B / (B - C).

4.3 Apparent specific gravity.

Calculate the apparent specific gravity, 73.4/73.4°F, as follows:

Apparent sp. gr. = A / (A - C)

4.4 Average specific gravity values.

When the sample is tested in separate size fractions, the average value for bulk specific gravity, bulk specific gravity (SSD), or apparent specific gravity can be computed as the weighted average of the values as computed using the following equation:

$$G = \frac{1}{\frac{P_1}{100\ G_1} \qquad \frac{P_2}{100\ G_2} \qquad \frac{P_n}{100\ G_n}}$$

Where:

G = Average specific gravity. All forms of expression of specific gravity can be averaged in this manner.

G_1, G_2 … G_3 = Appropriate specific gravity values for each size fraction depending on the type of specific gravity being averaged.

P_1, P_2 … P_n = Mass percentages of each size fraction present in the original sample.

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4.5 Absorption.

Calculate the percentage of absorption, as follows:

Absorption, percent = ((B - A) / A) x 100

4.6 Average absorption value.

When the sample is tested in separate size fractions, the average absorption value is the average of the values as computed in section 9.3, weighted in proportion to the mass percentages of the size fractions in the original sample as follows:

$$A = (P_1A_1 / 100) + (P_2A_2 / 100) \quad + \ldots (P_nA_n / 100)$$

Where:

A = Average absorption, percent,

A_1, A_2 … A_n = Absorption percentages for each size fraction, and

P_1, P_2 … P_n = Mass percentages of each size fraction present in the original sample.

4.7 Report the specific gravity of coarse aggregate to the nearest 0.01 for concrete, nearest 0.001 for asphalt, and the absorption to the nearest 0.1% for both.

4.8 Report the unit weight of riprap to the nearest whole lb./ft^3.

Unit weight of riprap = Use formula shown in paragraph 4.2 above.

5. References:

AASHTO T 85
ASTM E11 18
SD 201

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Method of Test for Percentage of Crushed Particles

---

1. Scope:

This test is for determining the percentage of pieces having one or more crushed faces. A crushed face is an angular, rough, or broken surface of a particle created by crushing, by other artificial means, or by nature.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Sieve. A #4 sieve conforming to ASTM E11.

2.3 Pans for washing and drying the samples.

2.4 Drying oven capable of maintaining a temperature of 230° ± 9°F.

3. Procedure:

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3.1 Obtain sample in accordance with SD 201.

3.2 The sample should be large enough to yield the minimum quantity of + #4 sieve material required by the table below. The sample includes all rock retained on the #4 sieve and above.

Nominal maximum size of aggregate	Minimum sample size of + #4 material
#4	200 grams
3/8”	400 grams
1/2”	700 grams
3/4”	1000 grams
1”	1500 grams
1 ½”	2500 grams

NOTE:Nominal maximum size of aggregate is denoted by the smallest sieve opening through which 90% or more of the sample being tested will pass.

3.3 The material used for this test may be the same material used for the total - #200 material tested in SD 202. This material will need to be screened over the #4 sieve prior to weighing.

If the material comes from the remaining portion of the original + #4 material, it shall be washed to remove the adhered fine material and to aid in the visual inspection of the crushed faces. Following washing, dry the material in an oven at 230 ± 9°F to a constant weight as per SD 108 and weigh it to the nearest 0.1 gram. The material shall then be screened over a #4 sieve, weighed to the nearest 0.1 gram, and the weight recorded as the Weight of Total + #4 Sample.

3.4 Spread the aggregate on a flat clean surface and separate the particles not having the required number of crushed faces from those that have. Following are the definitions for a fractured face:

<u>One crushed face</u>

The particle face will be considered "Crushed" only if it has a projected area of at least 25% of the maximum cross-sectional area of the particle and the face has sharp and well-defined edges.

<u>Two crushed faces</u>

The particle will be considered to have two "Crushed faces" when the largest crushed face has a projected area of at least 50% of the maximum cross-sectional area of particle and the other crushed face has a projected area of at least 25% of the maximum cross sectional area of the particle. The crushed faces shall have sharp and well defined edges.

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The maximum cross-sectional area of the particle would be the largest outline projected by the aggregate fragment when held under a light.

Weigh the crushed particles to the nearest 0.1 gram.

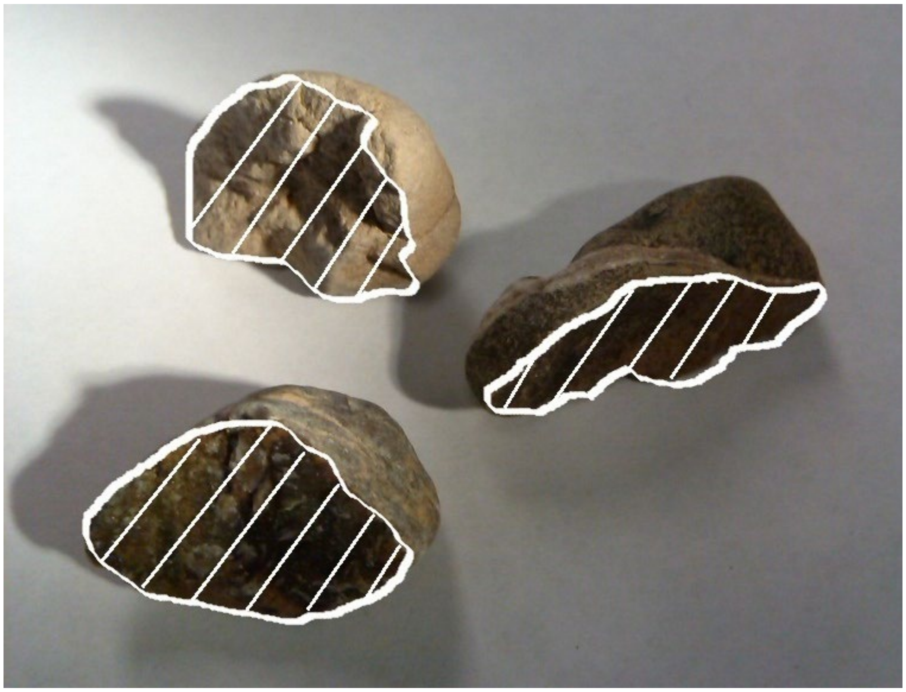

Figure 1
(Particles with one crushed face)

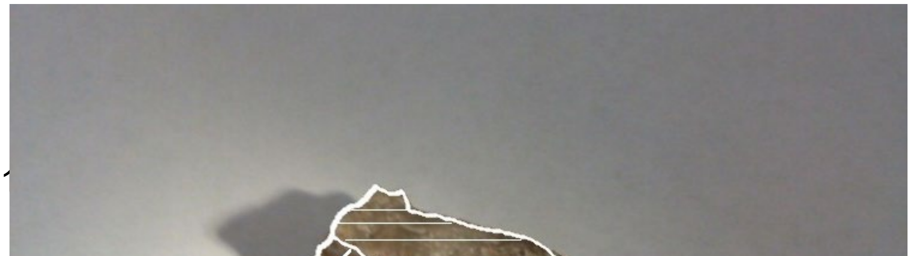

Figure 2
(Particles with two crushed faces)

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4. Report:

4.1 Calculate the percent of crushed particles as follows:

$$\text{Percent crushed particles retained on \#4 sieve \& above} = \frac{\text{Wt. of crushed particles}}{\text{Wt. of sample retained on \#4 sieve \& above}} \times 100$$

4.2 Report the percent of crushed particles retained on the #4 sieve and above to the nearest whole number.

5. References:

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ASTM E11
SD 108
SD 201
SD 202
DOT-3
DOT-69

Method of Test for Flat & Elongated Particles

---

1. Scope:

This test is for determining the percentage by weight of coarse aggregate that have a maximum to minimum dimension greater than the specified ratio of 5:1(5 to 1) or 3:1(3 to 1).

2. Apparatus:

2.1 Proportional caliper device that is equipped with a 5:1 ratio setting and/or 3:1 ratio setting consisting of a base plate with two fixed vertical posts and a swinging arm mounted between them so that the opening between the arms and the posts maintain a constant ratio. The apparatus must be calibrated as stated in the procedure.

2.2 Balance having the capacity to weigh any sample which may be tested utilizing this procedure, accurate and readable to the nearest 0.1 gram.

3. Procedure:

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3.1 Verification of Ratio: Ratio settings on the proportional caliper device shall be verified by the use of a calibrated machined block, micrometer, or other appropriate device.

A. The caliper device must close and bars touch on both sides of the caliper. Set the caliper to a 5:1 or 3:1 ratio as required by the specification. Open the larger end of the caliper to 5 inches or 3 inches and verify that the other opening is 1 inch. If needed, adjust the bars with the set screws under the caliper device to meet calibration.

3.2 Use + #4 material from the SD 202 sieve test. Record the weight of the sieve samples being tested as indicated below. Weigh and record the total amount of material retained on each sieve to the nearest 0.1 gram in column (A) “Total Sample Weight on Sieve” Record “Total Sample Weight” (F). Split out approximately 100 particles of material retained on each sieve group that is in the sample.

Passing the 2" sieve and retained on the 1½" sieve
Passing the 1½" sieve and retained on the 1" sieve
Passing the 1" sieve and retained on the 3/4" sieve
Passing the 3/4" sieve and retained on the 1/2" sieve
Passing the 1/2" sieve and retained on the 3/8" sieve
Passing the 3/8" sieve and retained on the #4 sieve

NOTE: If a 1 ¼” sieve is used in the sieving, the material retained on that sieve shall be combined with the material retained on the 1” sieve. If a 5/8” sieve is used in the sieving, the material retained on that sieve shall be combined with the material retained on the ½” sieve. If a ¼” sieve is used in the sieving, the material retained on that sieve shall be combined with the material retained on the #4 sieve. If there are not 100 pieces retained on any required sieve size for testing, test the entire amount retained on the sieve.

3.3 After counting out the first sample splits of approximately 100 particles per sieve size, obtain a weight to be able to use to split out the sample without counting particles in the future. Weigh the amount of particles split out to test for each sieve size to the nearest 0.1 gram and record in column (B) “Weight of tested portion”.

3.4 Set the longest length of the particle to be tested end to end in the larger end of the caliper device.

3.5 With the caliper device fixed in that position, tighten the pivot screw. Observe if the particle will pass through the smaller end of the caliper device at its minimum width or thickness. If it does, the particle should be counted as flat and elongated (F&E).

3.6 Repeat 3.4 and 3.5 for each particle to be tested.

3.7 Weigh the Flat and Elongated particles for each sieve sample to the nearest 0.1 gram and record in column (C) “Weight of Flat/Elongated Particles”.

3.8 Calculate the “Percent of Flat/Elongated Individual Sieve” and the “Percent Flat/ Elongated Weighted Average” to the nearest 0.1 percent by using the following equations.

Percent of Flat/Elongated Individual Sieve (D) = (C/B)100
Percent Flat/ Elongated Weighted Average (E) = (A/F)D

The Total Percent Flat and Elongated Particles (G) Is the sum of the Percent Flat/Elongated Weighted Average Column (E).

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	(A)	(B)	(C)	(D)	(E)
Sieve Size	**Total Sample Weight on Sieve**	**Weight of Tested Portion (100 pieces)**	**Weight of Flat/ Elongated Particles**	**Percent Flat/ Elongated Individual Sieve**	**Percent Flat/ Elongated Weighted Average**
2" to 1 1/2"	**0.0**				
1 1/2" to 1"	**0.0**				
1" to 3/4"	**1431.6**	**1431.6**	**0.9**	**0.1**	**0.0**
3/4" to 1/2"	**4818.7**	**809.3**	**6.7**	**0.8**	**0.4**
1/2" to 3/8"	**2095.4**	**228.5**	**4.6**	**2.0**	**0.4**
3/8" to #4	**1798.4**	**96.7**	**0.9**	**0.9**	**0.2**
Total Sample Weight	**10144.1**	**(F)**			

Total Percent Flat and Elongated Particles	**1.0**	**(G)**
(Rounded)	**1**	

Figure 1

3.9 Record all test results on the appropriate form; for concrete use the form DOT-3 Coarse or DOT-68 and for asphalt use form DOT-69.

4. Report:

4.1 Report the percent flat and elongated particles in the total sample (Weighted average) to the nearest 0.1 percent or whole number as required by the specification.

5. References

SD 202
DOT-3 Coarse
DOT-68
DOT-69

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Sample ID 2224661

Sieve Analysis and P.I. Worksheet

DOT-3
3-19

File No.

PROJECT PH 0066(00)15
COUNTY Aurora, Ziebach
PCN B015
Charge to (if not above project)
Field No. 09
Date Sampled 04/01/2019
Date Tested 04/01/2019
Sampled By Tester, One
Tested By Tester, One
Checked By Tester, Two
Material Type COARSE AGGREGATE
Paving
Source Hills Materils, Rapid City Quarry
Lot No.
Sublot No.
Weight Ticket Number or Station
Lift
of

[Wet Sample Weight (0.1g) ____ - **Original Dry Sample Weight (0.1g)** 10,312.3] / dry weight x 100 = ____

Sieve Size	**Retained (0.1g)**	**% total ret. (0.1g)**	**% passing (0.1g)**	**% passing (rounded)**	**Spec Req.**
4 in.					
3 in.					
2 1/2 in.					
2 in.					
1 1/2 in.	0.0	0.0	100.0	100	100 - 100
1 1/4 in.					
1 in.	0.0	0.0	100.0	100	95 - 100
3/4 in.	1,431.6	13.9	86.1	86	
5/8 in.	2,964.8	28.8	57.3	57	
1/2 in.	1,853.9	18.0	39.3	39	25 - 60
3/8 in.	2,095.4	20.3	19.0	19	
1/4 in.					
#4	1798.4	17.4	1.6	2	0 - 10
Pan					
Total					

+ #4 Gradation Check
within 0.3% of original dry weight: 0.09

Dush Check

wt. before washing (0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

Sieve Size	**Total Sample Weight on Sieve**	**Weight of Tested Portion**	**Weight of Flat/ Elongated Particles**	**% Flat/ Elongated Individual Sieve**	**% Flat/ Elongated Weighted Average**
2 in.					
1 1/2 in.					
1 in.					
3/4 in.	1431.6	1431.6	0.9	0.1	0.0
1/2 in.	4818.7	809.3	6.7	0.8	0.4
3/8 in.	2095.4	228.5	4.6	2.0	0.4
#4	1798.4	96.7	0.9	0.9	0.2
Total	10144.1				1.0
				(rounded)	1
				Specification	0.0 -10.0

Sieve Size	**Retained (0.1g)**	**% total ret. (0.1g)**	**% passing (0.1g)**	**% passing (rounded)**	**Spec Req.**
#6			1.6	2	
#8	60.7	0.6	1.0	1	0 - 5
#10					
#12					
#16					
#20					
#30					
#40					
#50					
#80					
#100					
#200					
Pan dry	98.4	98.4 / 1.0	wt before washing (0.1g)		3771.0
Pan wash	0.0		wt after washing (0.1g)		3728.2
Total	10303.2		loss from washing(-#200)		42.8

Coarse 1.13 % x % Retain/Design =
Fine % x % Passing/Design =
Total/Combined -#200

- #4 Gradation Check
within 0.3% of original dry weight

Crushed Particles Test

Weight of crushed particles	
Weight of total + #4 sample	
Percent of crushed pieces	
Specification ____ or more FF, min.	-

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)	
Weight of lightweight particles	
Weight of - #4 material	
% lightweight particles	
Specification	-

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		1.96
Weight of lightweight particles	(0.1g)	0.1
Weight of + #4 material	(0.1g)	1857.0
% lightweight particles		0.0
Specification		0.0 - 1.0

Comments

Figure 2

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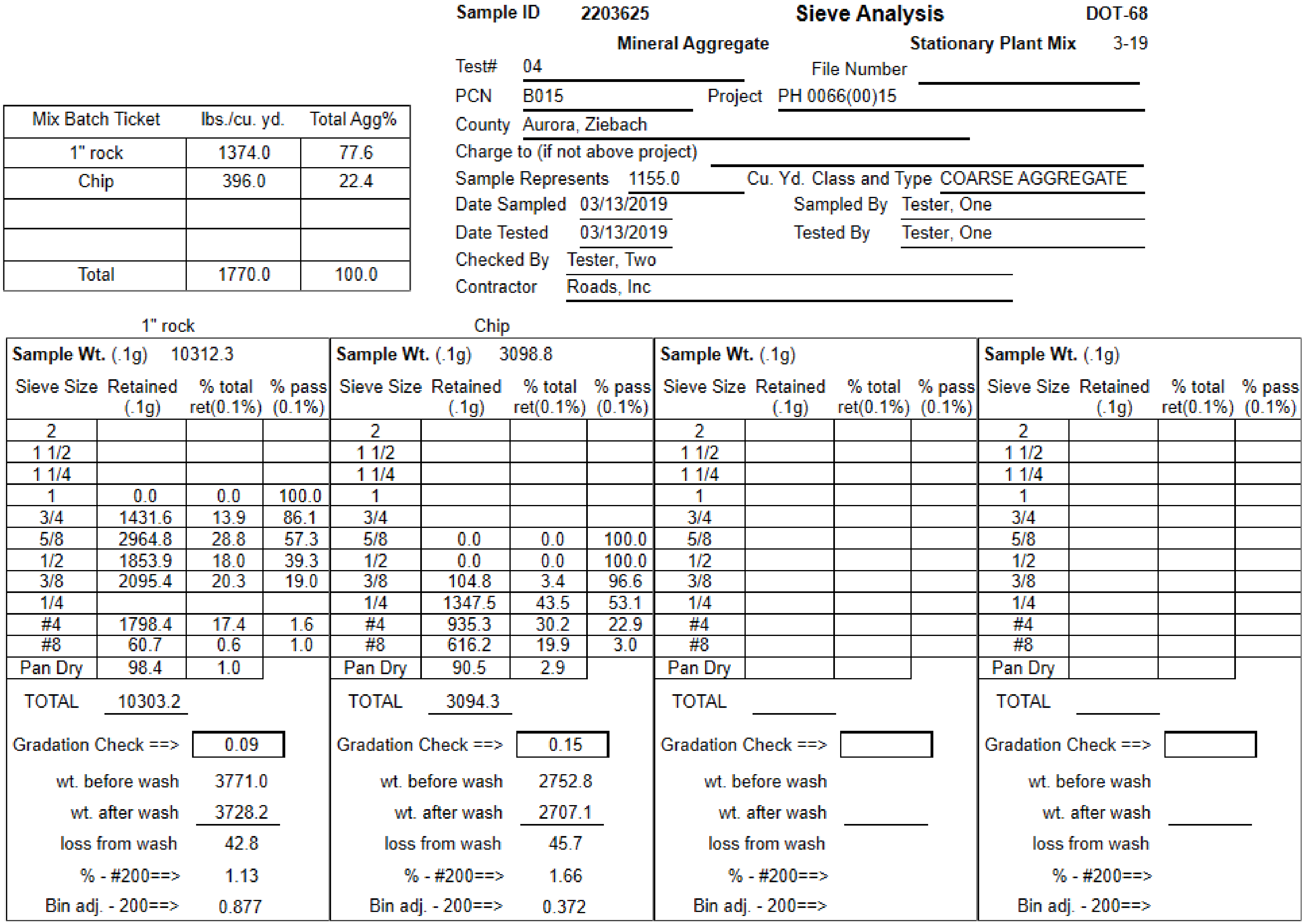

Sample ID 2203625 **Sieve Analysis** DOT-68

Mineral Aggregate **Stationary Plant Mix** 3-19

Test# 04

File Number

PCN B015

Project PH 0066(00)15

County Aurora, Ziebach

Charge to (if not above project)

Sample Represents 1155.0

Cu. Yd. Class and Type COARSE AGGREGATE

Date Sampled 03/13/2019

Sampled By Tester, One

Date Tested 03/13/2019

Tested By Tester, One

Checked By Tester, Two

Contractor Roads, Inc

Mix Batch Ticket	lbs./cu. yd.	Total Agg%
1" rock	1374.0	77.6
Chip	396.0	22.4
Total	1770.0	100.0

1" rock

Sample Wt. (.1g) 10312.3

Sieve Size	Retained (.1g)	% total ret(0.1%)	% pass (0.1%)
2			
1 1/2			
1 1/4			
1	0.0	0.0	100.0
3/4	1431.6	13.9	86.1
5/8	2964.8	28.8	57.3
1/2	1853.9	18.0	39.3
3/8	2095.4	20.3	19.0
1/4			
#4	1798.4	17.4	1.6
#8	60.7	0.6	1.0
Pan Dry	98.4	1.0	

TOTAL 10303.2

Gradation Check ==> 0.09

wt. before wash 3771.0

wt. after wash 3728.2

loss from wash 42.8

% - #200==> 1.13

Bin adj. - 200==> 0.877

Chip

Sample Wt. (.1g) 3098.8

Sieve Size	Retained (.1g)	% total ret(0.1%)	% pass (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8	0.0	0.0	100.0
1/2	0.0	0.0	100.0
3/8	104.8	3.4	96.6
1/4	1347.5	43.5	53.1
#4	935.3	30.2	22.9
#8	616.2	19.9	3.0
Pan Dry	90.5	2.9	

TOTAL 3094.3

Gradation Check ==> 0.15

wt. before wash 2752.8

wt. after wash 2707.1

loss from wash 45.7

% - #200==> 1.66

Bin adj. - 200==> 0.372

Sample Wt. (.1g)

Sieve Size	Retained (.1g)	% total ret(0.1%)	% pass (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8			
1/2			
3/8			
1/4			
#4			
#8			
Pan Dry			

TOTAL

Gradation Check ==>

wt. before wash

wt. after wash

loss from wash

% - #200==>

Bin adj. - 200==>

Sample Wt. (.1g)

Sieve Size	Retained (.1g)	% total ret(0.1%)	% pass (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8			
1/2			
3/8			
1/4			
#4			
#8			
Pan Dry			

TOTAL

Gradation Check ==>

wt. before wash

wt. after wash

loss from wash

% - #200==>

Bin adj. - 200==>

Figure 3

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Composite Coarse Aggregate

Sieve Size	1" rock	Chip			Retained Total	Cumulative Passing	Specification Gradation	Job Mix Formula
2					0.0	100.0	100	
1 1/2					0.0	100.0	100	100 - 100
1 1/4					0.0	100.0	100	
1	0.0				0.0	100.0	100	95 - 100
3/4	10.8				10.8	89.2	89	
5/8	22.3	0.0			22.3	66.9	67	
1/2	14.0	0.0			14.0	52.9	53	25 - 60
3/8	15.8	0.8			16.6	36.3	36	
1/4		9.7			9.7	26.6	27	
#4	13.5	6.8			20.3	6.3	6	0 - 10
#8	0.5	4.5			5.0	1.3	1	0 - 5
Pan	0.8	0.6			1.4	0.0	0	
Total	77.7	22.4			100.1			

Total Combined - #200 ==> **1.25**

Coarse	______	% x % Retain/Design	58.00	= ______
Fine	______	% x % Pass/Design	42.00	= ______
04 Referenced		**Total/Combined - #200**		

+ #4 % Particles less than 1.95 SP. GR.		1" rock	Chip
Specific gravity of solution	(1.95 ± 0.01)	1.96	1.95
wt. of lightweight particles	(0.1g)	25.0	11.0
weight of + #4 material	(0.1g)	1500.0	1430.0
% lightweight particles		1.7	0.8
Bin Adj. % lightweight particles		1.3	0.2
Composite % lightweight particles		**1.5**	
SPECIFICATION		0.0 - 1.0	

Figure 3A

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	Sieve Size mm	Sieve Size inches	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
Rock Size	50.0	2					
1" rock	37.5	1 1/2					
% of Rock	25.0	1	0.0				
77.6	19.0	3/4	1,431.6	1431.6	0.9	0.1	
	12.5	1/2	4,818.7	809.3	6.7	0.8	0.4
	9.5	3/8	2,095.4	228.5	4.6	2.0	0.4
	4.75	#4	1,798.4	96.7	0.9	0.9	0.2

Total sample wt. 10,144.1

Percent flat and enlongated particles in: 1.0

Percent flat and elongated particles in Total Rock: 0.8

	Sieve Size mm	Sieve Size inches	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
Rock Size	50.0	2					
Chip	37.5	1 1/2					
% of Rock	25.0	1					
22.4	19.0	3/4					
	12.5	1/2	0.0	0.0	0.0		
	9.5	3/8	104.8	75.0	0.0		
	4.75	#4	2,282.8	40.8	1.1	2.7	2.6

Total sample wt. 2,387.6

Percent flat and enlongated particles in: 2.6

Percent flat and elongated particles in Total Rock: 0.6

	Sieve Size mm	Sieve Size inches	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
Rock Size	50.0	2					
	37.5	1 1/2					
% of Rock	25.0	1					
	19.0	3/4					
	12.5	1/2					
	9.5	3/8					
	4.75	#4					

Total sample wt. ______

Percent flat and enlongated particles in:

Percent flat and elongated particles in Total Rock:

Combined Percent Flat and Elongated Particles for Total Rock: **1.4**

Rounded: 1

Comments ______________________________

Figure 3B

Sample ID 2203604
File No.

Gyratory Aggregate Worksheet

DOT-69
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Field No. QC03 Date Sampled 03/12/2019 Date Tested 03/12/2019

Sampled By Tester, One Tested By Tester, One Checked By Tester, Two

Material Type AGGREGATE COMPOSITE Source Jones Pit

Lot No. 1 Sublot No. 3

Weight Ticket Number or Station # 49627 Sta. 625+25 Lt Lift 1 of 1

% moist. = (wet wt. 8616.4 - dry wt.) / dry wt. x 100 = 3.9

Original Dry Sample Wt. (.1g) 8,289.9

Sieve Size mm	in	Retained (0.1g)	%total ret.(0.1%)	%pass. (0.1%)	%pass. (rounded)	Spec Req.
100	4					
75	3					
62.5	2 1/2					
50	2					
37.5	1 1/2					
31.5	1 1/4					
25	1	0.0	0.0	100.0	100	
19	3/4	0.0	0.0	100.0	100	100 - 100
16	5/8	7.3	0.1	99.9	100	
12.5	1/2	501.4	6.0	93.9	94	89 - 100
9.5	3/8	890.3	10.7	83.2	83	79 - 93
6.25	1/4	990.4	11.9	71.3	71	
4.75	#4	787.3	9.5	61.8	62	
Pan		5116.7	61.7			
Total		8293.4				

Sand Equiv. Test	Sand Rdg.	Clay Rdg.	S.E.
Reading #1	3.10	6.60	47
Reading #2	3.10	6.50	48

Sand Equivalent Tests Results	48	42 - 100
Fine Aggregate Angularity Test Results	41.8	41.0 - 100.0
Flat and Elongated Particles Test Results	1.1	-

+ #4 Graduation Check:
within 0.3% of orig dry wt. 0.04

Dust Chk	
wt. before washing(0.1g)	709.30
wt. after washing(0.1g)	707.10
loss from washing	2.2
% - #200	0.31

Sieve Size mm	#	Retained (0.1g)	%total ret.(0.1%)	%total x %pass. #4	%pass. (0.1%)	%pass. (rounded)	Spec Req.
3.35	6						
2.36	8	187.7	29.8	18.4	43.4	43	41 - 51
2.00	10						
1.70	12						
1.18	16	137.2	21.8	13.5	29.9	30	
0.850	20						
0.600	30	112.0	17.8	11.0	18.9	19	
0.425	40	54.3	8.6	5.3	13.6	14	
0.300	50	42.7	6.8	4.2	9.4	9	
0.180	80						
0.150	100	35.0	5.6	3.5	5.9	6	
0.075	200	10.5	1.7	1.1	4.8	4.8	2.9 - 6.9
Pan	dry	4.8	49.2	4.8	wt before washing (0.1g)		629.8
Pan	wash	44.40	7.8		wt after washing (0.1g)		585.4
Total		628.60			loss from washing(-#200)		44.4

Coarse	0.31	% x % Retain/Design	38.20	=	0.12
Fine	7.81	% x % Retain/Design	61.80	=	4.83
		Total/Combined - #200			5.0

- #4 Gradation check:
within 0.3% of the wt before washing 0.2

Osch Nat Fines	0.00	Na. Rock	31.00	Natural Fines	25.00
Natural Sand	0.00	Natural Sand	0.00	Osch Nat Fines	16.00
Cr.Fines	28.00				

+ #4 % Particles less than 1.95 SP. GR.

Specific gravity of solution	(1.95 ± 0.01)	1.95
wt. of lightweight particles	(0.1 g)	16.4
weight of + #4 material	(0.1 g)	1516.9
% lightweight particles		1.1
SPECIFICATION		0.0 - 3.0

- #4 % Particles less than 1.95 SP. GR.

Specific gravity of solution	(1.95 ± 0.01)	1.95
wt. of lightweight particles	(0.1 g)	3.1
weight of - #4 material	(0.1 g)	342.9
% lightweight particles		0.9
SPECIFICATION		0.0 - 3.0

Crushed Particles Test

weight of crushed particles	651.7
weight of total + #4 sample	729.3
percent of crushed particles	89
SPECIFICATION 2 or more FF, min	100 - 100

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Figure 4

Weight of measure and glass plate		327.1
Weight of measure, glass plate & water		426.8
M = net mass of water		99.7
Water Temperature / Density	77 F	997.03
V = volume of cylinder, mL		

Dry - #4 bulk specific gravity (Gsb)	2.563		
Volume of cylinder, mL(V)	100.0		
Weight of cylinder, g (A)	183.0		
Wt of cylinder + aggregate, g (B)	332.5	332.2	
Wt. aggregate, g (F=B-A)	149.5	149.2	Average
Uncompacted voids, (nearest 0.1%) U=((V-(F/Gsb))/V) x 100	41.7	41.8	41.8

Sieve Size		Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/ Elongated Particles	Percent Flat/ Elongated Individual Sieve	Percent Flat/ Elongated Weighted Average
mm	in					
50.0	2					
37.5	1 1/2					
25.0	1					
19.0	3/4					
12.5	1/2	508.7	475.3	1.8	0.4	0.1
9.5	3/8	890.3	237.4	0.5	0.2	0.1
4.75	#4	1777.7	63.7	1.0	1.6	0.9

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Total sample wt. 3176.7

Percent flat and enlongated particles 1.1

in the total sample (weighted average) rounded 1

Specifications 0.0 - 10.0

Comments 12" sieves used

Figure 4A

Procedure for Reducing Samples to Testing Size

---

1. Scope:

These procedures are for the reduction of field samples of aggregates to the appropriate size for testing.

2. Apparatus:

2.1 Mechanical Method.

A. Mechanical sample splitter shall be equipped with 3 receptacles large enough to hold the sample following splitting. Only these receptacles shall be used when reducing the sample to the required testing size.

B. Sample splitters shall have an even number of equal width chutes. The number of chutes for coarse aggregate shall not be less than 8, and for fine aggregate, not less than 12. The chutes shall discharge alternately to each side of the splitter. The minimum width of the individual chutes shall be approximately 50% larger than the largest particles in the sample to be split. For fine aggregate a splitter having chutes 1/2” wide will be satisfactory when the entire sample passes the 3/8” sieve.

C. The splitter shall be equipped with a hopper or a straight edge pan, which has a width equal to or slightly less than the overall width of the assembly of chutes.

D. The splitter shall be leveled in a manner to ensure uniform material distribution throughout the chutes.

2.2 Quartering Method.

A. Canvas, heavy polyethylene or other suitable surface, or minimum of 24” x 24” x 4” pan.

B. Straightedge, scoop, shovel, or trowel.

C. Broom or brush.

3. Procedure:

3.1 Fine aggregate that is drier than saturated surface dry shall be reduced in size with a mechanical splitter. Fine aggregate with free moisture on the aggregate may be reduced by quartering before reducing the sample to required size.

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Fine aggregate is defined as an aggregate in which the entire sample will pass the 3/8” sieve.

Saturated surface dry condition may be determined, as a quick approximation, if the fine aggregate will retain its shape when molded in the hand, it may be considered to be wetter than saturated-surface dry.

If the moist sample is large, a preliminary split may be made using a mechanical splitter having wide chute openings 1½” or more to reduce the sample to not less than 5000 grams. This portion is then dried and reduction to test sample size is completed.

Coarse aggregates and mixtures of coarse and fine aggregates may be reduced to test sample size using a mechanical splitter, in which the sample will flow smoothly without restriction or loss of material. The quartering method may be used without regard to moisture in the aggregates.

3.2 Mechanical Splitter (Figure 1).

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Depending on the type of material, number of samples to be tested and the size of the sample needed for the required testing the appropriate method of splitting must be used.

Prior to splitting, blend and mix the sample a minimum of three times by using the mechanical splitter or mixing the buckets on large samples.

Method 1 Used when only one container is needed to hold all the material for testing and backups. (Figure 2)

A. Adjust splitter bars for required chute width.

B. Place sample in closed hopper, in an evenly distributed manner. 23

C. Split the material by opening the gates of the hopper. The sample shall be fed at a controlled rate into the chutes.

D. Check for approximately equal splits by weighing material in each pan.

Coarse aggregate splits should be within 500 grams and fine aggregate within 30 grams. If splits are not within the tolerance, the material will be re-combined and re-split.

E. Sample A may be tested or if needed, material will be reintroduced into the splitter as many times as necessary to reduce the sample to the size specified for the intended test. Sample B may be saved as a backup or used for Independent Assurance testing.

When Independent Assurance testing is performed in conjunction with Acceptance test, both samples should be large enough to allow backup samples.

Method 2 Used when two containers are needed to hold all the material for testing and backup. (Figure 3)

A. Adjust splitter bars for required chute width.

B. Place sample in closed hopper, in an evenly distributed manner.

C. Combine and blend Original Sample (1) and Original Sample (2). 23

D. To assure representative samples, split Blended Sample (1) and Blended Sample (2) to obtain the four samples (a), (b), (c), (d). These samples can be tested or reduced further as needed.

E. Check for approximately equal splits by weighing material in each pan. Coarse aggregate splits should be within 500 grams and fine aggregate within 30 grams. If splits are not within the tolerance, the material will be re-combined and re-split.

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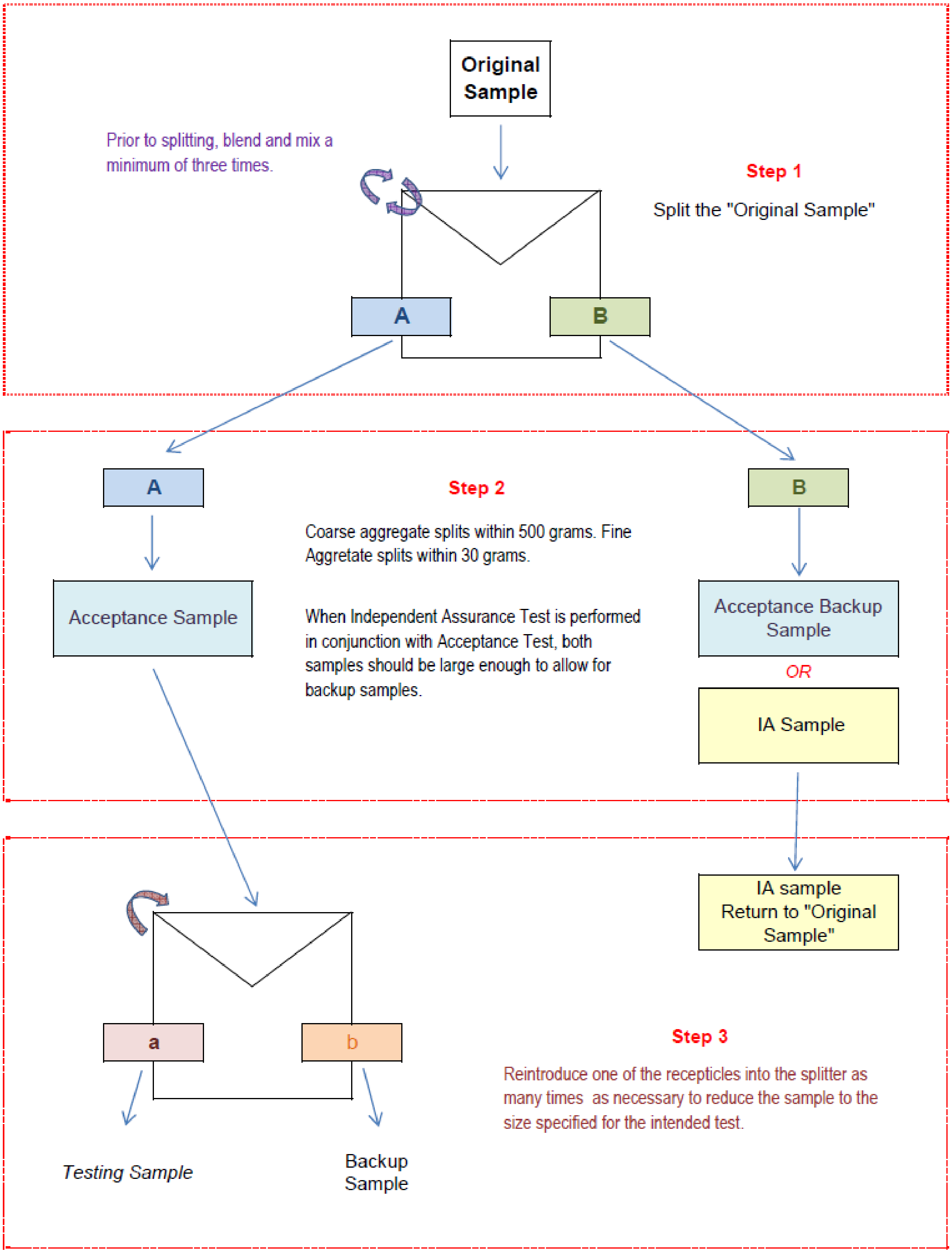
F. If eight samples are required then split samples (a), (b), (c) and (d) to have eight approximately equal samples.

Figure 1

Method 1



Prior to splitting, blend and mix a minimum of three times.

Step 1

Split the "Original Sample"

Step 2

Coarse aggregate splits within 500 grams. Fine Aggretate splits within 30 grams.

When Independent Assurance Test is performed in conjunction with Acceptance Test, both samples should be large enough to allow for backup samples.

Step 3

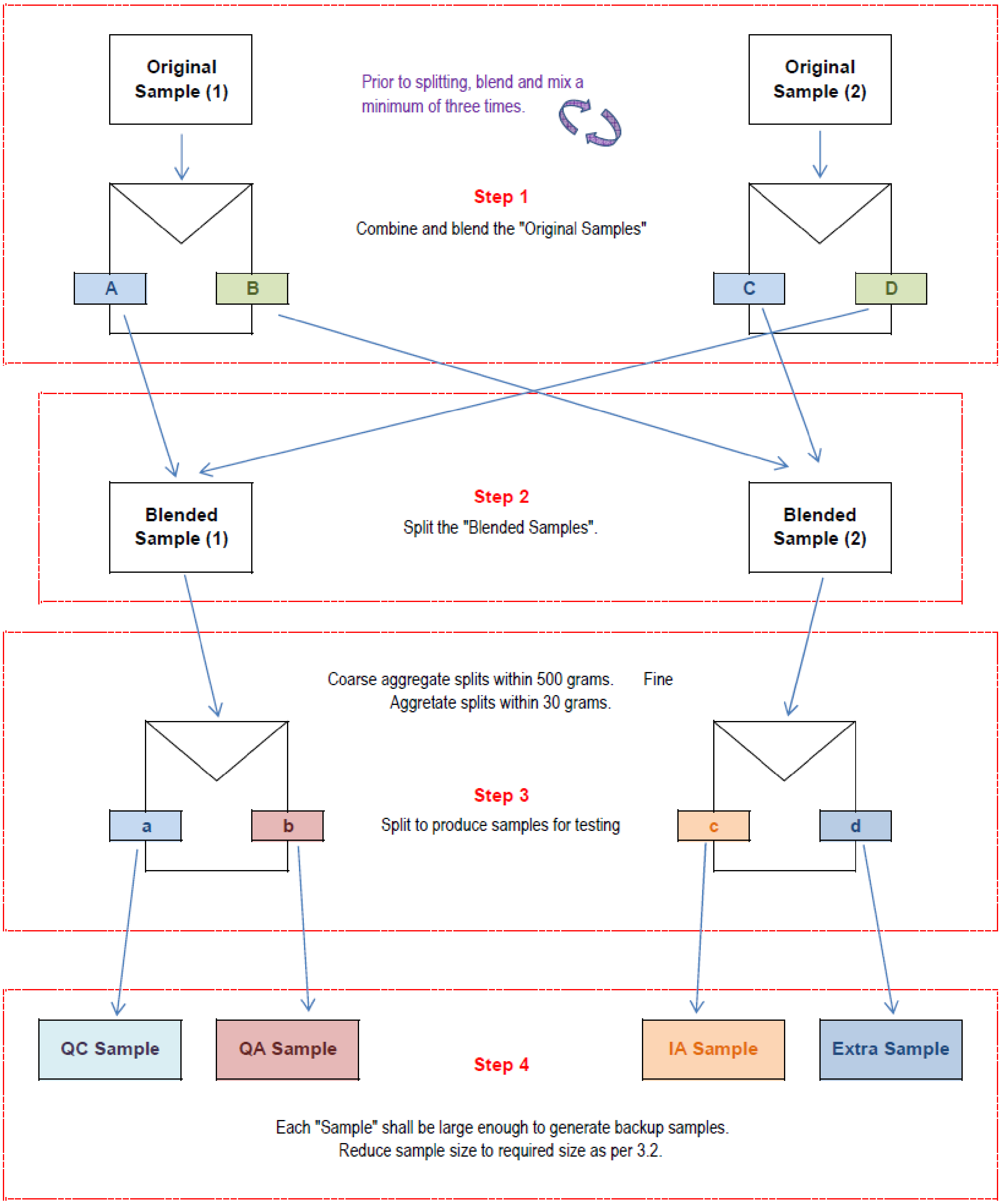
Reintroduce one of the recepticles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test.

Figure 2

Back

METHOD 2
Class Q Asphalt

Back



Prior to splitting, blend and mix a minimum of three times.

Step 1

Combine and blend the "Original Samples"

Step 2

Split the "Blended Samples".

Coarse aggregate splits within 500 grams. Fine Aggretate splits within 30 grams.

Step 3

Split to produce samples for testing

Step 4

Each "Sample" shall be large enough to generate backup samples. Reduce sample size to required size as per 3.2.

Figure 3

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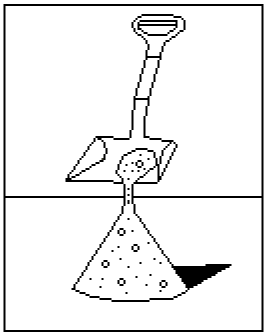
3.3 Quartering.

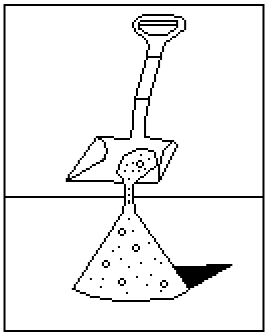
A. Place the sample on a hard, clean, level surface where there will be neither loss of material nor the addition of foreign material. Thoroughly mix the sample by turning the entire sample over at least three times. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with a shovel so that each quarter sector of the resulting pile will contain the material originally in it. The diameter should be approximately 4 to 8 times the thickness. Divide the flattened mass into 4 equal quarters with a shovel or trowel and remove 2 diagonally opposite quarters, including all fine material, and brush the cleared spaces clean. Successively mix and quarter the remaining material until the sample is reduced to the desired size as shown in figure 4.

B. As an alternative when the floor surface is uneven, the field sample may be placed on a canvas blanket and mixed with a shovel as described in paragraph 3.3.A. or by alternately lifting each corner of the canvas and pulling it over the sample toward the diagonally opposite corner causing the material to be rolled. Flatter and divide the sample as described in paragraph 3.3.A. or if the surface beneath the blanket is uneven, insert a stick or pipe beneath the blanket and under the center of the pile, then lift both ends of the stick, dividing the sample into 2 equal parts. Remove the stick, leaving a fold of the blanket between the divided portions. Insert the stick under the center of the pile at right angles to the first division and again lift both ends of the stick, dividing the sample into 4 equal parts. Remove 2 diagonally opposite quarters, being careful to clean the fines from the blanket. Successively mix and quarter the remaining material until the sample is reduced to the desired size as shown in figure 5.

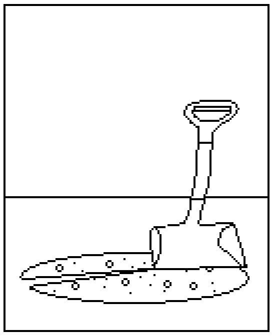
Back



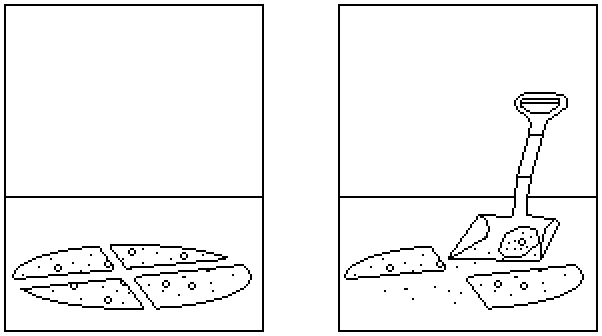
Cone sample on hard, clean level surface



Mix by forming new cone



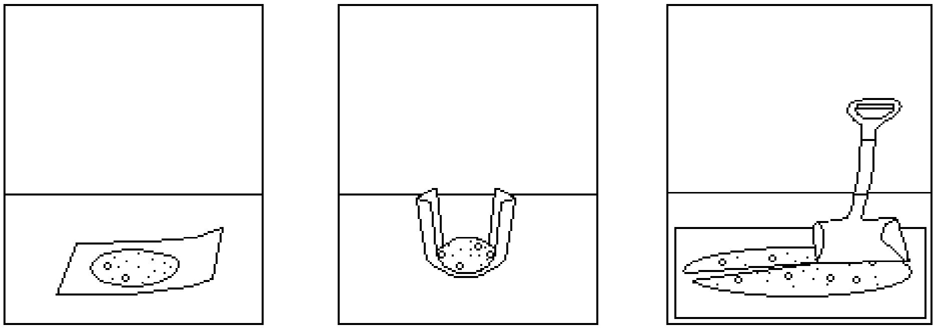
Quarter after flattening cone



Sample into quarters

Retain opposite quarters
& Reject other two quarters

Figure 4

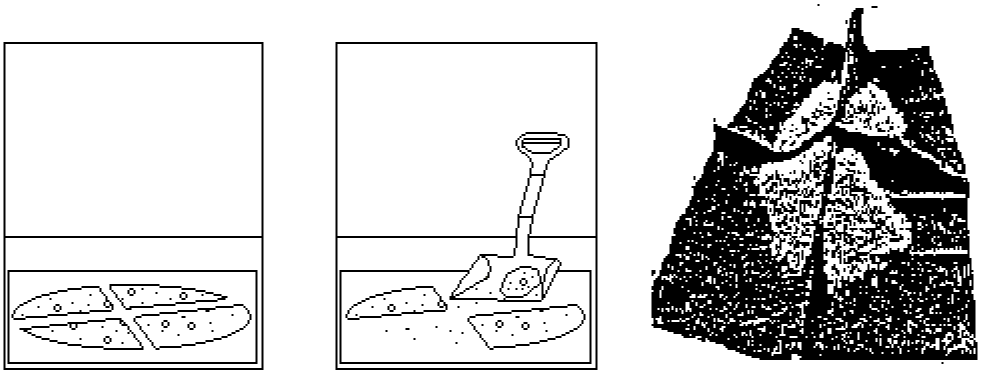


Mix by rolling on blanket

Form cone after mixing

Quarter after flattening cone

Back



Sample into quarters

Retain opposite quarters
Reject other Two Quarters

Figure 5

4. Report:

None required.

5. References:

AASHTO R 76

SD 214

Method of Test for Percentage of Particles of Less Than 1.95 Specific Gravity in Coarse Aggregate

---

1. Scope:

This test is for determining the percentage of lightweight particles in coarse aggregate.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 A suitable container and basket that will permit submerging the specimen to a minimum of 2” below the surface of the solution. The basket shall have openings not larger than a #8 mesh.

2.3 A #4 sieve conforming to ASTM E11.

Back

2.4 A strainer with openings not larger than a #8 mesh.

2.5 A glass graduate of at least 250 mL capacity and a hydrometer for measuring the specific gravity of the liquid, readable to 0.01.

2.6 Zinc chloride solution having a specific gravity of 1.95 ± 0.01.

2.7 Drying oven capable of maintaining a temperature of 230° ± 9°F.

3. Procedure:

3.1 Using a graduate and hydrometer check the specific gravity of the zinc chloride solution and record on the worksheet to the nearest 0.01.

3.2 Obtain a 1500 to 2000 g sample in accordance with SD 201. The sample will consist of material retained above the #4 sieve unless it is a concrete coarse aggregate sample. For concrete coarse aggregates, the sample will consist of the full portion of material including that which passes the #4 sieve.

Dry it to a constant weight as per SD 108 and weigh the material to the nearest 0.1 gram. 24

Material previously washed in a testing procedure may not be used for this test.

3.3 Place the material in the basket and lower into the zinc chloride solution. Stir the aggregate with a large spoon. Skim off the floating particles using a strainer and save them. Repeat this process until no additional particles surface.

The solution in the tank should be approximately 3 times the volume of the aggregate.

3.4 Thoroughly wash the particles that have been skimmed off, dry to a constant weight in an oven at 230° ± 9°F and weigh the material to the nearest 0.1 gram.

4. Report:

4.1 Calculate the percentage of lightweight particles in the following manner.

$$\text{\% lightweight particles} = \frac{\text{Weight of lightweight particles x 100}}{\text{Weight of + \#4 material}}$$

4.2 Report the percentage to the nearest 0.1%.

5. References:

ASTM E11
SD 108
SD 201
DOT-3
DOT-68
DOT-69

Back

SD 215

Method of Test for Pulverization of Clay Additive for Granular Material

---

1. Scope:

This test determines the approximate percentage of pulverization obtained on undried clay used as admixture for granular material.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Container. Pails or pans of sufficient size for transporting and testing the sample.

2.3 Sieve. Standard square opening, conforming to ASTM E11. 18

2.4 Pans, scoops, brushes, etc., for handling materials.

Back

3. Procedure:

3.1 Obtain a representative sample from the belt feeding clay to the plant.

NOTE: Obtain and handle samples with care to prevent breakdown of oversize material. Reduce the sample to size using the quartering method. Do not use a sample splitter.

The sample shall be of sufficient size to yield test specimens having a minimum weight as shown below.

Maximum sieve size	Minimum weight of sample, grams
3/8”	1000
1/2”	2500
3/4”	3000

3.2 Weigh the sample to the nearest 0.1 g and record as total weight of sample on form DOT-26.

3.3 Hand sieve the sample using sieves necessary to determine compliance with the specifications. Consider the thoroughness of sieving satisfactory when not more than 0.5% of the weight of the material on the sieve will pass through it in 1 minute of shaking. The particles must not be turned or manipulated through the sieve by hand.

NOTE: When sieves are shaken individually (Not in a stack), care must be taken to ensure all material passing the sieve is introduced on the next sieve in the series being used.

3.4 Weigh and record the material retained on each sieve to the nearest 0.1 gram.

3.5 Reintroduce the weighed material to the largest sieve for re-screening.

In making this separation, thoroughly wash material through each sieve. Continue washing until all soil and fine particles have been removed and only the rock remains on each sieve.

NOTE: When unpulverized clay cannot be washed through a sieve, but can be broken down or otherwise identified as unpulverized clay, discard the pieces; however, be careful not to discard the rock.

3.6 After blotting with a soft cloth or absorbent paper to remove excess moisture, weigh the material on each sieve and record to the nearest 0.1 gram.

4. Report:

4.1 The percent of unpulverized clay will be recorded on a DOT-26 to the nearest 0.1% calculated as follows:

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$$\text{Percent unpulverized soil retained on a sieve} = \frac{\text{Weight unpulverized soil retained on a sieve}}{\text{Total weight of soil after rock is removed}} \times 100$$

4.2 Report to the nearest whole percent.

5. References:

ASTM E11 18
DOT-26

SD 216

Determination of Percentage of Chocolate Rock In Coarse Aggregate

---

1. Scope:

This test is for determining chocolate rock in + #4 coarse aggregate. Brownish clay lumps, silt-stone, chalk, iron materials, and various concretions are referred to as chocolate rock.

NOTE: The sample of coarse aggregate used for SD 206 and/or SD 218 should be used for this test, to eliminate the need for separate samples.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Drying oven capable of maintaining a temperature of 230° ± 9°F.

2.3 Sieve. A #4 sieve conforming to the requirements of ASTM E11. 18

Back

3. Procedure:

3.1 Obtain a sample of 5000 grams minimum in accordance with SD 201.

3.2 Wash and dry the material retained on the #4 sieve in an oven at 230° ± 9°F. Weigh the material to the nearest 0.1 gram and dry it to a constant weight as per SD 108.

3.3 Weigh the sample to the nearest 0.1 gram.

3.4 Spread the aggregate out on a flat surface so that each rock can be examined to determine if it is chocolate rock.

3.5 Collect all chocolate rock and weigh to the nearest 0.1 gram.

NOTE: When this test is performed in conjunction with SD 218, the chocolate rock is collected from the individual sieve sizes and then combined and weighed to the nearest 0.1 gram.

4. Report:

4.1 The percentage of chocolate rock shall be calculated from the following formula:

$$\text{\% of chocolate rock} = \frac{\text{Weight of chocolate rock}}{\text{Total weight of + \#4 aggregate}} \times 100$$

4.2 Report on a DOT-38.

4.3 Report the percentage to the nearest 0.1%.

5. References:

ASTM E11 | 18
SD 108
SD 201
SD 206
SD 218
DOT-38

Back

Method of Test for Fine Aggregate Angularity

---

1. Scope:

The fine aggregate angularity test determines the loose uncompacted void content of a fine aggregate sample.

2. Apparatus:

2.1 Cylinder dimensions: Capacity of approximately 3.38 oz., inside diameter 1.5 in., inside height 3.4 in., and base will be 0.24 in. thick and securely sealed to the cylinder. The cylinder will be made of drawn copper meeting ASTM B 88 Type M or C specifications. Calibration needs to be completed before starting procedure as to use the correct cylinder volume.

2.2 Funnel having a smooth inside with at least 1.5 in high sides. The funnel opening needs to be 0.5 ± 0.2 in. diameter with the right frustum of a cone sloped at 60 ± 4° from the horizontal. The required volume is 200 mL. If the funnel does not support this capacity, use an additional container on the top of the funnel to reach the specified volume.

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2.3 Funnel stand supported by three or four legs holding the funnel firmly in position. The axis of the funnel collinear needs to be inline with the cylindrical measure axis. The funnel opening will be placed 4.5 ± 0.07 in. above the cylinder top.

2.4 Glass plate with approximate dimensions of 2.4 in. x 2.4 in. and a thickness of 0.15 in. that will be used to calibrate the cylinder.

2.5 Spatula with a blade 0.8 in. wide and 4 in. long with straight edges and the end cut off at a 90° angle to the edges.

2.6 Metal or plastic pan large enough to contain the funnel stand and retain all material during and after completion of the procedure.

2.7 Balance accurate and readable to 0.1 grams capable of weighing the cylindrical measure and its contents.

3. Calibration of Cylinder:

3.1 Calibrate the cylinder to be used for the fine aggregate angularity tests.

A. Weigh the measuring cylinder and glass plate to the nearest 0.1g.

B. Fill the cylinder with distilled water at a temperature of 64.4 to 75.2°F.

C. Record the actual temperature of the water in the cylinder and place the glass plate on top of the filled cylinder while making sure that no air bubbles remain.

D. Completely dry the outside of the glass plate and cylinder filled with water and record the weight to the nearest 0.1 gram.

E. Use the temperature conversion table and volume formula to calculate the volume of the cylinder using the density of water in kg/m³ to the nearest 0.1mL:

Temperature (°F)	**Density of Water (kg/m^3)**
65°	998.54
66°	998.43
67°	998.31
68°	998.20
69°	998.08
70°	997.97
71°	997.84
72°	997.71
73°	997.58
74°	997.45
75°	997.32
76°	997.17
77°	997.03
78°	996.88
79°	996.74
80°	996.59

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$V = 1000\ M/D$

Weight of measure and glass plate
weight of measure,glass plate& water
M = net mass of water
D = density of water at test temp.
V = volume of cylinder, mL

4. Procedure:

4.1 Obtain the sample from the fine (- #4) washed gradation in SD 202. After the - #4 gradation has been completed in SD 202 test procedure, keep individual sieves separate so that the following sieve amounts are obtained:

Passing the #8 and retained on the #16 =	44 grams
Passing the #16 and retained on the #30 =	57 grams
Passing the #30 and retained on the #50 =	72 grams
Passing the #50 and retained on the #100 =	17 grams
Total =	190 grams

The tolerance for the sample is ± 0.2 grams per sieve.

4.2 Mix together thoroughly the 190 ± 0.8 gram sample.

4.3 Pour test sample into funnel while blocking the opening with your finger. Level the material in the funnel with a spatula.

4.4 Release the material into the cylinder, using something small like a pencil to unblock the opening should it become blocked. Once all the material has flowed from funnel and the cylinder is full, strike-off excess material with a single pass using the spatula with the width of the blade vertical, keeping the straight part of the blade horizontal and in light contact with the top of the measure. Make sure not to tap or move the cylinder. When strike-off is completed, lightly tap the cylinder to settle material. Brush off any loose material clinging to the cylinder. Weigh the cylinder with the material to the nearest 0.1 gram.

4.5 Repeat steps 4.3 and 4.4 with same sample for 2nd trial.

5. Report:

5.1 Calculate the uncompacted voids (Us) for each trial as follows:

$$U = \frac{\text{Volume of cylinder – (Mass of aggr. / - \#4 Gsb of aggr.)}}{\text{Volume of cylinder}} \text{ x } 100$$

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To perform these calculations you will need the G_{sb} of the - #4 aggregate which can be obtained from the mix design report (Mix designers use SD 209) and the weight of the cylinder to obtain aggregate mass. Average the two test results to get the uncompacted voids (Us) for the sample.

Sample ID	1st trial	2nd trial	Average
Dry -#4 bulk specific gravity (Gsb)			
(from calibration) Volume of cylinder, mL (V)			
Weight of cylinder, g (A)			
Wt. of cylinder + aggregate, g (B)			
Wt. of aggregate, g (F=B-A)			
Uncompacted voids, (nearest 0.1%) U=((V-(F/Gsb))/V)*100			

5.2 Report the test results for uncompacted voids (Us) on form DOT-69. Report the average test result to the nearest 0.1 percent.

6. References

AASHTO T 304
SD 202
DOT-69

Method of Test for Scratch Hardness of Coarse Aggregate

---

1. Scope:

This test is for determining the quantity of soft particles in coarse aggregate on the basis of scratch hardness.

NOTE: Use the sample of coarse aggregate for SD 206 for this test, to eliminate the need for an additional sample.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Brass rod. 1/16” in diameter, with a rounded point, mounted in a device so a 2 ± 0.1 lbs. is applied to the specimen tested. A suitable design for this apparatus is shown in figure 1. The brass rod shall be of suitable hardness so that when filed to a sharp point, it will scratch a copper penny (U.S. Lincoln design), but fail to scratch a nickel (U.S. Jefferson design). Brass rod may be purchased from Humboldt Mfg. part # H-3421.

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2.3 Drying oven capable of maintaining a temperature of 230°F ± 9°F.

2.4 Sieves conforming to the requirements of ASTM E 11. | 18

2.5 Pans suitable for holding the sample.

3. Procedure:

3.1 Obtain a sample in accordance with SD 201 which meets the minimum weight requirements outlined in 3.4 of this procedure.

3.2 Place the sample in the container and add water to cover it. Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the #200 sieve from the coarser particles, and bring the fine material into suspension. Pour the wash water containing the suspended and dissolved solids over the #200 sieve. Avoid the decantation of coarser particles of the sample. Repeat the operation until the wash water is clear.

3.3 Weigh the material to the nearest 0.1 gram and dry it to a constant weight as per SD 108. Separate into a series of sizes using the 1 1/2”, 1”, 3/4”, 1/2”, 3/8”, and #4 sieves. Weigh the material retained on each sieve to the nearest 0.1 gram.

3.4 The minimum weight of the material to be tested on the individual sieves shall conform to the following table.

Sieves Passing	Sieves retained	Minimum weight, grams
1/2”	3/8”	200
3/4”	1/2”	600
1”	3/4”	500
1 1/2”	1”	4500
2”	1 1/2”	12000

NOTE: Should the sample contain less than 10% (Determined by SD 202) of any size prescribed above, that size shall not be tested; but for the purpose of calculating test results, it shall be considered to contain the same percentage of soft particles as the average of the next larger and next smaller size; or if one of these sizes is absent, it shall be considered to have the same loss as the next larger or next smaller size, whichever is present.

NOTE: On size 1 coarse aggregate, since the specification on the 1” sieve precludes having 10% retained, the percentage shown on the DOT-38, column C, will be the same as that shown for the 3/4”.

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3.5 Subject each particle of aggregate (Except that removed for SD 216) to a scratching motion of the brass rod, using the device for applying weight. Particles are considered to be soft, if, during the scratching process, a groove is made in them without deposition of metal from the brass rod, or if separate particles are detached from the rock mass.

In case of question, make a scratch test on a freshly broken surface of the aggregate particle. (Use a hammer to lightly tap the particle to cause it to split.)

If the particle contains more than one type of rock and is partly hard and partly soft, it shall be classed as “Soft” only if the soft portion is one third or more of the volume of the particle.

3.6 Weigh the soft particles to the nearest 0.1 gram for each size tested.

NOTE: The chocolate rock that is removed from each size tested is combined with the chocolate rock on the - 3/8”, + #4 sieves, (SD 216).

4. Report:

Report the total weighted percent of soft particles to the nearest 0.1 %, (See DOT-38, figure 2).

5. References:

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ASTM E 11
SD 201
SD 202
SD 206
SD 216
DOT-38

Back

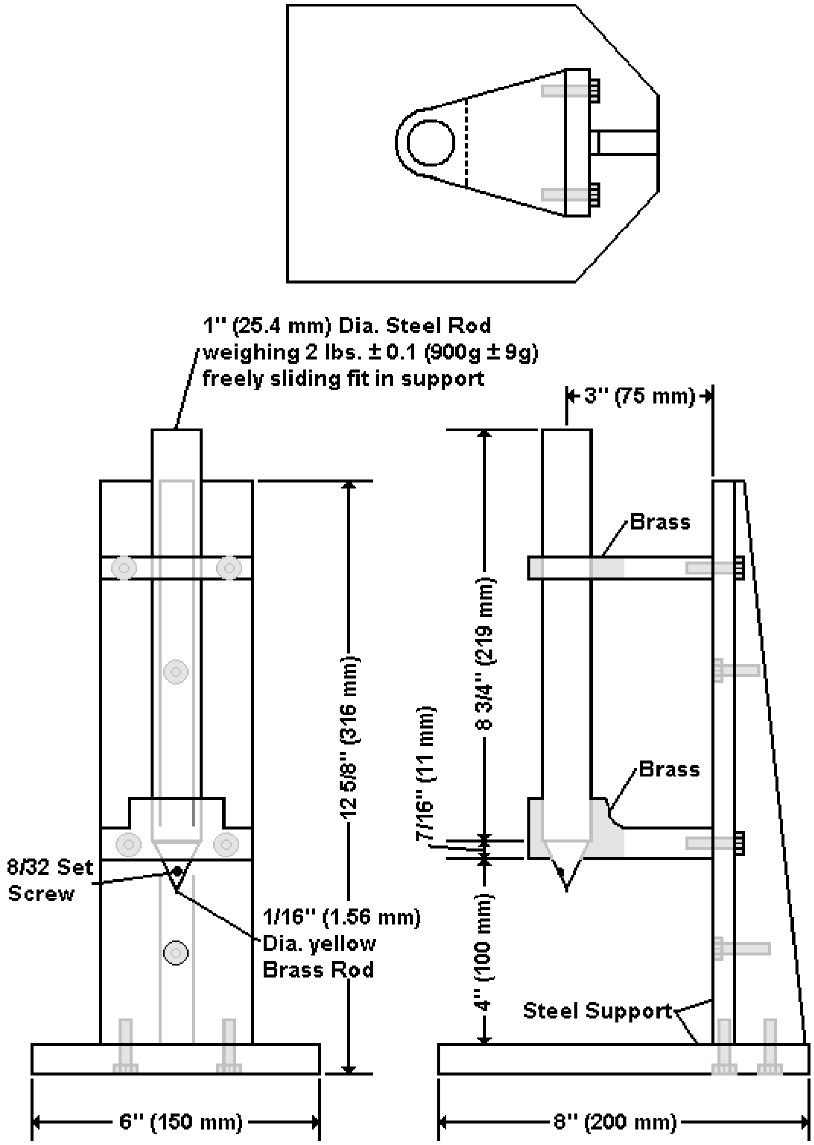

Figure 1

DOT-38
9-14

SCRATCH HARDNESS OF COARSE AGGREGATE PARTICLES

FILE # 30.2

PROJECT IM 90-2(27) 309 COUNTY Aurora PCN 1234

SAMPLE NO. 25 SAMPLE WEIGHT 7180 DATE 4-9-14

TESTED BY Mary C. Clauson CHECKED BY Carl Waddington

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				A.	B.	C.	D.	E.
SIEVE SIZES				Total Retained (Grams)	Soft Rock (Grams)	Percent Soft Rock	% Retained From Total Sample	Weighted % of Each Sieve
Passing mm		Retained mm						
50	2"	37.5	1 1/2"					
37.5	1 1/2"	25.0	1"	254		3.91	3.6	0.14
25.0	1"	19.0	3/4"	1510	59	3.91	10.9	0.43
19.0	3/4"	12.5	1/2"	3116	44	1.41	28.4	0.40
12.5	1/2"	9.5	3/8"	1208	13	1.08	19.9	0.21
9.5	3/8"	4.75	# 4	633				
PAN				459				
TOTAL				7180				1.18

FORMULA: B / A x 100 = C
(C x D) / 100 = E

Light Weight Particles - SD 214 = 0.3 %
Chocolate Rock - SD 216 = 0.1 %
Soft Rock (Total from above Test) = 1.2 %
TOTAL Deleterious = 1.6 %

NOTE: Column D taken from the DOT-3

Attach this sheet to DOT-3
Comments: 25.0 mm - 1" sieve not tested because less than 10% was retained. M.C.C.

Figure 2

Method of Test for Determining Target Dry Density & In-place Density of Salvaged/Recycled Materials Using the Nuclear Gauge (Test Strip)

---

1. Scope:

This test is for determining the target dry density of a test strip and determining in-place density of salvaged material or recycled granular material, i.e., subbase, base course, asphalt concrete or any combination of these materials using the nuclear gauge.

2. Apparatus:

2.1 Nuclear moisture-density gauge capable of determining densities by the direct transmission method and conforming to the requirements of AASHTO T 310.

2.2 A reference standard block for taking standard counts.

2.3 A drill rod, extraction tool, and combination guide-scraper plate for preparing the test site and punching the hole for the source rod.

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2.4 A manufacturer's instruction manual for the nuclear gauge.

2.5 A nuclear gauge information book, transportation documents book, and nuclear badge.

2.5 A hammer to drive the drill rod, and a shovel and other tools for site preparation.

2.7. Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.8 Drying equipment: An oven capable of maintaining a temperature of 230° ± 9°F.

3. Procedure:

3.1 Calibration and standardization of nuclear gauge.

A. Calibration and performing the standard count of the nuclear gauge will be in accordance with SD 114, paragraph 3.1 and 3.2.

3.2 Target density determination (Test strip).

A. Select a test strip a minimum of 500' in length.

B. Select 4 test sites within the test strip for nuclear gauge readings. Select a test site where the nuclear gauge will be at least 2' away from any vertical projection, at least 10' away from any vehicle and at least

30’ away from another nuclear gauge. The first and the last 100’ segment of the test strip will not be used. The test sites must be a minimum of 25’ apart and must be aligned so each is covered by the same pass of the roller.

A roller pass is one application of roller loading by one roller unit. Tandem rollers are considered to be one roller unit.

C. Accurately mark each test site with paint or crayon, in order that the nuclear gauge can be repositioned and oriented the same for each reading.

D. The maximum depressions beneath the gauge will not exceed 1/8”. Use native fines or fine sand to fill voids and level the excess with the scraper plate. The total areas thus filled with fines or sand should not exceed 10% of the bottom area of the gauge.

E. Following the initial “Breakdown” rolling, nuclear gauge readings (1 minute wet density reading) will be taken at each of the 4 test sites.

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F. Place the guide-scraper plate on the prepared test site and drive the drill rod with the extraction tool attached through the guide to a depth at least 2” below the depth of material to be tested. Remove the drill rod by pulling straight up and twisting the extraction tool, to avoid disturbing the hole. It is desirable to do the testing as close to the bottom of the lift as possible, but not closer than 1” from the bottom.

Example:

If the lift depth is 4”, subtracting the 1” from the bottom restriction leaves a 3” depth, but since the source rod cannot be locked at 3”, the testing will have to be accomplished at 2”. Each additional lift will be tested as the first lift described above.

G. Place the nuclear gauge over the test site and extend the source rod into the hole to the desired depth. Release the trigger at the desired depth and listen for the “Click” indicating that the source rod is properly locked into position on the index rod. Verify the depth shown on the display of the gauge agrees with the actual depth of the source rod. Slide the gauge so the surface of the source rod nearest the keypad is in contact with the edge of the hole. Take a 1 minute reading to determine the wet density in lbs./ft^3.

H. Record the total number of passes and the wet density in lbs./ft^3 from the gauge for each location on the DOT-28.

I. Continue to take readings at each of the 4 test sites following each series of roller passes. The number of roller passes used per series will have to be determined on the project but 4 per series is a good rule of thumb.

J. Continue the series of roller passes until 4 successive passes fail to increase the average wet density by 1.0 lb./ft^3.

K. Sample the material for moisture from below the 4 nuclear gauge test sites. Take the samples from the top of the lift to the depth of the source rod directly below the nuclear gauge and immediately place in an airtight container for moisture testing.

NOTE: The minimum sample size for this moisture test will be 2000 grams.

L. SD 108, oven drying method is to be used to determine the moisture content of the material. Determine the weight of a clean, dry container, and record it on the DOT-28 as “Weight of can”.

M. Determine the target dry density of the test strip by averaging the 4 test site dry density results on the DOT-28.

N. This result is the average test strip dry density and should be recorded on line (U) to the nearest 0.1 lb./ft^3 as the 1-point maximum density on the DOT-41. This value is used to compute the percent of density.

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O. A test strip will be completed for each lift of material.

3.3. In-place density determination.

A. Select a location for a test where the nuclear gauge will be at least 2’ away from any vertical projection, at least 10’ away from any vehicle and at least 30’ away from another nuclear gauge.

B. Follow the procedures of Section 3.2, steps F through G to obtain the wet density with the nuclear gauge. It is allowable to take more than one reading at each test site and average the results.

C. Record the wet density in 0.1 lb/ft^3 from the gauge on the DOT- 41.

D. Sample the material for moisture from below the nuclear gauge. Take the samples from the top of the lift to the depth of the source rod directly below the nuclear gauge and immediately place in an airtight container for moisture testing.

NOTE: The minimum sample size for this moisture test will be 2000 grams.

E. SD 108, oven drying method is to be used to determine the moisture content of the material. Determine the weight of a clean, dry container, and record it on the DOT-28 as “Weight of can”.

4. Report:

4.1 Target density (Test strip).

A. The nuclear gauge readings, averages and the number of roller passes will be recorded on a DOT-28 as shown in the example.

B. Calculate the percent moisture at each site as shown on DOT-28.

C. Calculate the dry density at each site.

Dry density = (A x 100) / (100 +G)

A = Wet density from nuclear gauge

G = Moisture content (% moisture)

D. Report the average test strip dry density to the nearest 0.1 lb./ft^3 on a DOT-28.

4.2. In-place density:

Back

A. The nuclear gauge wet density and field moisture will be recorded on a DOT-41 as shown in the example. Record the average test strip dry density on line U of the DOT-41.

B. Calculate the dry density and percent density as shown on the DOT-41.

C. Report the percent density obtained to the nearest whole percent on the DOT-41.

5. References:

SD 108
DOT-28
DOT-41

Sample ID **2205425**

Test Strip Worksheet

DOT-28
3-19

File No.

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Test No. 02 Test Date 04/29/2019 12:00:00 Lift 2 of 3 Thickness 4"

Tested By Tester, One Checked By Tester, Two

Nuclear Gauge No. MQ 778 Test Mode 2" DIRECT TRANSMISSION

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NUCLEAR GAUGE WET DENSITY

	STATION 32+50	STATION 33+50	STATION 34+50	STATION 35+50	AVERAGE
1st Reading Total Passes 4	125.7	131.5	130.9	126.6	128.7
2nd Reading Total Passes 8	128.5	133.8	133.1	130.2	131.4
3rd Reading Total Passes 12	131.4	134.2	133.6	132.0	132.8
4th Reading Total Passes 16	132.4	134.7	134.5	131.9	133.4
5th Reading Total Passes ___					
6th Reading Total Passes ___					
7th Reading Total Passes ___					

MOISTURE AND DRY DENSITY DETERMINATION

A. Final Wet Density	132.4	134.7	134.5	131.9
B. Weight of Can and Wet Material	2643.3	2476.9	2701.7	2519.8
C. Weight of Can and Dry Material	2524.4	2368.4	2584.1	2407.0
D. Weight of Moisture (B - C)	118.9	108.5	117.6	112.8
E. Weight of Can	452.4	344.3	574.8	311.9
F. Weight of Dry Material (C - E)	2072.0	2024.1	2009.3	2095.1
G. % Moisture (D x 100) / F	5.7	5.4	5.9	5.4
H. Dry Density (Ax100) / (100 +G)	125.3	127.8	127.0	125.1

Average Dry Density 126.3

Comments

Figure 1

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Sample ID 2205560
File No.

Density Report

DOT - 41
6-21

County Aurora, Ziebach
PCN/PROJECT B015 PH 0066(00)15
Station 47+15
Dist From CL 13' L
Width (Gravel) 52.00
Depth 4" (from top of Subgrade or Pipe)
Field # 07
Tested By Tester, One
Checked By Tester, Two
Date 06/21/2021

WORK AREA REPRESENTED (Circle what applies)

EMBANKMENT STA. TO STA. (per half mile, for each roadbed)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 5 ft.

BRIDGE END EMBANKMENT STA. TO STA.
1 per zone within plan limits 3 equal zones when backwall is less than 7ft. 4 equal zones when backwall is greater than 7ft.
Zone 1 Zone 2 Zone 3 Zone 4 Zone 5

BERM STA. TO STA. (100 ft. from Bridge End)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 3 ft.

PIPE
CROSS 24" or smaller undercut (1/2 way up) (0-2 ft. Above)
STORM 30" to 72" undercut (Lower 1/2) (Upper 1/2) (0-2 ft. Above)
INTERSECTION 72" or more undercut (Bottom 1/3) (Middle 1/3) (Top 1/3) (0-2 ft. Above)
After Minimum for size pipe installation ☐ 1 per 3 ft of backfill beginning at 2' above top of pipe

SUBBASE STA. TO STA. LIFT
[✓ BASE COURSE] STA. TO STA. 36+00 to 67+50 LIFT 2 of 3

Curve Type	Curve Used	Standard Density Maximum Density	Standard Density Optimum Moisture	Granular Material 4-Point Range
Ohio		U.	%	-

SPECIFICATION 95%
% Obtained 100X(G/U) 97%

Balloon Method

B. Wt. Undried Matl. from Hole
C. Volumeter Reading in Hole
D. Initial Volumeter Reading
E. Volume of Test Hole (C-D)
F. Wet Density (B/E)
G. Dry Density F/(100+M{Field}) x 100

Sand Method

A. Std. Sand PCF
B. Wt. Undried Matl. from Hole
C. Initial Wt. Sand
D. Final Wt. Sand Plus Cone Sand
E. Volume of Test Hole (C-D)/A
F. Wet Density (B/E)
G. Dry Density F/(100+M{Field}) x 100

Nuclear Method

Meter No. MQ 778
Test Mode 2" DIRECT TRANSMISSION
F. Wet Density from Gauge 128.70
+/-Corr. * 0.00 = 128.7
G. Dry Density F/(100+M{Field}) x 100 122.0

1-Point Density Determination

O. Weight of Mold & Specimen
P. Weight of Mold
Q. Wet Wt. of Molded Specimen (O-P)
R. Factor of Mold No. Used in Test
S. Wet Density (QxR)
T. Dry Density S/(100+M [1-PT])x100

Moisture Determination

	1-Point	Field
H. Wt. of Wet Matl. and Container		3,120.4
I. Wt. of Dry Matl. and Container		3,009.9
J. Wt. of Moisture (H-I)		110.5
K. Wt. of Container		990.20
L. Wt. of Dry Matl. (I-K)		2,019.7
M. Percent Moisture (Jx100)/L		5.5

Rock Determination

A. Total Sample Weight
B. Weight of Material Retained on 3/4" Sieve
C. Percent Retained On 3/4" Sieve (Bx100)/A

* Correction from DOT-39. If there is no correction or, if the correction has been applied to the meter show "NA".
Comments: 1-Point Not Made this Test, Refer to Test Strip Maximum Density : 126.30

Figure 2

Procedure for Sodium Sulfate Soundness of Aggregates

---

1. Scope:

This test is for determining sodium sulfate soundness on coarse and fine aggregates.

Follow AASHTO T 104 in its entirety.

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Method of Test for Sand Equivalent of Fine Aggregate

---

1. Scope:

This test is for determining the relative proportion of detrimental fine dust or clay-like particles in fine aggregates (Passing the #4 sieve).

2. Apparatus:

2.1 Balance having a sufficient capacity to weigh any sample which may be tested utilizing this procedure, accurate and readable to the nearest 0.1 gram.

2.2 Transparent plastic graduated cylinder having; a 1.25 in. inside diameter, approximately 17 in. in height and graduated up to 15 in. in intervals of 0.1 in. starting at the base. The base dimensions must be ½ x 4 x 4 in. Do not expose the plastic cylinders to direct sunlight any more than is necessary.

2.3 A rubber stopper that fits into the open end of the graduated cylinder.

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2.4 Stock solution and set up must meet the requirements of AASHTO T-176. 3 oz. (85 ± 5 ml) of stock solution added to 1 gallon of distilled water. The solution needs to be maintained as close to 72 ± 5°F as possible to obtain representative results. Working solution more than 30 days old will be discarded. If organic growth is present in the working solution, discard the solution, and then clean the container, tubing, irrigation tube and system with a 50:50 mixture of Clorox and water. Rinse the complete system with distilled water. Mix and use new solution.

2.5 An irrigator tube made of brass, stainless steel or copper with a 0.25 in. outside diameter, approximately 20 in. long, with one end closed to form a wedge-shaped tip with 2 small #60 holes through the flat side of the wedge. A rubber hose that is approximately 48 in. long with an inside diameter of approximately 3/16 in. 24

2.6 A weighted foot assembly consisting of a metal rod connected to a foot with a flat, smooth surface at the lower end with the upper end weighted to give the total assembly a weight of 1000 ± 5 grams.

2.7 A 1 gallon glass or plastic bottle equipped with a siphon assembly consisting of a 2 hole rubber stopper and pieces of copper tubing. The bottle sits 3 feet ± 1 inch above the work surface. A larger glass or plastic vat may be used provided that the liquid level of the working solution is maintained between 36 in. to 46 in. above the working surface.

2.8 A measuring can with a capacity of 3 ounces (85 ± 5 ml) approximately 2.25 inches in diameter at the mouth.

2.9 A timer reading in minutes and seconds.

2.10 A manually operated shaker capable of producing an oscillating motion at a rate of 100 complete cycles in 45 ± 5 seconds with a hand-assisted half stroke length of 5.0 ± 0.2 in. or a mechanical shaker having a throw of 8.00 ± 0.04 in. and operating at 175 ± 2 cycles per minute. The shaker set up should be level and secure for either type system.

2.11 A splitting cloth made of plastic or canvas material approximately 2 ft. by 2 ft.

2.12 Drying oven capable of maintaining a temperature of approximately 230° ± 9°F.

2.13 Funnel with a wide mouth about 4 in. in diameter.

2.14 Spatula or straightedge that is used to strike off the measuring can after obtaining the sample.

3. Procedure:

3.1 Obtain a split sample of - #4 material from SD 202 of approximately 750 to 1000 grams. Mix the sample in a pan using a spatula and add enough water so the material, when squeezed in the hand, forms a cast without free water present. The cast of material should break up slightly when rolled gently in the palm of the hand. If the material crumbles, add more water and mix the sample and recheck to see if a cast can be made which does not crumble. If the material forms a cast which does not break up, the material has free water and it must be allowed to dry before the sample is ready to be taken. After the required moisture content is obtained the sample will sit a minimum of 15 minutes covered with a lid or damp cloth.

Back

3.2 Place the sample on the splitting cloth and alternately lift each corner and pull toward the center to thoroughly mix the material. After thoroughly mixing the material, make a pile in the center of the cloth.

3.3 To take a sample, hold the 3 oz. sample can on its side on one side of the sample pile with the other hand palm facing the pile on the other side. Fill the container by pushing it through the pile while pushing the material into the container with the other hand. Press firmly so that the maximum amount of material will be placed in the tin. Strike off the top of the tin with a level spatula or straightedge.

3.4 Place the tin in an oven at 230° ± 9°F and dry to a constant weight. Material may also be removed from the tin and placed in a pan to dry. Remove the sample from the oven and cool to room temperature.

3.5 Repeat steps 3.2 to 3.4 to get a 2^{nd} sample to test.

3.6 Siphon 4 ± 0.1 in. of working calcium chloride solution into a plastic cylinder. Pour the sample into the cylinder using a funnel to assure material is not spilled. Tap the bottom of the cylinder with the heel of your hand several times to release air bubbles and make sure the sample is wetted thoroughly.

3.7 Put the cylinder on the counter and allow to stand undisturbed for 10 ± 1 minute.

3.8 Put the stopper in the cylinder and loosen the material in the cylinder by tipping (Partially inverting) the cylinder and shaking it at the same time.

3.9 A. Manual Shaker Method.

Make sure the stopper is securely in the cylinder. Place the cylinder in the manual shaker. Set the counter to zero. Apply enough force to the steel strap to make the cylinder move to the range markers on the shaking apparatus. The tip of the pointer should reverse direction within the marker limits. Continue the shaking action until 100 strokes (within 45 ± 5 seconds) are reached.

B. Mechanical Shaker Method.

Secure the cylinder in the mechanical shaker and operate for a complete cycle (usually 45 seconds.)

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3.10 Take the cylinder out of the apparatus and set upright on the working table. Remove the stopper, take irrigator tube and rinse material from the side of the cylinder while moving the tube down into the material to the bottom of the cylinder. Irrigate the material at the bottom, by stabbing and twisting to make sure that all the fine material is being agitated from the bottom and moves towards the top of the solution. When the solution in the cylinder is close to the 15 in. mark, slowly pull the irrigator out of the material and towards the top of the cylinder. Regulate the flow of solution so the 15 in. mark is reached when the irrigator is completely removed from the cylinder.

3.11 Set the cylinder on a flat surface that does not have any other vibrating equipment on it and let the material solution settle for 20 min. ± 15 sec. Time clock should be set right after the irrigator is completely withdrawn.

Field laboratories will be adequately anchored to the ground, leveled, and rigidly supported to eliminate floor and workbench vibrations. Vibrations may cause the suspended material to settle at a rate greater than normal.

3.12 When 20 min. is up, take the “Clay reading” which is at the top of the clay suspension. If there is no definite line, let the solution set till a clay line appears. If there is no definite line after 30 minutes, the test must be rerun with three separate samples of the same material. Read and record the sample with the shortest sedimentation period only.

If clay or sand readings fall between 0.1 in. graduations, record the level of the higher graduation as the reading. A clay reading of 6.95 would be recorded as 7.0 and a sand reading of 2.63 would be recorded as 2.7.

3.13 After the clay reading is taken, the “Sand reading” will be taken by using a weighted foot as described. Slowly set the foot into the cylinder allowing it to rest on the sand, taking caution as to not jar the cylinder during this process. Take a reading at the top edge of the weighted foot indicator, and then subtract 10 in. Record the reading of the sand level.

4. Report:

4.1 Calculate the sand equivalent reading as follows:

$$Sand\ Equivalent\ (SE) \quad = \quad \frac{Sand\ Reading\ \times 100}{Clay\ Reading}$$

If the calculated sand equivalent is not a whole number, report the result to the next higher whole number.

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$$\left(\frac{4.2}{7.9}\right) \times 100 = 53.16 = 54$$

4.2 Average the test results of the two samples as follows: if the average of the two test results in not a whole number, raise the test result to the next higher whole number.

$$\frac{(53+54)}{2} = 53.5 = 54$$

4.3 Test results will be reported on form DOT-69.

5. References:

AASHTO T 176
SD 202
DOT-69

Table of Contents

Asphalt Section

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Method of Field Sampling Asphalt Materials

---

1. Scope:

This test covers the procedure for sampling Performance Graded (PG) asphalt binder, emulsified asphalt, cutback asphalt, etc.

2. Apparatus:

2.1 Containers.

1 Quart Metal Cans (with screw tops) used for:

- PG 58-28, PG 58-34, PG 64-28, PG 64-34, PG 70-28, PG 70-34, and all other PG binders.
- MC-70, MC-800, MC-3000, RC-800, and all other grades of cutback asphalt.

1/2 Gallon Plastic Bottles used for:

- SS-1H, CSS-1H, AE-150S, CRS-2P, CQS-1P, CQS-1HP, and all other liquid emulsions.

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2.2 The contractor furnished bulkhead sampling valve (submerged) will conform to the requirements shown in Figure 1. The size of the pipe may vary from the ¾” shown.

2.3 The contractor furnished in-line asphalt sampling device will conform approximately to the requirements shown in Figure 2.

The device shown is a detachable design to be installed in the unloading line between the truck transport or railroad car and the contractor’s equipment. This device will also be installed between the contractor’s storage tank and the asphalt concrete mix plant. In-line sampling valves may vary in configuration, pipe diameter and length.

In-line sampling valves may be permanently mounted in the discharge line of the supply vehicle or contractor’s unloading equipment, provided the following conditions are met.

A. The size, location and configuration are such that samples can be readily obtained.

B. Adequate provisions are made to keep the sample valve clean and operable.

2.4 Heat resistant gloves, protective clothing, tongs, or other devices for handling the containers and valves. 24

3. Procedure:

3.1 Bulkhead Sampling Valve.

A. Inspect the containers to ensure that they are clean and dry.

B. Immediately after the beginning of the transfer of material, drain off a minimum of 1 gallon of the asphalt and then completely fill the first container.

C. When approximately ½ of the load has been transferred, drain off approximately 1 gallon of the asphalt and then completely fill the second container.

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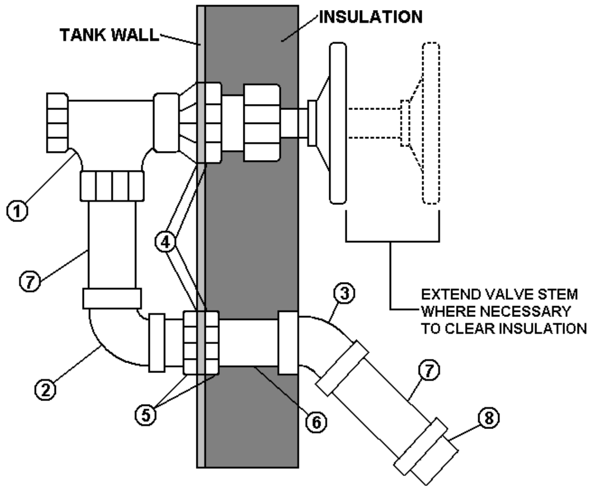

<u>Mount in Lower Half of the Bulkhead at Least 1’ from the Shell</u>

Ref. #	Description	Number Req.
1	¾" "Vogt" P-9844 steel angle valve or similar, panel mounted	1
2	¾" steel or mall iron 90° elbow	1
3	¾" steel or mall iron 45° elbow	1
4	Asbestos gaskets snug on the thread or wound with yarn	4
5	¾" 150# screwed M. I. lock nut	2
6	¾" x 3 ½" = Parallel threaded steel pipe nipple (Cut from ¾" std. tank nipple, if otherwise unobtainable)	1
7	¾" x 3" threaded steel pipe nipple	2
8	¾" mall iron pipe cap	-

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Figure 1

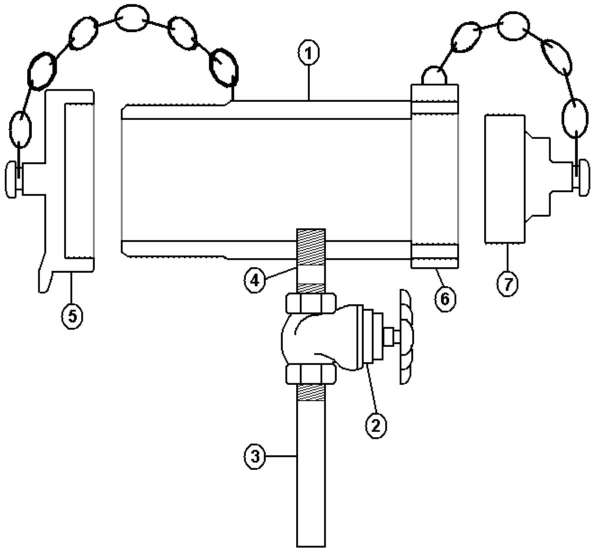
3.2 In-Line Sampling Valve.

A. Inspect the containers to ensure they are clean and dry.

B. Truck transport or railroad car – When approximately ⅓ of the load has been used or transferred, drain off a minimum of 1 gallon of asphalt and then completely fill the first container.

When approximately ⅔ of the load has been used or transferred, drain off 1 gallon of asphalt and then completely fill the second container.

C. Between the storage tank and the mix plant – Drain off 1 gallon of asphalt and then completely fill 2 one-quart sample containers.



Ref. #	Description	Number Req.
1	3" x 10" steel pipe, threaded outside at both ends and inside at one	1
2	¾" steel gate valve	1
3	¾" x 3" steel nipple, threaded at one end	1
4	¾" x 2" steel close nipple	1
5	3" brass cap with chain	1
6	3" brass pipe coupling	1
7	3" brass pipe plug with chain	-

Figure 2

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3.3 Distributor Sampling.

A. Inspect the containers to ensure they are clean and dry.

B. Method 1: Drain off a minimum of 1 gallon of asphalt through a nozzle on the spray bar and completely fill 2 containers.

C. Method 2: Take the sample from a nozzle on the spray bar after a portion of a load has been applied. Completely fill 2 containers.

D. Method 3: Take the sample from a distributor bulkhead sampling valve (shown in Figure 1) after draining off a minimum of 1 gallon from the sampling valve and then completely filling two containers.

3.4 General.

A. If the asphalt is delivered in a truck transport and pup combination, take both of your samples from either one of the units. Do not take one can from one unit and the other from the other unit.

B. Tightly seal all sample containers, immediately after filling, using tape, if necessary.

C. The filled cans must not be submerged in, or cleaned with solvents, or solvent saturated rags. Spilled materials will be wiped from the outside containers with clean dry cloths only.

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D. Place the field sample number and project number on each container for the sample and tape the 2 containers together, i.e. 01A & 01B.

E. For other methods of sampling asphalt materials, use AASHTO R 66 or contact the Materials and Surfacing Office.

4. Report:

Certificate of Compliance and forms DOT-1 and DOT-2.

5. References:

AASHTO R 66
DOT-1
DOT-2

Method of Test for Compatibility of Hot Poured Rubber Asphalt Joint Sealer with Asphalt Concrete

---

1. Scope:

This test covers the procedure for determining the compatibility of hot poured rubber asphalt joint sealer with asphalt concrete.

2. Apparatus:

2.1 An oven capable of maintaining a temperature of 140° ± 5°F.

2.2 Masonry saw.

2.3 A stiff bristled brush.

2.4 Cloth backed adhesive tape.

2.5 Knife.

Back

2.6 A Marshall compaction machine, mold and rammer.

3. Procedure:

3.1 Prepare a specimen using proportioned aggregate and asphalt cement.

3.2 The specimen shall be molded in the Marshall Density apparatus. The minimum height of the specimen shall not be less than 2 3/8”.

3.3 Compaction of the specimen shall be in accordance with SD 313.

3.4 After cooling to room temperature, wet saw a groove 4” x 1/2” ± 1/8” x 3/4” ± 1/8” deep into the surface of the specimen, using a power driven masonry saw.

3.5 Hold the specimen under running water and scrub the groove with a stiff bristled brush, to remove all residue from sawing.

3.6 Allow the specimen to dry and return to room temperature. Wrap the specimen with tape or otherwise reinforce it to prevent slumping or collapse during the ensuing test period. Caulk the ends of the grooves to prevent leaking.

3.7 Prepare and heat the joint sealing compound to the manufacturer’s recommended temperature and pour into the sawed groove, slightly overfilling the groove; however, do not allow any sealing compound to overflow onto the adjacent surface of the asphaltic concrete.

After the sealing compound has cooled to room temperature, remove any overfill of compound with a hot knife blade, so the sealing compound is even with the surface of the specimen.

3.8 Place the specimen in an oven at a temperature of 140° ± 5°F for 96 hours for Crumb Rubber and 72 hours for all others. Inspect the specimen each day to check for slumping or collapse.

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3.9 If the test fails for Crumb Rubber sealant at the end of the 96 hour period, repeat the procedure using a new specimen for a period of 168 hours.

3.10 Remove the specimen from the oven and cool to room temperature. Examine the specimen for compatibility of the joint sealant with asphaltic concrete.

Any evidence of failure in adhesion, cohesion, formation of an oily exudate at the interface between the sealing compound and the asphaltic concrete, and softening or other deleterious effects to the asphaltic concrete, shall be cause for rejection of the sealing compound.

4. Report:

Back

4.1 Rejection or acceptance shall be noted on the test report. (DOT-5)

5. References:

SD 311
DOT-5

Method of Test for Linear Shrinkage of Filler for Bituminous Surfacing

---

1. Scope:

This procedure is for calculating linear shrinkage of filler.

2. Apparatus:

2.1 A rigid collapsible mold, made of wood or metal, with a smooth plain, waxed, varnished or polished interior surface. The interior surface shall form an oblong 1” x 1” x 10” within a tolerance of ±.05”. The base shall be separate and unattached from sides and ends. The base may be plate glass, wood or metal that is smooth and plain.

2.2 Waxed or varnished wood or hard rubber tamper approximately 3/4” x 3/4” x 12” or 1/2” x 1” x 12” with a square cut end.

2.3 Spatula or pointing trowel with a 3” or 4” blade.

2.4 Electric drying oven, adjustable from 140° to 230°F.

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2.5 Glass graduates, 150 mL capacity or similar container.

2.6 Non-absorptive slab or table top.

2.7 A #40 sieve conforming to ASTM E11. | 18

2.8 Eye dropper.

2.9 Ruler, 12” in length, 1/10” divisions.

3. Procedure:

3.1 Obtain a dry sample of approximately 500 grams of - #40 material that has been prepared in accordance with SD 101.

3.2 Heap approximately 400 grams of prepared sample on the clean slab or tabletop. Make a crater in the middle of the sample. Pour 50 mL of water into the crater, fold in dry soil, allow 30 seconds to a minute for absorption, and mix vigorously by squeezing and kneading with the hands until the material becomes pliable. Add additional water, as needed.

3.3 Smooth off a portion of the surface with the trowel or spatula. Place a drop of water on the surface of the material, if the drop does not disappear in 30 seconds but leaves a shiny surface without free water, the material is ready for molding. If the drop of water disappears in less than 30 seconds, add more water, re-mix the sample and repeat the above process. If the free water remains on the surface, add dry filler and repeat mixing procedure above.

3.4 Place the mixed material in the mold in approximately 2 equal layers. Tamp each layer 25 times with a tamper. Tamp firmly enough so that there are no air pockets. Heap the top layer slightly higher than the mold. Strike off surface with dampened trowel. Avoid pulling the ends inward. Remove side and end forms.

3.5 Dry to constant weight in an oven at approximately 140°F. If experience with the material shows that cracking does not occur at a higher temperature, the temperature may be increased up to 230°F.

4. Report:

4.1 Calculate the linear shrinkage as follows:

% linear shrinkage = (10” – oven dry length) x 10”)

4.2 Report the linear shrinkage to the nearest 0.1%.

5. References:

Back

ASTM E11
SD 101

SD 304

Method of Test for Water Asphalt Preferential (W.A.P.)

---

1. Scope:

This test is for measuring water asphalt preferential.

2. Apparatus:

2.1 Electric hot plate capable of maintaining a temperature of 140°F.

2.2 Glass jars, minimum of 4 oz., maximum of 8 oz.

2.3 Water bath capable of holding 4 glass jars.

2.4 Electric stirrer (Mixer), 1500 RPM with rod and paddle to fit glass jars.

2.5 Balance having a capacity of at least 200 g sensitive and readable to 0.01 gram.

2.6 A #200 sieve conforming to ASTM E11.

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2.7 Thermometers, range of 20°F to 200°F.

2.8 Stop watch.

2.9 An oven capable of maintaining a constant temperature of 140°F ± 5°F.

2.10 Asphalt of the grade specified.

3. Procedure:

3.1 Obtain a sample of - #200 material weighing at least 10.00 grams from material that has been prepared in accordance with SD 101.

3.2 Preheat the water bath to 140°F ± 2°F.

3.3 Pour 50 grams of asphalt that has been heated in an oven to 140°F ± 5°F into a glass and add 10.00 grams of the filler.

3.4 Place a thermometer in the glass and put the glass in the water bath until the temperature of the asphalt reaches 140°F.

3.5 Mix the asphalt and filler with the electric mixer for 5 minutes. Add 50 mL of water at 140°F to the asphalt/filler and mix an additional 5 minutes.

3.6 Allow the mixture to stand until the water is clear.

3.7 Visually observe the asphalt free filler that has settled out. Estimate the volume of settled out material compared to the volume of the original 10 grams.

4. Report:

Report the amount of material settled out expressed as a percent of the original sample.

5. References:

ASTM E11 18
SD 101

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Method of Test for Determining the Moisture Content in Uncompacted Bituminous Paving Mixtures and Reclaimed Asphalt Pavement (RAP)

1. Scope:

This test is for determining the amount of moisture in an uncompacted bituminous paving mixture or a reclaimed asphalt pavement (RAP) mixture.

2. Apparatus:

2.1 Container with cover suitable for a sample of hot uncompacted hot mix or reclaimed asphalt pavement mixture (cement can or suitable container).

2.2 Convection oven capable of maintaining the temperature at 270° ± 10°F.

2.3 Balance with a capacity of at least 5,000 grams, sensitive and readable to 0.1 gram. Use of a piece of wood or metal on the scale is recommended to protect the scale from the elevated temperatures.

2.4 Gloves.

Back

3. Procedure:

3.1 Weigh and record the weight of a sample container and cover to the nearest 0.1 gram.

3.2 Obtain a representative 1,500 to 3,000 gram sample of uncompacted hot mix from the paver area in accordance with SD 312 or RAP mix from the belt or stockpile.

3.3 Place the sample in the container, put on the cover and transport back to the lab.

3.4 Weigh and record the weight of the container, cover and uncompacted hot mix or RAP to the nearest 0.1 gram. Subtract the weight obtained in 3.1 above from this weight to determine the original weight of the uncompacted hot mix (Which includes moisture).

3.5 Place the container and uncompacted hot mix or RAP without the cover in an oven set at 270° ± 10°F for 2 hours.

3.6 Weigh and record the weight of the container and uncompacted hot mix or RAP to the nearest 0.1 gram.

3.7 Place the container and hot mix or RAP back in the oven and weigh at 1 hour intervals until constant weight is obtained. Constant weight for this test procedure is defined as when the material does not lose more than 0.05% of the original weight of the hot mix or RAP sample (Obtained in 3.4 above) in a one hour period.

3.8 Once constant weight has been obtained, record the weight of the container, cover, and hot mix or RAP to the nearest 0.1 gram.

3.9 Subtract the final weight of the uncompacted hot mix or RAP, container, and cover from the original weight of the uncompacted hot mix or RAP, container and cover determined in 3.4 to determine the amount of moisture in the mix.

4. Report:

4.1 Calculate the moisture content in the mix to the nearest 0.1 percent. Report on form DOT-35.

$$\frac{A - B}{B} \quad X \quad 100$$

A = Initial weight of uncompacted hot mix or RAP
B = Final dry weight of uncompacted hot mix or RAP

Back

5. References:

SD 312
DOT-35

Method of Test for Determining the Drain Down Percent in Uncompacted Bituminous Paving Mixtures

---

1. Scope:

This test is for determining the amount of drain down in an uncompacted bituminous paving mixture such as Class S or SMA type mixes.

2. Apparatus:

2.1 Container with cover suitable for a sample of hot uncompacted hot mix (cement can).

2.2 Forced draft convection oven capable of maintaining the temperature at any temperature up to 350° ± 5° F.

2.3 Balance with a capacity of at least 5,000 grams, sensitive and readable to 0.1 gram. Use of a piece of wood or metal on the scale is recommended to protect the scale from the elevated temperatures.

Back

2.4 Gloves

2.5 Standard basket with a height of 6.5” ± 0.7” by 4.3” ± 0.4” with a bottom basket shelf at 1.0” ± 0.1” measured from the base, made of standard 0.25” sieve cloth.

2.6 Plates such as pie tins, tops of cement cans or small metal pans.

3. Procedure:

3.1 Sample shall be obtained from a truck at the plant site at the plant production temperature.

3.2 Obtain a representative 1,000 to 3,000 gram sample of uncompacted hot mix from a truck box at the plant site.

3.3 Place the sample in the container, put on the cover and transport back to the lab.

3.4 Transfer 1200 ± 200 grams of hot plant produced mix sample to a tared wire basket. Determine the weight of the sample not including the basket to the nearest 0.1 gram.

3.5 Weigh and record the initial weight of the plate to the nearest 0.1 gram. Place the basket with hot mix material on the plate and place in an oven that is at the temperature the hot mix is being discharged from the drum for 60 ± 5 minutes.

3.6 Weigh and record the final weight of the plate with drain down material to the nearest 0.1 gram.

4. Report:

4.1 Calculate the percent of hot mix that drained by subtracting the initial plate weight from the final plate weight and dividing this value by the weight of the sample. Multiply the result by 100 to get the percent and record to the nearest 0.1 percent. Report on form DOT- 91.

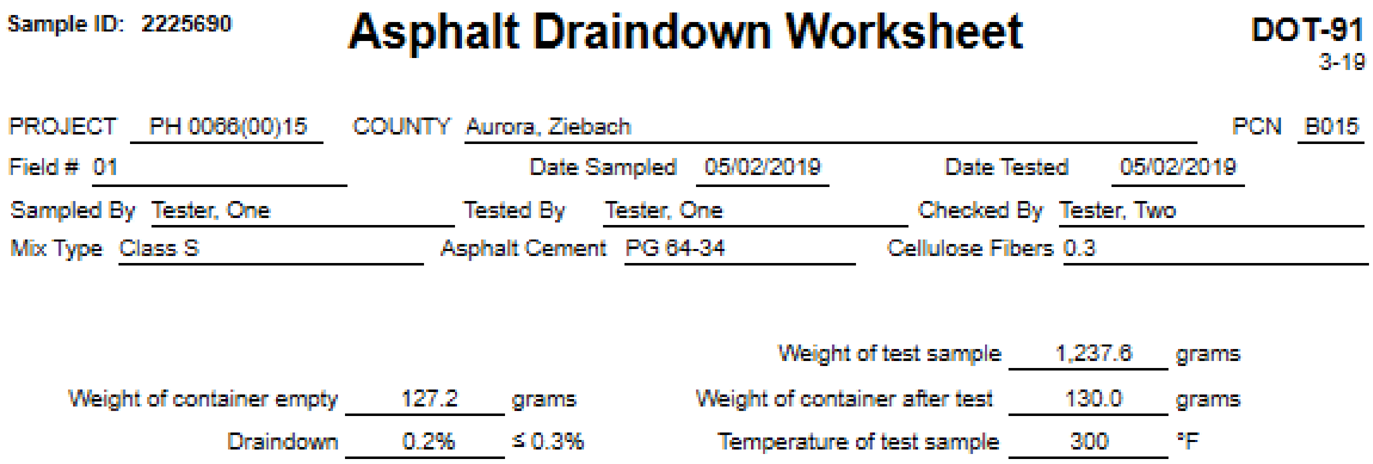
$$\% \text{ Drain down} = \frac{A - B}{C} \times 100$$

A = Final plate weight
B = Initial plate weight
C = Weight of the sample

5. References:

AASHTO T 305
DOT-91

Back



Sample ID: 2225690

Asphalt Draindown Worksheet

DOT-91
3-19

PROJECT PH 0066(00)15
COUNTY Aurora, Ziebach
PCN B015
Field # 01
Date Sampled 05/02/2019
Date Tested 05/02/2019
Sampled By Tester, One
Tested By Tester, One
Checked By Tester, Two
Mix Type Class S
Asphalt Cement PG 64-34
Cellulose Fibers 0.3

Weight of test sample 1,237.6 grams
Weight of container empty 127.2 grams
Weight of container after test 130.0 grams
Draindown 0.2% ≤ 0.3%
Temperature of test sample 300 °F

Figure 1

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Method for Field Determination of the Daily Lime Content

---

1. Scope:

This test covers the determination of the daily lime content for an asphalt hot mix plant.

2. Apparatus:

None

3. Procedure:

3.1 Record the weight of lime in the tank at the start of the day. ($\mathbf{A}$)

3.2 Calculate the weight of lime added to the tank by taking the summation of all truckloads of lime received for the day. ($\mathbf{B}$)

3.3 Record the weight of lime in the tank at the end of the day. ($\mathbf{C}$)

3.4 Record the weight of asphalt hot mix produced for the day. ($\mathbf{E}$)

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Note: All weights to the nearest 0.01 ton

4. Report:

4.1 Calculate the weight of lime used for the day ($\mathbf{D}$) to the nearest 0.01 ton.

$$\mathbf{D} = \mathbf{A} + \mathbf{B} - \mathbf{C}$$

4.2 Calculate the daily percent of lime in the mix ($\mathbf{F}$) to the nearest 0.01 percent.

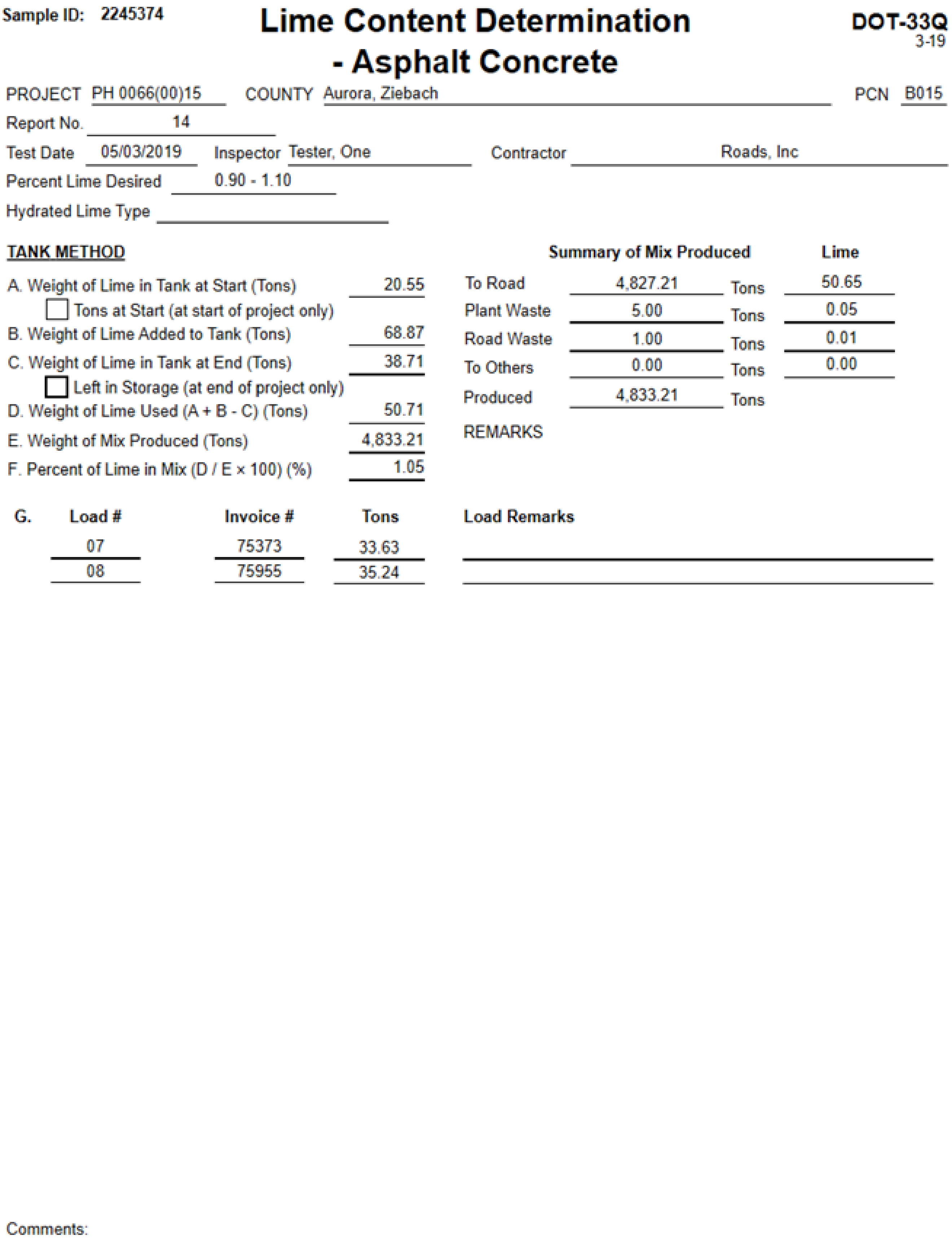
$$\mathbf{F} = \left(\frac{\mathbf{D}}{\mathbf{E}}\right)\mathbf{X\,100}$$

A = Weight of lime in tank at start of day.
B = Weight of lime added to tank.
C = Weight of lime in tank at end of day.
D = Weight of lime used.
E = Weight of mix produced.
F = Percent of lime in mix.

4.3 Report the daily lime content on the DOT-33Q form to the nearest 0.01 percent.

5. References:

DOT-33Q



Sample ID: 2245374

Lime Content Determination - Asphalt Concrete

DOT-33Q
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Report No. 14

Test Date 05/03/2019 Inspector Tester, One Contractor Roads, Inc

Percent Lime Desired 0.90 - 1.10

Hydrated Lime Type

TANK METHOD

A. Weight of Lime in Tank at Start (Tons) 20.55

☐ Tons at Start (at start of project only)

B. Weight of Lime Added to Tank (Tons) 68.87

C. Weight of Lime in Tank at End (Tons) 38.71

☐ Left in Storage (at end of project only)

D. Weight of Lime Used (A + B - C) (Tons) 50.71

E. Weight of Mix Produced (Tons) 4,833.21

F. Percent of Lime in Mix (D / E × 100) (%) 1.05

	Summary of Mix Produced		Lime
To Road	4,827.21	Tons	50.65
Plant Waste	5.00	Tons	0.05
Road Waste	1.00	Tons	0.01
To Others	0.00	Tons	0.00
Produced	4,833.21	Tons	

REMARKS

G.	Load #	Invoice #	Tons	Load Remarks
	07	75373	33.63	
	08	75955	35.24	

Comments:

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Density Determinations for Liquid Asphalt Treated Base and Subbase

---

1. Scope:

This test is for determining the relationship between the density of laboratory and field compacted liquid bitumen treated aggregate.

2. Apparatus:

2.1 Mold. A 6” diameter mold conforming to the requirements of AASHTO T 99, calibrated in accordance with SD 205.

2.2 Rammer. A manually or mechanically operated rammer conforming to the requirements of AASHTO T 99.

2.3 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.4 Drying oven capable of maintaining a temperature of 230° ± 9°F.

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2.5 Miscellaneous. 12” straightedge, spatula, pans, scoops, gloves and knife.

2.6 Sample extruder (Optional). A device adapted for the purpose of extruding compacted specimens from the mold.

3. Procedure:

3.1 Standard density determination.

A. Obtain a sample from the windrow in accordance with SD 201 and test in accordance with SD 104 method 4.

3.2 Density of material in place.

A. The density of material in place shall be determined in accordance with SD 105.

4. Report:

4.1 Calculate the dry density and moisture determinations as shown on form DOT-41.

4.2 Report the percent of moisture to the nearest 0.1%.

4.3 Report the percent of standard density obtained to the nearest whole percentage point.

5. References:

AASHTO T 99
SD 104
SD 105
SD 201
SD 205
DOT-41

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Moisture Sensitivity of Compacted Asphalt Concrete Paving Mixtures

---

1. Scope:

This test method covers the procedure for preparing and testing asphalt concrete specimens for the effect of water on the tensile strength of the paving mixture.

2. Apparatus:

2.1 Marshall slant foot rotating base compaction hammer.

2.2 Vacuum container, preferably a metal container and vacuum pump or water aspirator including a manometer or vacuum gauge.

2.3 Water bath at 140° ± 2°F and a water bath at 77° ± 2°F.

2.4 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

Back

2.5 Loading jack or mechanical testing machine with a vertical motion rate of 2” per minute.

2.6 Steel loading strips with a concave surface having a radius of curvature equal to the nominal radius of the test specimen. The strips shall be 0.5” wide for 4” specimens and have a length that exceeds the thickness of the specimens.

2.7 Calipers capable of measuring to the nearest 0.01".

3. Procedure:

3.1 Preparation of laboratory specimens.

A. At least 8 specimens are prepared as described in the South Dakota Mix Design Procedure. When adding a dry powder additive such as lime to the material, use the same procedure to add lime as will be used in the field. If adding a liquid anti-stripping to the asphalt binder, add the required quantity of liquid anti-strip to the asphalt binder, mix with a mechanical mixing device for at least 3 minutes.

Maintain the asphalt binder at the mixing temperature until it is used. Two samples of the minimum size specified in SD 312 are to be prepared to determine the theoretical maximum specific gravity of the uncompacted mix.

B. After mixing, the samples are put in a covered container in an oven at the compaction temperature for 2 hours prior to compaction.

C. The specimens shall be compacted to an air void level of 7% ± 1% by adjusting the number of Marshall blows.

D. Cool the specimens until the mold can be handled without gloves and extract from the molds. Allow the specimens to set overnight and then proceed with the test procedure.

3.2 Preparation of field samples.

A. Obtain a random sample of mix from behind the paver screed.

B. Stabilize the mix at the compaction temperature for 1 hour in the lab.

C. Compact at least 8 specimens to 7% ± 1% air void level using SD 313 test procedures.

D. Cool the specimens to room temperature and extract from the molds. Allow the specimens to set overnight and then proceed with the test procedure.

3.3 Preparation of core test specimens.

Back

A. Select the core locations by using a random number table. Obtain at least 8 cores for testing. Separate the core lifts by use of a cutoff saw.

B. When determining the dry weight, make sure no moisture is remaining in the core.

3.4 Procedure for determining subsets.

A. Determine the theoretical maximum specific gravity of the mixture by using SD 312.

B. Determine specimen thickness to the nearest .01” by using calipers to measure the thickness at four quarter point locations on the specimen.

C. Determine the bulk specific gravity of the specimens by using SD 313. Record the dry weight, the submersed weight, and the saturated surface dry weight on a DOT-48. The SSD weight minus the submersed weight is the volume of the specimen in cubic centimeters.

D. Calculate the air voids as shown in SD 313. (The theoretical maximum specific gravity minus the specimen bulk specific gravity divided by the theoretical maximum specific gravity times 100 will be the percent of air voids.) Record the air voids to the nearest 0.01 percent.

E. Sort specimens into two subsets of at least three specimens each, so that the average air voids of the two subsets are approximately equal.

The 2 extra samples can be used to determine the correct amount of vacuum needed in the saturation procedure.

F. One subset will be tested dry and the other subset will be preconditioned before testing. The dry subset will be stored at room temperature until tested.

3.5 Procedure for subset to be saturated. (Laboratory, field, or core specimens)

A. Partially saturate the subset to be moisture conditioned with room temperature distilled water using a vacuum container and a vacuum gauge or manometer to control the level of vacuum applied. Put one of the specimens in a vacuum container for 3 to 5 minutes with a specific level of vacuum applied such as 10” of Hg. After the vacuum saturation, place in 77° ± 2°F water for 3 to 3.5 minutes and then determine the submerged weight and the saturated surface dry weight of the partially saturated specimen. Determine the volume of water absorbed by subtracting the air dry mass of the specimen in 3.4 C. from the saturated surface dry mass obtained above. Continue to place in the vacuum container and reapply a higher level of vacuum until the specimen is saturated to the level required by this test procedure. If the level of saturation exceeds the upper limit allowed, the specimen is damaged and must be discarded.

Back

B. If the average air voids of the subset to be saturated is 6.5% or less, saturate to a level of 70% to 80%. If the average air voids of the subset is between 6.6% and 7.4%, saturate to a level of 55% to 80%. If the average air voids of the subset is 7.5% or more, saturate to a level of 55% to 65%. One of the extra samples may be used to determine the correct amount of vacuum to apply to get the required level of saturation.

Remember, if the specimen is saturated to a level exceeding the upper limit, the specimen is damaged and must be discarded. The level of saturation is determined by dividing the volume of the absorbed water in 3.5 A. above by the volume of air voids in 3.4 D. and expressing as a percentage.

C. Moisture condition the partially saturated specimens by soaking in distilled water at 140° ± 2°F for 24 hours.

After the 24 hour period, remove the specimens and place them in a 77° ± 2°F water bath for one hour.

D. After one hour, measure the height of the moisture conditioned specimens to the nearest .01” and determine the saturated surface dry weight, the submersed weight and the difference which is the volume of the saturated specimen. Return the specimens to the 77° ± 2°F water bath until ready to determine the tensile strength.

E. Determine the water absorption and the degree of saturation. A degree of saturation exceeding 80% is acceptable at this stage in the testing procedure.

F. Determine the swell of the partially saturated subset by dividing the change in specimen volumes from 3.5 A. and 3.4 C. by the specimen volume in 3.4 C. Determine the swell of the moisture conditioned specimens by dividing the change in specimen volumes from 3.5 E. and 3.4 C. by the specimen volume in 3.4 C.

3.6 Procedure for subset to be tested dry.

A. Adjust the temperature of the dry subset by soaking in a water bath for 20 minutes at 77° ± 2°F.

3.7 Procedure for determining the tensile strength.

A. Determine the tensile strength at 77° ± 2°F of both subsets.

Back

B. Place a specimen in the loading strip apparatus and position the loading strips so that they are parallel and centered on the vertical diametral plane. Apply a diametral load at 2” per minute until the maximum load is reached, and record the maximum load on a DOT-48.

C. Continue loading until the specimen fractures. Break open the specimen and visually estimate the degree of moisture damage, if any.

D. Record observations on the degree of broken or cracked aggregate.

4. Report:

4.1 Calculate the tensile strength (S) as follows:

S = Tensile strength, psi

P = Maximum load, pounds

t = Specimen height immediately before tensile strength test, .01 inches

D = Specimen diameter, .01 inches

π = 3.1416

$$S = \frac{(2 \times P)}{(\pi \times t \times D)}$$

TSR = Tensile strength ratio, percent

Stm = Average tensile strength of the moisture conditioned subset, psi

Back

Std = Average tensile strength of the dry subset, psi

$$TSR = \frac{Stm}{Std} \times 100$$

4.2 Record the test data on a DOT-48. Weights shall be recorded to the nearest 0.1 gram. Bulk specific gravity and maximum specific gravity shall be recorded to the nearest thousandth. Load shall be recorded to the nearest pound.

4.3 Volume and percentage calculations shall be reported to the nearest 0.01.

4.4 Tensile strength shall be calculated to the nearest 0.1 and the TSR reported to the nearest whole number.

5. References:

AASHTO T 245
ASTM D4867
SD 312
SD 313
SD 316
DOT-48
SD Mix Design Procedures

MOISTURE SENSITIVITY REPORT - BITUMINOUS SURFACING

DOT - 48
3-19

FILE NUMBER ______________

PROJECT: P 3079(00)219
PCN: 5415
COUNTY: Harding
DATE: 09/27/2019
ASPHALT BINDER: Cenex PG 58-28
ADDITIVE & DOSAGE: 0.75 percent hydrated lime
METHOD OF ADDING: dry to aggregate with 3% H_2O
COMPACTION BLOWS: 13 blows per side

DESIGN LEVEL: I Q2
DESIGN AIR VOIDS: 4.0
DESIGN AC CONTENT: 6.0

		Spec.'s
AVERAGE AIR VOIDS	6.72	6-8
AVERAGE SATURATION LEVEL	65.0	55-80
TENSILE STRENGTH RATIO	82	> 80

SPECIMEN NUMBER		1	2	3	4	5	6	7	8	9	10
DIAMETER (.01 in.)	D	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
THICKNESS (.01 in.)	t	2.53	2.57	2.61	2.57	2.57	2.59	2.56	2.58	2.59	2.66
DRY MASS IN AIR (0.1 g)	A	1169.4	1154.7	1177.4	1173.9	1163.5	1167.5	1181.4	1168.0	1175.8	1200.7
MASS IN WATER (0.1 g)	B	650.5	641.5	650.0	654.5	648.5	642.8	663.9	648.1	652.3	662.4
SSD MASS (0.1 g)	C	1170.6	1157.3	1179.1	1175.7	1164.9	1169.4	1182.6	1169.5	1177.7	1201.9
VOLUME (C - B)	E	520.1	515.8	529.1	521.2	516.4	526.6	518.7	521.4	525.4	539.5
BULK SP. GR. (A / E)	F	2.248	2.239	2.225	2.252	2.253	2.217	2.278	2.240	2.238	2.226
THEO. MAX SP. GR.	G	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403
% AIR VOIDS ((G-F)/G)x100	H	6.45	6.82	7.41	6.28	6.24	7.74	5.20	6.78	6.87	7.37
VOLUME AIR VOIDS (HE)/100	I	33.55	35.18	39.21	32.73	32.22	40.76	26.97	35.35	36.09	39.76
LOAD (LB.)	P	1105	1235				1235			1270	

AVERAGE AIR VOIDS OF DRY SUBSET: 6.97
AVERAGE AIR VOIDS OF SAT. SUBSET: 6.96

SATURATED: 3 MIN. 19 "HG

		1	2	3	4	5	6	7	8	9	10
MASS IN WATER (0.1 g)	B'			674.0	672.7				670.2		687.1
SSD MASS (0.1 g)	C'			1203.6	1194.0				1191.6		1226.6
VOLUME (C' - B')	E'			529.6	521.3				521.4		539.5
VOL. ABS. WATER (C' - A)	J'			26.2	20.1				23.6		25.9
% SATURATION (J'/ I) x 100				66.8	61.4				66.8		65.1
% SWELL ((E' -E) / E) x 100				0.09	0.02				0.00		0.00

CONDITIONED 24 HOURS IN 140 DEGREE F WATER

		1	2	3	4	5	6	7	8	9	10
THICKNESS (.01 in.)	t"			2.61	2.58				2.59		2.66
MASS IN WATER (0.1 g)	B"			681.9	680.1				678.2		695.5
SSD MASS (0.1 g)	C"			1217.4	1205.8				1206.3		1242.6
VOLUME (C" - B")	E"			535.5	525.7				528.1		547.1
VOL. ABS. WATER (C" - A)	J"			40.0	31.9				38.3		41.9
% SATURATION (J" / I) x 100				102.0	97.5				108.4		105.4
% SWELL((E" - E) / E) x 100				1.21	0.86				1.29		1.41
LOAD (LB.)	P"			1000	1030				950		1035
DRY STRENGTH ((2P) / tDπ)	Std	69.5	76.5				75.9			78.0	
WET STRENGTH ((2P") / t"Dπ)	Stm			61.0	63.5				58.4		61.9
VISUAL MOISTURE DAMAGE											
CRACK / BREAK DAMAGE											

π = 3.1416

TENSILE STRENGTH RATIO

$$\frac{\text{Average Wet Strength (psi)}}{\text{Average Dry Strength (psi)}} \qquad \frac{Stm1+ Stm2 + \ldots + Stmn}{Std1 + Std2 + \ldots + Stdn} = \frac{61.2}{75.0} \times 100 = \boxed{81.6}$$

Figure 1

Back

Method of Test for Residue of Specified Penetration

---

1. Scope:

This test is for determining the percent of residue having a specified penetration at 100 g, 5 sec. 77°F.

2. Apparatus:

2.1 Container. The container in which the sample is to be tested shall be a flat-bottomed, cylindrical seamless tin box, approximately 2 3/4” in diameter and 1 3/4” in depth.

2.2 Heating bath. The heating bath shall be a cast iron air bath permitting the immersion of the container to a depth of 1 1/4” through an opening 1/16” larger in diameter than the container. It shall support the container 1/4” above the hot plate and with at least 1/4” free air space between the sides of the container and of the air bath below the opening.

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2.3 Hot plate. The air bath shall be heated on a suitable mounted hot plate, heated either electrically or by means of a gas flame. The plate shall be capable of maintaining the sample continuously at the required temperature.

2.4 Thermometer. An open flash thermometer, graduated in either Fahrenheit or Celsius degrees as specified, having a range of 20° to 760°F and conforming to the requirements for this thermometer as prescribed in (ASTM E1).

2.5 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

3. Procedure:

3.1 Thoroughly stir and agitate a complete mixture before removing the portion for testing.

3.2 Weigh a 100 ± 10 g sample of the material to be tested in a tared container. Place the container in the air bath in position to be heated. Support the thermometer in the sample equidistant from the sides of the container and with the bottom of the bulb neither more than 1/4” above nor touching the bottom of the container. Completely immerse the bulb in the sample throughout heating.

3.3 Heat the sample, as rapidly as possible without foaming, to 480°F and during the evaporation, the temperature shall be maintained between 480°F and 500°F. Stir the sample with the thermometer from time to time to prevent local overheating and, to maintain a homogeneous sample. Flux all cakes of hardened bitumen which form at the sides of the container.

3.4 Judge approximately what percentage of residue is needed to secure the desired penetration. When it is supposed that the residue will show the required penetration, scrape off the bitumen on the thermometer and return to the container. Remove the container from the air bath, cool and weigh. Determine the penetration of the residue in accordance with AASHTO T 49, with the exception that a 6 oz. container shall be used instead of the 3 oz. container specified in the AASHTO T 49 for the evaporation.

3.5 It is frequently necessary to make several trials before a residue of the required penetration is obtained. If it is determined to be greater than that required, remove the water from the container and the surface of the sample and repeat the heating and determination of penetration. Consider a residue satisfactorily obtained when its penetration is within 15 of that desired. Calculate its percentage by weight of the original sample. When it is necessary to determine the percentage more precisely, calculate by interpolation between percentages of 2 residues, one having a penetration greater and one having a penetration lower than specified.

3.6 Duplicate determinations by this method should not differ from each other by more than 1.0% with the same operator nor more than 2.5% between operators.

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4. Report:

The percentage shall be reported as:

Percentage of residue of ____________ penetration (determined ________). Stating first, the specified penetration, and second, the penetration actually determined for the sample tested or calculated by interpolation.

5. References:

AASHTO T 49
ASTM E1

Method of Test for Determining the Cutout Correction and In Place Density of Asphalt Concrete by the Nuclear Gauge Method

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1. Scope:

This test is for determining the in place density of asphalt concrete by using the nuclear gauge. A correction needs to be applied to the nuclear gauge to obtain an accurate in place density. A gauge reading will be taken at the cutout or core site prior to the removal the asphalt concrete. The density of the cutout or core will then be determined.

Definitions:

Standard Density: Average of the 5 most recent theoretical maximum specific density determinations.

Lot: A quantity of material from a single source, representing a specific segment of construction, upon which decision is made for acceptance.

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Random Measurement: A specific individual measurement of in place density (One of 5 measurements made for a lot), the location is chosen such that each portion of the lot has an equal probability of being selected.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram. The scale or balance will be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the weighing device.

2.2 The water bath for immersing the sample will be equipped with an overflow outlet for maintaining a constant water level. An aquarium heater will suffice to control the temperature of the water bath at 77° ± 2° F. The water bath must be large enough to allow the suspension apparatus holder to be covered with water at all times. The sample and suspension apparatus must be completely covered with water during weighing. The wire suspending the suspension apparatus will be the smallest practical size to minimize any possible effects of a variable immersed length.

2.3 A thermometer with subdivisions and maximum scale error of 1˚F to cover the range of testing.

2.4 Power-driven masonry saw capable of cutting a 6” x 6” compaction sample or a coring device capable of cutting a 6” diameter core from the pavement. Furnished and operated by Contractor.

2.5 Miscellaneous. Pails, pans, hammer, roofing tacks, aluminum foil or pavement marking tape, spray paint, 50’ tape measure, 1” x 2” x 12” stakes.

2.6 Nuclear moisture-density gauge capable of determining densities by the backscatter method and conforming to the requirements of AASHTO T 310.

2.7 A reference standard block for taking standard counts.

2.8 A manufacturer’s instruction manual for the nuclear gauge.

2.9 A nuclear gauge logbook with transportation documents, and dosimeter.

3. Procedure:

3.1 Calibration and Standardization of Nuclear Gauge.

A. Calibration

(1) The Central Laboratory will calibrate nuclear gauges annually and each time repairs are made.

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B. Standard Count – Troxler Model 3440

(1) Turn the gauge on and allow the gauge to warm up for at least 10 minutes.

(2) Place the gauge on the reference standard block and take the standard count as recommended by the manufacturer.

(3) Take at least one 4 minute standard count daily. This count should compare within 1% of the average of the 4 previous standard density counts and compare within 2% of the average of the 4 previous standard moisture counts for the gauge. If the standard count varies by more than these tolerances, do not accept the standard count. Check that all the manufacturer’s guidelines have been followed and take another standard count.

NOTE: If the second count also fails, follow the manufacturer’s recommendation for the particular model gauge for taking and recording 4 additional standard counts.

(4) Record the results of the standard count in the gauge’s logbook.

C. Standard Count – Troxler Model 4640-B

(1) Turn the gauge on and allow the gauge to warm up for at least 10 minutes.

(2) Place the air gap spacer on the Magnesium (Mg) reference block and then place the gauge on top of the spacer. Take the 4 minute standard count as recommended by the manufacturer.

(3) Take at least one standard count daily. The results will be compared with the average of the 4 previous standard counts for the gauge. The system 1 count should compare within 1.0% and the system 2 within 1.2%. If the standard count varies by more than these tolerances, do not accept the standard count. Check that all the manufacturer's guidelines have been followed and take another standard count.

NOTE: If the second count also fails, follow the manufacturer's recommendation for the particular model gauge for taking and recording 4 additional standard counts.

(4) Record the results of the standard count in the gauge's logbook.

3.2 Compaction Sample Test Sites

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A. Randomly select test sites. The compaction samples will be representative of the lift thickness. A minimum of 3 compaction samples will be obtained per lift.

B. Tack a double layer of aluminum foil or pavement marking tape, approximately 12” x 18” in size, to the base with roofing nails at each test site. There will be 3 compaction sample sites plus a backup for each lift. The backup will be cut or cored if one of the three samples is damaged.

C. Mark the location of the foil or tape by measuring from the center of the foil or tape to 2 offset stakes and recording the distance.

D. After the asphalt concrete has been placed and compacted, locate the foil by measuring the recorded distance from each stake and swinging arcs.

3.3 Compaction Sample Density

A. Just prior to obtaining the compaction samples from the road, take 3 nuclear wet density readings in backscatter mode. Place the gauge near the middle of the test site and make sure that it doesn't “Rock” or shift due to an uneven surface. Keep the gauge turned parallel with the direction of travel of the paver and rollers. Lower the handle to the first notch, being careful not to pass the proper position and take a 1 minute reading to determine the wet density. Move the gauge approximately 3 inches perpendicular to the direction of travel and take the second reading. Move the gauge approximately 6 inches in the opposite direction and take the third reading.
Note: When using the Troxler 4640-B, you must enter into the gauge the asphalt concrete thickness minus ¼ inch.

B. Record the 3 wet density readings to the nearest 0.1 lbs./ft³ in the Cutout/Core Correction section on form DOT-42 and determine the average of the 3 wet densities at each compaction sample location.

C. The Contractor will cool, saw and remove a 6” square sample or a 6” diameter core sample from the area designated. Check the sample closely for damage caused during removal.

D. Immediately upon removal from the pavement, place the samples with the finished side down in a clean pan and place in a level position away from exposure to heat or other damaging conditions. As soon as sampling has been finished, transport the samples to the laboratory for the density determination. When the samples arrive at the field laboratory, place on a clean surface.

E. Perform the following steps and record on DOT-42Q.

  (1) Weigh the core and record the apparent dry weight in air to the nearest 0.1 gram on line (B).

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  (2) Immerse each specimen in water at 77° ± 2° F for 3 to 3 1/2 minutes and record the submersed weight to the nearest 0.1 gram on line (C).

  (3) Remove each specimen from the water and surface dry by blotting with a damp terry cloth towel. Weigh and record the saturated surface dry (SSD) weight in air to the nearest 0.1 gram on line (D).

  (4) Calculate the volume of the core (D - C). Record on line (E).

  (5) Record the pan number on line (F).

  (6) Record the weight of the pan to the nearest 0.1 gram on line (G).

  (7) Place the core in the pan and place in an oven at 230° ± 9° F for 2 hours, record the initial time.

  (8) After the 2 hour period, record the weight of the core and the pan to the nearest 0.1 gram on line (J), record the time of weighing.

  (9) Place the core and pan back in the oven and weigh at 1 hour intervals until the core has reached a constant weight. Constant weight is attained when the weight loss is within 0.1 percent of the apparent dry weight. Calculate the amount of

allowable loss (B x 0.001) to the nearest 0.1 gram. Record on line (M).

(10) After a constant weight has been attained, cool the pan and core to room temperature. Record the weight to the nearest 0.1 gram on line (N).

(11) Determine the actual dry weight of the core (N - G). Record on line (H).

(12) Determine the core bulk specific gravity (H / E) to the nearest 0.001. Record on line (I).

(13) Determine the moisture in the core (D - H). Record on line (K).

(14) Calculate the percent water absorbed by volume (K / E x 100) to the nearest 0.1 percent. Record on line (L).

F. Compare the average of the 3 wet densities determined by the nuclear gauge to the average density determined by the 3 compaction samples. When the nuclear gauge average is <u>greater</u> than the compaction sample average, the correction will be <u>subtracted</u> and when the nuclear gauge average is <u>less</u>, the correction will be <u>added</u> to the wet density determined by the nuclear gauge. (Figure 2)

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3.4 Standard Density.

A. The standard unit weight will be determined by the theoretical maximum specific gravity method in accordance with SD 312 (Figure 2).

(1) The average of the 5 most recent standard unit weight determinations will be used as the standard density.

(2) Until 5 standard unit weight determinations have been made, base the standard density on the first determination, then on the average of the first 2, 3, 4, and 5 determinations. Each standard density thereafter will be the average of the 5 most recent valid standard unit weight determinations and will be used when the same source, mix and plant are being used on one or more projects.

3.5 Selecting Density Test Locations.

A. Record the location of the lot to be tested by indicating Sta. to Sta. and the distance right or left of the centerline. Show the length, width, and quantity represented by the lot.

B. Select 5 sites within the lot by use of the random number table. (Figure 3) 22

(1) Determine and record each site for the lot being tested to the nearest foot.

(2) The procedure for using the random number table is as follows:

Assume the lot to be tested is from Sta. 25+00 to Sta. 45+00 and extends from 12' left to centerline. The length of the lot is then 2000' and the width is 12'. Randomly select a number from the random number table.

(3) Stationing of each site is determined by multiplying each random number by 2000' then adding the resulting distances to the beginning station.

(4) Distance from centerline for each site is determined by multiplying each random number by 12'.

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Measurement Site	Longitudinal distance	Transverse distance
1	2000 x 0.43 = 860	12 x 0.75 = 9.0
2	2000 x 0.85 = 1700	12 x 0.02 = 1.0*
3	2000 x 0.50 = 1000	12 x 0.40 = 4.8
4	2000 x 0.80 = 1600	12 x 0.14 = 1.7
5	2000 x 0.90 = 1800	12 x 0.47 = 5.6

* The transverse distance for site 2 was actually 0.24; however, transverse measurements falling closer than 1.0' to the edge are moved to 1.0' from the edge.

C. Pacing longitudinal distances from station stakes or other known references and tape measurements of the transverse distances will be acceptable.

D. When compaction has been completed and the lot is ready for testing, locate the selected test sites. The selected sites will not be marked, or their location revealed before the material represented by the lot is compacted and ready for acceptance testing (Figure 2).

3.6 In place density.

A. Base the density of the in place material on the average of random measurements made at pre-selected sites within the lot.

B. Set the gauge on each test site with the gauge parallel to the direction of travel of the paver and rollers. Ensure that the gauge does not rock. The gauge base must be completely in contact with the asphalt material. Small shifts in the site locations necessary for proper seating of the gauge are permissible. Take a 1 minute wet density reading in the backscatter mode and record the results. Rotate the gauge 180 degrees and take a 2nd reading in the backscatter mode. Average the two results.

Note: When using the Troxler 4640-B, you must enter into the gauge the asphalt concrete thickness minus ¼ inch.

C. Record the wet density to the nearest 0.1 lb./ft³ on the DOT-42.

4. Report:

4.1 Calculations – Nuclear Gauge Correction.

A. Calculate the cutout/core density (PCF) in lbs./ft³ from numbers recorded on DOT-42Q in the cutout calibration check on the DOT-42 in the following manner.

Weight of water (77° F) = 62.245 lb./ft³

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H = Actual dry weight.

D = Saturated surface dry weight (SSD) in air

C = Submersed weight in water

Cutout/Core Density = H / (D - C) x 62.245

B. Calculate the Correction as follows:

Correction in lb./ft³ = Cutout/Core average – Nuclear Gauge average

4.2 Calculations - Percent of Standard Density

A. Calculate the percent of standard density for each random measurement as follows:

$$\text{Percent of Standard Density} = \frac{\text{Wet density lb./ft}^3 \pm \text{correction lb./ft}^3 \times 100}{\text{Standard density}}$$

B. Record the percent of standard density for each random measurement to the nearest whole percent.

C. Calculate the percent of standard density for the lot by averaging the 5 random measurement percents of standard as recorded and report to the nearest whole percent.

5. References:

AASHTO T 310
SD 312
DOT-42
DOT-42Q

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Sample ID: 2311503

Density Report - Bituminous Surfacing

DOT-42Q
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Class and Type Class E Asphalt Concrete Lift ___ of ___ Thickness ___
% Asphalt Binder ___ Actual Finished Width ___ Station ___
Field Nbr 01 Tested By Tester, One Checked By ___ Date Tested 04/14/2020
Specification Requirement - Percent of Standard Required 92.0 - 100.0
Lot No. ___ Lot Location Sta. ___
Core Site Length ___ Lot Width ___ Quantity Represented ___ tons

Core Measurement Before Sawing																		
Core Number																		
Lift Measured Thickness																		

A. Sawed core thickness	2.25	2	2.25															
B. Apparent dry weight in air	2,617.30	2,497.50	2,576.00															
C. Submersed weight in water	1,482.30	1,426.90	1,462.00															
D. SSD weight in air	2,632.50	2,504.60	2,585.30															
E. Volume of the core (D - C)	1,150.20	1,077.70	1,123.30															
F. Pan number	1	2	3															
G. Weight of pan	31.900	31.800	34.200															
H. Actual dry weight (N - G)	2,614.6	2,496.1	2,574.6															
I. Core bulk specific gravity (H / E)	2.273	2.316	2.292															
K. Moisture in core (D - H)	17.9	8.5	10.7															
L. Percent water absorbed by volume (K / E) * 100	1.6	0.8	1.0															
M. Maximum allowable weight loss in 1 hour (B × 0.001)	2.6	2.5	2.6															

Figure 1

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Core Drying Weigh Back Area

	Time (J)	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
After reaching constant weight, allow the core & pan to cool to room temp. before weighing for the final time (N)	10:00 am	2,664.00	2,536.30	2,619.40															
	12:05 pm	2,647.20	2,527.90	2,609.00															
	1:05 pm	2,646.80	2,527.60	2,608.60															
N. Weight of cooled core and pan		2,646.50	2,527.90	2,608.80															

Theoretical Maximum Specific Gravity

Sublot No.	
Max. Sp. Gr.	

Lot Average Maximum Specific Gravity (Standard) ________

In-Place Density Measurement

Percent of Standard = [(Core Bulk Specific Gravity / Lot Average Maximum Specific Gravity)] × 100

Core Sublot No.	Height	Rand. No.	Cumulative Tonnage	Station for Core	Rand. No.	Paving Width	Distance from C/L	Actual Dry Weight	Weight in Water	SSD Weight	Core Bulk Sp. Gr.	% of Stand.	**Avg. % Stand.**
													Percent Density

Figure 1A

Sample ID: 2311051

Density Report - Bituminous Surfacing

DOT-42
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Test No. 04 Class and Type Class E Asphalt Concrete Lift ___ of ___ Thickness ___
% Asphalt Binder ___ Actual Finished Width 12.50 Station ___
Tested By Tester, One Test Date 04/15/2020 Checked By Tester, Two
Specification Requirements - % of Standard Required 92 Min.

Nuclear Density Gauge Data

Daily Check Gauge No. MQ 781 Standard Count ___ Previous Standard ___
Standard Density Test No. 04 Sample Obtained From ___

Theoretical Maximum Density (Rice)

	1	2
A. Wt. of sample in Air		
B. Wt. of Canister + Water		
C. Wt. of Canister + Water + Sample		
Temperature of the Water		
D. Water Correction Factor		
E. Max. Specific Gravity [A / (A + B - C)] × D		
F. Max. Unit Weight (E × 62.245)		

G. Average Unit Weight ___
H. Moving Avg. (Last 5 Tests) 154.3

Gyratory Density

	1	2
A. Wt. of Sample in Air		
B. Wt. of sample under water		
C. Saturated Surface Dry Wt.		
D. Volume Displaced (C - B)		
E. Bulk Specific Gravity (A / D)		
F. Unit Weight (E × 62.245)		
G. Compaction Sample Temp.		

H. Avg. Unit Weight ___

Cutout Calibration Test

Cutout No.	Station	Distance from C/L	Actual Dry Wt.	Submersed Wt. in Water	SSD Wt. in Air	Wet Density PCF	Nuclear Gauge Readings			Average	Waiver
1	271+77	6 LT	2,614.6	1,482.3	2,632.5	141.5	140.9	139.2	138.5	139.5	☐
2	270+00	6 LT	2,496.1	1,426.9	2,504.6	144.2	144.3	142.9	141.5	142.9	☐
3	269+32	6 LT	2,574.6	1,462.0	2,585.3	142.7	143.3	141.9	141.1	142.1	☐

PCF Average 142.8 PCF Average 141.5
Calibration Correction 1.3 PCF

In-Place Density Measurement

Lot Location Station 286+30 to Station 370+10 Distance from Center 12.5 LT
Length 8,380 Width 12.5 Quantity Represented 1136.81

Site No.	Random No.	Distance Lot. Beg.	Station	Random No.	Dist. from Out. Edge	Wet Density PCF	Corrected PCF	% of Standard	DOT-8?	Waiver
1	0.350	2933.0	315+63	0.720	9.0	140.0	141.3	92		☐
2	0.300	2514.0	311+44	0.790	9.9	141.1	142.4	92		☐
3	0.580	4860.4	334+90	0.490	6.1	143.7	145.0	94		☐
4	0.630	5279.4	339+09	0.320	4.0	143.2	144.5	94		☐
5	0.820	6871.6	355+02	0.240	3.0	139.2	140.5	91		☐

Lot Average 93

No more than 2 tests below spec.
Only 1 test may be 2% below spec.
1 test @ 3% below fails the entire lot.

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Figure 2

SDDOT
TABLE OF RANDOM NUMBERS

.53 .74 .23 .99 .67	.61 .32 .28 .69 .84	.94 .62 .67 .86 .24	.98 .33 .74 .19 .95	.47 .53 .53 .38 .09
.63 .38 .06 .86 .54	.99 .00 .65 .26 .94	.02 .82 .90 .23 .07	.79 .62 .67 .80 .60	.75 .91 .12 .81 .19
.35 .30 .58 .21 .46	.06 .72 .17 .10 .94	.25 .21 .31 .75 .96	.49 .28 .24 .00 .49	.55 .65 .79 .78 .07
.63 .43 .36 .82 .69	.65 .51 .18 .37 .88	.61 .38 .44 .12 .45	.32 .92 .85 .88 .65	.54 .34 .81 .85 .35
.98 .25 .37 .55 .26	.01 .91 .82 .81 .46	.74 .71 .12 .94 .97	.24 .02 .71 .37 .07	.03 .92 .18 .66 .75
.02 .63 .21 .17 .69	.71 .50 .80 .89 .56	.38 .15 .70 .11 .48	.43 .40 .45 .86 .98	.00 .83 .26 .91 .03
.64 .55 .22 .21 .82	.48 .22 .28 .06 .00	.61 .54 .13 .43 .91	.82 .78 .12 .23 .29	.06 .66 .24 .12 .27
.85 .07 .26 .13 .89	.01 .10 .07 .82 .04	.59 .63 .69 .36 .03	.69 .11 .15 .83 .80	.13 .29 .54 .19 .28
.58 .54 .16 .24 .15	.51 .54 .44 .82 .00	.62 .61 .65 .04 .69	.38 .18 .65 .18 .97	.85 .72 .13 .49 .21
.34 .85 .27 .84 .87	.61 .48 .64 .56 .26	.90 .18 .48 .13 .26	.37 .70 .15 .42 .57	.65 .65 .80 .39 .07
.03 .92 .18 .27 .46	.57 .99 .16 .96 .56	.30 .33 .72 .85 .22	.84 .64 .38 .56 .98	.99 .01 .30 .98 .64
.62 .95 .30 .27 .59	.37 .75 .41 .66 .48	.86 .97 .80 .61 .45	.23 .53 .04 .01 .63	.45 .76 .08 .64 .27
.08 .45 .93 .15 .22	.60 .21 .75 .46 .91	.98 .77 .27 .85 .42	.28 .88 .61 .08 .84	.69 .62 .03 .42 .73
.07 .08 .55 .18 .40	.45 .44 .75 .13 .90	.24 .94 .96 .61 .02	.57 .55 .66 .83 .15	.73 .42 .37 .11 .16
.01 .85 .89 .95 .66	.51 .10 .19 .34 .88	.15 .84 .97 .19 .75	.12 .76 .39 .43 .78	.64 .63 .91 .08 .25
.72 .84 .71 .14 .35	.19 .11 .58 .49 .26	.50 .11 .17 .17 .76	.86 .31 .57 .20 .18	.95 .60 .78 .46 .75
.88 .78 .28 .16 .84	.13 .52 .53 .94 .53	.75 .45 .69 .30 .96	.73 .89 .65 .70 .31	.99 .17 .43 .48 .76
.45 .17 .75 .65 .57	.28 .40 .19 .72 .12	.25 .12 .74 .75 .67	.60 .40 .60 .81 .19	.24 .62 .01 .61 .16
.96 .76 .28 .12 .54	.22 .01 .11 .94 .25	.71 .96 .16 .16 .88	.68 .64 .36 .74 .45	.19 .59 .50 .88 .92
.43 .31 .67 .72 .30	.24 .02 .94 .08 .63	.38 .32 .36 .66 .02	.69 .36 .38 .25 .39	.48 .03 .45 .15 .22
.50 .44 .66 .44 .21	.66 .06 .58 .05 .62	.68 .15 .54 .35 .02	.42 .35 .48 .96 .32	.14 .52 .41 .52 .48
.22 .55 .22 .15 .86	.26 .63 .75 .41 .99	.58 .42 .36 .72 .24	.58 .37 .52 .18 .51	.03 .37 .18 .39 .11
.96 .24 .40 .14 .51	.23 .22 .30 .88 .57	.95 .67 .47 .29 .83	.94 .69 .40 .06 .07	.18 .16 .36 .78 .86
.31 .73 .91 .61 .19	.60 .20 .72 .93 .48	.98 .57 .07 .23 .69	.65 .95 .39 .69 .58	.56 .80 .30 .19 .44
.78 .60 .73 .99 .34	.43 .89 .94 .36 .45	.56 .69 .47 .07 .41	.90 .22 .91 .07 .12	.78 .35 .34 .08 .72
.84 .37 .90 .61 .56	.70 .10 .23 .98 .05	.85 .11 .34 .76 .60	.76 .48 .45 .34 .60	.01 .64 .18 .39 .96
.36 .67 .10 .08 .23	.98 .93 .35 .08 .86	.99 .29 .76 .29 .81	.33 .34 .91 .58 .93	.63 .14 .52 .32 .52
.07 .28 .59 .07 .48	.89 .64 .58 .89 .75	.83 .85 .62 .27 .89	.30 .14 .78 .56 .27	.86 .63 .59 .80 .02
.10 .15 .83 .87 .60	.79 .24 .31 .66 .56	.21 .48 .24 .06 .93	.91 .98 .94 .05 .49	.01 .47 .59 .38 .00
.55 .19 .68 .97 .65	.03 .73 .52 .16 .56	.00 .53 .55 .90 .27	.33 .42 .29 .38 .87	.22 .13 .88 .83 .34
.53 .81 .29 .13 .39	.35 .01 .20 .71 .34	.62 .33 .74 .82 .14	.53 .73 .19 .09 .03	.56 .54 .29 .56 .93
.51 .86 .32 .68 .92	.33 .98 .74 .66 .99	.40 .14 .71 .94 .58	.45 .94 .19 .38 .81	.14 .44 .99 .81 .07
.35 .91 .70 .29 .13	.80 .03 .54 .07 .27	.96 .94 .78 .32 .66	.50 .95 .52 .74 .33	.13 .80 .55 .62 .54
.37 .71 .67 .95 .13	.20 .02 .44 .95 .94	.64 .85 .04 .05 .72	.01 .32 .90 .76 .14	.53 .89 .74 .60 .41
.93 .66 .13 .83 .27	.92 .79 .64 .64 .72	.28 .54 .96 .53 .84	.48 .14 .52 .98 .94	.56 .07 .93 .89 .30
.02 .96 .08 .45 .65	.13 .05 .00 .41 .84	.93 .07 .54 .72 .59	.21 .45 .57 .09 .77	.19 .48 .56 .27 .44
.49 .83 .43 .48 .35	.82 .88 .33 .69 .96	.72 .36 .04 .19 .76	.47 .45 .15 .18 .60	.82 .11 .08 .95 .97
.84 .60 .71 .62 .46	.40 .80 .81 .30 .37	.34 .39 .23 .05 .38	.25 .15 .35 .71 .30	.88 .12 .57 .21 .77
.18 .17 .30 .88 .71	.44 .91 .14 .88 .47	.89 .23 .30 .63 .15	.56 .34 .20 .47 .89	.99 .82 .93 .24 .98
.79 .69 .10 .61 .78	.71 .32 .76 .95 .62	.87 .00 .22 .58 40	.92 .54 .01 .75 .25	.43 .11 .71 .99 .31
.75 .93 .36 .57 .83	.56 .20 .14 .82 .11	.74 .21 .97 .90 .65	.96 .42 .68 .63 .86	.74 .54 .13 .26 .94
.38 .30 .92 .29 .03	.06 .28 .81 .39 .38	.62 .25 .06 .84 .63	.61 .29 .08 .93 .67	.04 .32 .92 .08 .09
.51 .28 .50 .10 .34	.31 .57 .75 .95 .80	.51 .97 .02 .74 .77	.76 .15 .48 .49 .44	.18 .55 .63 .77 .09
.21 .31 .38 .86 .24	.37 .79 .81 .53 .74	.73 .24 .16 .10 .33	.52 .83 .90 .94 .76	.70 .47 .14 .54 .36
.29 .01 .23 .87 .88	.58 .02 .39 .37 .67	.42 .10 .14 .20 .92	.16 .55 .23 .42 .45	.54 .96 .09 .11 .06
.95 .33 .95 .22 .00	.18 .74 .72 .00 .18	.38 .79 .58 .69 .32	.81 .76 .80 .26 .92	.82 .80 .84 .25 .39
.90 .84 .60 .79 .80	.24 .36 .59 .87 .38	.82 .07 .53 .89 .35	.96 .35 .23 .79 .18	.05 .98 .90 .07 .35
.46 .40 .62 .98 .82	.54 .97 .20 .56 .95	.15 .74 .809 .08 .32	.16 .46 .70 .50 .80	.67 .72 .16 .42 .79
.20 .31 .89 .03 .43	.38 .46 .82 .68 .72	.32 .14 .82 .99 .70	.80 .60 .47 .18 .97	.63 .49 .30 .21 .30
.71 .59 .73 .05 .50	.08 .22 .23 .71 .77	.91 .01 .93 .20 .49	.82 .96 .59 .26 .94	.66 .39 .67 .98 .60

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Figure 3

Method of Test for Theoretical Maximum Specific Gravity of Asphalt Concrete Paving Mixtures

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1. Scope:

This test is to determine the theoretical maximum specific gravity and/or density of uncompacted asphalt concrete paving mixtures. The theoretical maximum specific gravity or density is the standard used in the determination of in-place density of asphalt concrete pavements.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram. The scale or balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the weighing device.

2.2 Vacuum pycnometer capable of holding 3000 grams of loose asphalt mix.

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2.3 Vacuum pump or water aspirator for evacuating air from the container. If a vacuum pump is used a suitable trap shall be installed between the pycnometer and the vacuum source.

2.4 Vibrating plate for continuously agitating the asphalt concrete mixture and container.

2.5 Water container that will provide a sufficient amount of potable water to maintain a uniform temperature throughout the testing procedure. An aquarium heater will work to control the temperature of water at 77° ± 2° F.

2.6 A thermometer with subdivisions and maximum scale error of 1° F to cover the range of testing.

2.7 A mercury or digital residual pressure manometer is required to measure the amount of vacuum.

2.8 A bleeder valve attached to the vacuum system to facilitate adjustment of the vacuum being applied to the vacuum container.

2.9 The water bath for immersing the sample if using the (Weighing in water method) shall be equipped with an overflow outlet for maintaining a constant water level. The water bath must be large enough to allow the suspension apparatus holder to be covered with water at all times. The sample and suspension apparatus must be completely covered with water during weighing. The wire suspending the suspension apparatus shall be the smallest practical size to minimize any possible effects of a variable immersed length.

3. Procedure:

3.1 Sampling of uncompacted mix.

A. A random sample, approximately 160 to 180 lbs., of hot mix shall be taken from the paver area, - plus an additional 80 to 90 lbs., when IA testing is required. Samples may be obtained from behind the paver screed or from the windrow in front of the pickup machine. Material from the same sample shall be used for both SD 312 and SD 313 test procedures. On projects not requiring QC/QA testing a minimum sample size of 40 to 45 lbs. is required.

Sampling from the windrow in front of the pickup machine.

The random sample for QC/QA projects shall be selected by using random numbers such as from the tables included in this test procedure. Use the random number selected to determine the tonnage location in the sublot where the sample will be obtained.

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Do not sample the top surface of the windrow. Use a square bottom shovel to remove and discard the top foot of material from the windrow. Next, remove and discard the outside edge of the remaining windrow to create a vertical face parallel to the windrow. Obtain the sample from the exposed vertical face. Split samples can be obtained by alternating equal shovels of hot mix into the sample containers. The QC, QA and IA sample splits can be obtained by using this procedure. The sample in each sample container must be large enough for two complete sets of all required tests.

Sampling from behind the paver screed (Only when there is not a windrow available).

Example: Select a location in the random number table. Take that number (0.58) times the tonnage in the lot (1000). The sample will be taken at 580 tons into the lot on the road at the location the truck unloads where the weigh ticket is nearest to 580 tons. Record the weigh ticket number on the DOT 42Q. Use a 2nd random number (0.17) to select the distance from centerline where the sample will be taken. An example of this is 0.17 x 12’ width = 2.0’ from centerline.

Sample the mix by placing a template through the entire lift of hot mix or by using a square bottom shovel to create a sample area with vertical faces. Remove all material within the template or between the vertical lifts and place in the sample container or containers. On QC/QA projects obtain at least three approximately equal increments from this sample area for each sample container by placing the increments by alternating between sample container using a square bottom shovel or scoop. The QC/QA and IA sample splits can be obtained by using this procedure. The sample in each sample container must be large enough for two complete sets of all required tests.

B. There will be a 200 ton buffer between the random locations of the hot mix samples.

C. Transport the sample in a pail or box that is insulated or protected to help retain heat.

3.2 Calibration of the pycnometer for the weighing in air method.

A. Determine the weight of the container completely full of water with the calibration lid on, over the range of temperatures that will likely be encountered in service. Be sure the outside of the container is dry when weighed. Measure and record the temperature of the water and the weight of the container to the nearest 0.1 gram for at least one calibration point per 4° F after allowing the water to be in the container for 15 minutes. Construct a calibration curve for the water and container that is being used so that the weight of the container filled with water can be determined for any temperature from the calibration curve. At least weekly check the weight of the container filled with water to verify the weight is very close to the same as obtained from the calibration curve. Record the checks in the field diary.

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Correction factor for different water temperatures °F

°F		°F		°F	
60	1.0020	71	1.0008	81	0.9994
61	1.0019	72	1.0007	82	0.9992
62	1.0018	73	1.0005	83	0.9991
63	1.0017	74	1.0004	84	0.9989
64	1.0016	75	1.0003	85	0.9988
65	1.0015	76	1.0001	86	0.9986
66	1.0014	77	1.0000	87	0.9984
67	1.0013	78	0.9999	88	0.9983
68	1.0012	79	0.9998	89	0.9981
69	1.0011	80	0.9996	90	0.9979
70	1.0009				

NOTE: Whenever possible, use water that is close to 77°F.

3.3 Sample size and preparation.

A. The size of the sample shall conform to the following requirements.

Nominal maximum size of aggregate	Minimum size of sample
#4	500 grams
3/8”	1000 grams
1/2”	1500 grams
3/4”	2000 grams
1”	2500 grams
1¼”	3000 grams

B. Obtain 2 representative samples for testing from the sample taken in accordance with paragraph 3.1. Use the quartering method in SD 213, an asphalt quartering device, or by using the method as follows. Place the original sample in a large clean pan where there will be neither loss of material nor the addition of foreign matter. Mix the sample thoroughly and flatten the material in the pan. Obtain a representative cross section of the pan area by using a heated flat bottom scoop to obtain material for testing. Scoop material from several selected locations in the pan to achieve a sample size that will conform to the requirements in the sample size table 3.3 A.

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C. Separate the particles of the sample on a clean surface, to prevent contamination. The fines portion of the hot mix shall be separated such that no lumps are larger than ¼”. If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven until it can be handled.

D. Cool the sample to room temperature before beginning the test.

3.4 Determine the theoretical maximum specific gravity by one of the following methods.

(Weighing in air method)

A. Weigh the cooled sample to the nearest 0.1 gram in a tared container and record the weight. Add sufficient water to cover the sample approximately 1”. The release of entrapped air may be facilitated by the addition of a suitable wetting agent such as Aerosol OT in concentration of 0.001 percent or 0.2 grams in 20L of water. This solution is then diluted by about 20:1 to make a wetting agent of which 5 to 10 mL may be added to the container.

B. Remove entrapped air by subjecting the contents to a partial vacuum of 25 to 30 mm Hg. absolute pressure for 15 minutes ± 30 seconds. Agitate the container and contents continuously by a mechanical device. A manometer shall be installed inline to measure the amount of vacuum applied. A bleeder valve shall be installed in the vacuum system to maintain the vacuum at the required level.

C. Upon completion of the 15 minute vacuum period, slowly release the vacuum on the system. Fill the container with water. Place a thermometer in the container and record the water temperature 9 minutes after completing the vacuum period. Replace the calibration lid, dry the outside of the container, and record the weight of the container, sample and water to the nearest 0.1 gram.

D. Repeat A., B., and C. for a duplicate sample. The values of the two samples will be averaged for final results.

E. Duplicate specific gravity values not within 0.011 should be considered suspect and performed again.

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(Weighing in water method)

F. Weigh the cooled sample to the nearest 0.1 gram in a tared container and record the weight. Add sufficient water to cover the sample approximately 1”. The release of entrapped air may be facilitated by the addition of a suitable wetting agent such as Aerosol OT in concentration of 0.001 percent or 0.2 grams in 20L of water. This solution is then diluted by about 20:1 to make a wetting agent of which 5 to 10 mL may be added to the container.

G. Remove entrapped air by subjecting the contents to a partial vacuum of 25 to 30 mm Hg. absolute pressure for 15 minutes ± 30 seconds. Agitate the container and contents continuously by a mechanical device. A manometer shall be installed inline to measure the amount of vacuum applied. A bleeder valve shall be installed in the vacuum system to maintain the vacuum at the required level.

H. Upon completion of the 15 minute vacuum period, slowly release the vacuum on the system. Suspend the container and material in the water bath for 9 minutes. Record the water temperature. Record the weight of the container and sample suspended under water to the nearest 0.1 gram. Maintain a constant level of water in the water bath with the use of an overflow outlet.

I. Weigh the empty container suspended under water and record the weight to the nearest 0.1 gram.

J. Repeat F., G., H., and I. for a duplicate sample. The values of the two samples will be averaged for final results.

K. Duplicate specific gravity values not within 0.011 should be considered suspect and performed again.

4. Report:

4.1 Calculate the theoretical maximum specific gravity of the asphalt concrete mix in one of the following manners:

4.2 (Weighing in air method) (Figure 1 or figure 2)

Theoretical maximum specific gravity = (A / (A + B - C)) x D

A = Dry weight of the sample.

B = Calibration weight of the canister and water at the test temperature.

C = Final weight of the canister, water & sample.

D = Correction factor for water temperature.

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(Weighing in water method) (Figure 1 or figure 3)

Theoretical maximum specific gravity = ((A / (A + B - C)) x D

A = Dry weight of the sample.

B = Weight of the canister suspended under water.

C = Weight of the canister and sample suspended under water.

D = Correction factor for water temperature.

Report the theoretical maximum specific gravity to the third decimal place.

4.3 Calculate the standard unit weight in the following manner if required by the specifications:

Standard Unit Weight (lb./ft^3) = Theo. maximum specific gravity x 62.245

4.4 Report the standard unit weight to one decimal place if required by the specifications.

5. References:

SD 213
SD 313
DOT-42
DOT-86

Sample ID: 2224267

Gyratory Specific Gravity

DOT-86
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Field No. QC01QA01 Date Sampled 08/05/2019 Date Tested 08/05/2019
Sampled by Tester, One Tested by Tester, One Checked by Tester, Two
Material Type Class Q2 Hot Mixed Asphalt Concrete Ticket No. 15729
Source Lift 1 of 1
Lot No. 1 Sublot No. 1

Mix Temp. 270 Offset 6 ESAL's Q2
Daily Ton 483.83 Total Ton 2,632.46 Oil Type PG 64-28

			No. of gyrations			
% binder Pb	5.1	N initial	6		Gse	2.681
Gsb	2.636	N design	50		Pba	0.66
binder Gb	1.032	N max	75		Pbe	4.5
dust (-#200)	4.9					
lime	0.49					
dust (-#200) + lime	5.4					

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	Spec. A (Ndes)		**Spec. B (Ndes)**		**Spec. M (Nmax)**		
	@ N ini	@ N des	@ N ini	@ N des	@ N ini	@ N des	@ N max
a) Height, mm	123.60	113.40	123.90	113.90			
b) Weight in air		4,705.1		4,708.3			
c) Weight in water		2,729.6		2,729.0			
d) SSD weight		4,707.9		4,710.9			
e) Bulk SpGr meas b / (d - c)		2.378		2.376			
f) Bulk SpGr calc (Gmb)	2.182		2.184				
Waiver		☐		☐			☐

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	Gmm #1	**Gmm #2**
Weight of sample in air	1,522.0	1,524.9
Weight of canister + water	1,376.4	1,376.4
Weight of canister + water + sample	2,284.1	2,286.2
Temperature of the water	77 °F	77 °F
Water correction factor	1.0000	1.0000
Rice SpGr (Gmm)	2.478	2.479

Average Maximum SpGr (Gmm) 2.479

	N initial	**N design**	**N maximum**
Average Gmb	2.183	2.377	
% of Rice SpGr (Gmm)	88.1	95.9	

% Air Voids (Va) 4.1 % VMA 14.4 % VFA 72 Dust to binder ratio 1.2

Figure 1

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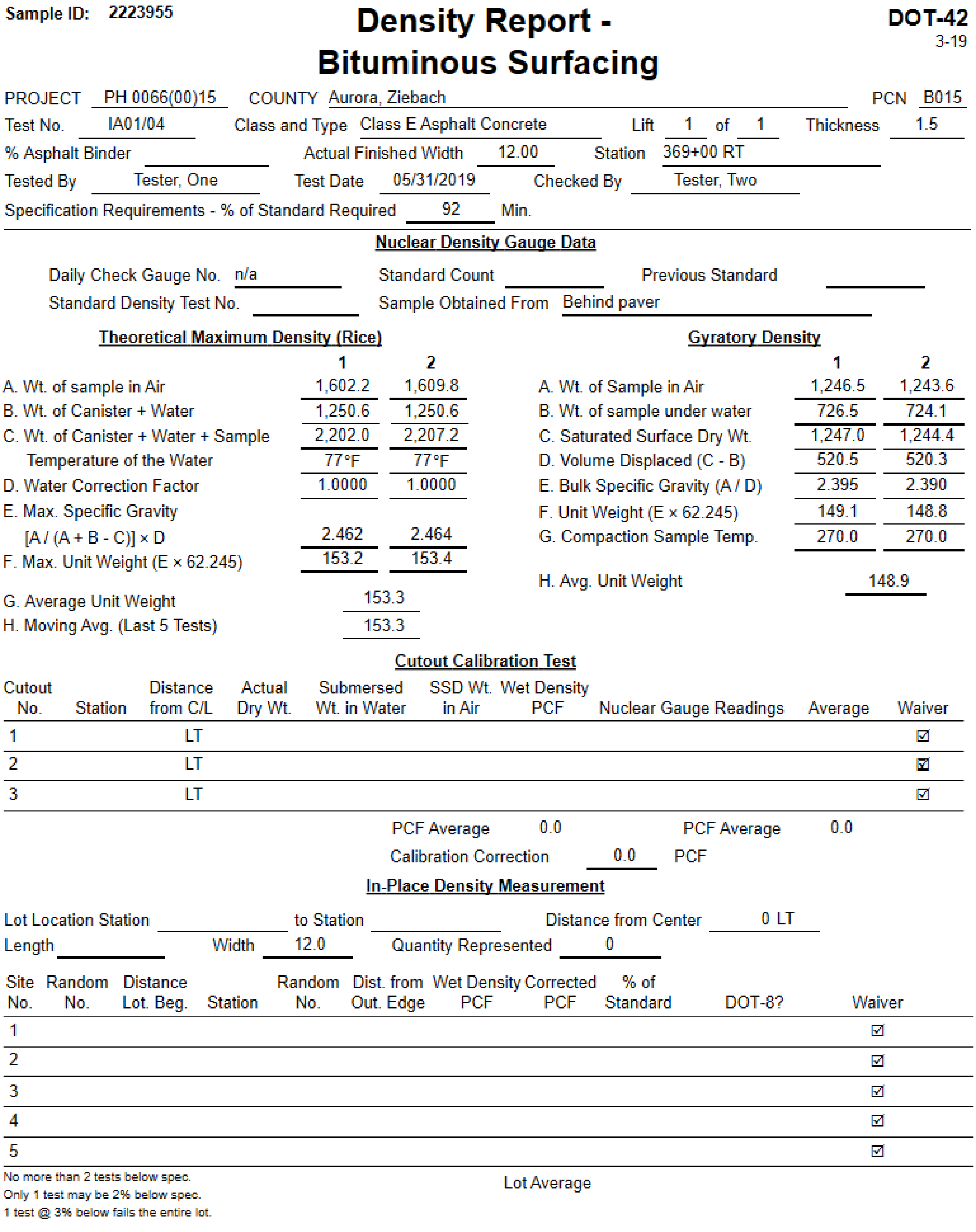


Sample ID: 2223955

Density Report -
Bituminous Surfacing

DOT-42
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Test No. IA01/04 Class and Type Class E Asphalt Concrete Lift 1 of 1 Thickness 1.5
% Asphalt Binder Actual Finished Width 12.00 Station 369+00 RT
Tested By Tester, One Test Date 05/31/2019 Checked By Tester, Two
Specification Requirements - % of Standard Required 92 Min.

Nuclear Density Gauge Data

Daily Check Gauge No. n/a Standard Count Previous Standard
Standard Density Test No. Sample Obtained From Behind paver

Theoretical Maximum Density (Rice)

	1	2
A. Wt. of sample in Air	1,602.2	1,609.8
B. Wt. of Canister + Water	1,250.6	1,250.6
C. Wt. of Canister + Water + Sample	2,202.0	2,207.2
Temperature of the Water	77°F	77°F
D. Water Correction Factor	1.0000	1.0000
E. Max. Specific Gravity [A / (A + B - C)] × D	2.462	2.464
F. Max. Unit Weight (E × 62.245)	153.2	153.4

G. Average Unit Weight 153.3
H. Moving Avg. (Last 5 Tests) 153.3

Gyratory Density

	1	2
A. Wt. of Sample in Air	1,246.5	1,243.6
B. Wt. of sample under water	726.5	724.1
C. Saturated Surface Dry Wt.	1,247.0	1,244.4
D. Volume Displaced (C - B)	520.5	520.3
E. Bulk Specific Gravity (A / D)	2.395	2.390
F. Unit Weight (E × 62.245)	149.1	148.8
G. Compaction Sample Temp.	270.0	270.0

H. Avg. Unit Weight 148.9

Cutout Calibration Test

Cutout No.	Station	Distance from C/L	Actual Dry Wt.	Submersed Wt. in Water	SSD Wt. in Air	Wet Density PCF	Nuclear Gauge Readings	Average	Waiver
1		LT							☑
2		LT							☑
3		LT							☑

PCF Average 0.0 PCF Average 0.0
Calibration Correction 0.0 PCF

In-Place Density Measurement

Lot Location Station to Station Distance from Center 0 LT
Length Width 12.0 Quantity Represented 0

Site No.	Random No.	Distance Lot. Beg.	Station	Random No.	Dist. from Out. Edge	Wet Density PCF	Corrected PCF	% of Standard	DOT-8?	Waiver
1										☑
2										☑
3										☑
4										☑
5										☑

No more than 2 tests below spec.
Only 1 test may be 2% below spec.
1 test @ 3% below fails the entire lot.

Lot Average

Figure 2

SDDOT
TABLE OF RANDOM NUMBERS

.53 .74 .23 .99 .67	.61 .32 .28 .69 .84	.94 .62 .67 .86 .24	.98 .33 .74 .19 .95	.47 .53 .53 .38 .09
.63 .38 .06 .86 .54	.99 .00 .65 .26 .94	.02 .82 .90 .23 .07	.79 .62 .67 .80 .60	.75 .91 .12 .81 .19
.35 .30 .58 .21 .46	.06 .72 .17 .10 .94	.25 .21 .31 .75 .96	.49 .28 .24 .00 .49	.55 .65 .79 .78 .07
.63 .43 .36 .82 .69	.65 .51 .18 .37 .88	.61 .38 .44 .12 .45	.32 .92 .85 .88 .65	.54 .34 .81 .85 .35
.98 .25 .37 .55 .26	.01 .91 .82 .81 .46	.74 .71 .12 .94 .97	.24 .02 .71 .37 .07	.03 .92 .18 .66 .75
.02 .63 .21 .17 .69	.71 .50 .80 .89 .56	.38 .15 .70 .11 .48	.43 .40 .45 .86 .98	.00 .83 .26 .91 .03
.64 .55 .22 .21 .82	.48 .22 .28 .06 .00	.61 .54 .13 .43 .91	.82 .78 .12 .23 .29	.06 .66 .24 .12 .27
.85 .07 .26 .13 .89	.01 .10 .07 .82 .04	.59 .63 .69 .36 .03	.69 .11 .15 .83 .80	.13 .29 .54 .19 .28
.58 .54 .16 .24 .15	.51 .54 .44 .82 .00	.62 .61 .65 .04 .69	.38 .18 .65 .18 .97	.85 .72 .13 .49 .21
.34 .85 .27 .84 .87	.61 .48 .64 .56 .26	.90 .18 .48 .13 .26	.37 .70 .15 .42 .57	.65 .65 .80 .39 .07
.03 .92 .18 .27 .46	.57 .99 .16 .96 .56	.30 .33 .72 .85 .22	.84 .64 .38 .56 .98	.99 .01 .30 .98 .64
.62 .95 .30 .27 .59	.37 .75 .41 .66 .48	.86 .97 .80 .61 .45	.23 .53 .04 .01 .63	.45 .76 .08 .64 .27
.08 .45 .93 .15 .22	.60 .21 .75 .46 .91	.98 .77 .27 .85 .42	.28 .88 .61 .08 .84	.69 .62 .03 .42 .73
.07 .08 .55 .18 .40	.45 .44 .75 .13 .90	.24 .94 .96 .61 .02	.57 .55 .66 .83 .15	.73 .42 .37 .11 .16
.01 .85 .89 .95 .66	.51 .10 .19 .34 .88	.15 .84 .97 .19 .75	.12 .76 .39 .43 .78	.64 .63 .91 .08 .25
.72 .84 .71 .14 .35	.19 .11 .58 .49 .26	.50 .11 .17 .17 .76	.86 .31 .57 .20 .18	.95 .60 .78 .46 .75
.88 .78 .28 .16 .84	.13 .52 .53 .94 .53	.75 .45 .69 .30 .96	.73 .89 .65 .70 .31	.99 .17 .43 .48 .76
.45 .17 .75 .65 .57	.28 .40 .19 .72 .12	.25 .12 .74 .75 .67	.60 .40 .60 .81 .19	.24 .62 .01 .61 .16
.96 .76 .28 .12 .54	.22 .01 .11 .94 .25	.71 .96 .16 .16 .88	.68 .64 .36 .74 .45	.19 .59 .50 .88 .92
.43 .31 .67 .72 .30	.24 .02 .94 .08 .63	.38 .32 .36 .66 .02	.69 .36 .38 .25 .39	.48 .03 .45 .15 .22
.50 .44 .66 .44 .21	.66 .06 .58 .05 .62	.68 .15 .54 .35 .02	.42 .35 .48 .96 .32	.14 .52 .41 .52 .48
.22 .55 .22 .15 .86	.26 .63 .75 .41 .99	.58 .42 .36 .72 .24	.58 .37 .52 .18 .51	.03 .37 .18 .39 .11
.96 .24 .40 .14 .51	.23 .22 .30 .88 .57	.95 .67 .47 .29 .83	.94 .69 .40 .06 .07	.18 .16 .36 .78 .86
.31 .73 .91 .61 .19	.60 .20 .72 .93 .48	.98 .57 .07 .23 .69	.65 .95 .39 .69 .58	.56 .80 .30 .19 .44
.78 .60 .73 .99 .34	.43 .89 .94 .36 .45	.56 .69 .47 .07 .41	.90 .22 .91 .07 .12	.78 .35 .34 .08 .72
.84 .37 .90 .61 .56	.70 .10 .23 .98 .05	.85 .11 .34 .76 .60	.76 .48 .45 .34 .60	.01 .64 .18 .39 .96
.36 .67 .10 .08 .23	.98 .93 .35 .08 .86	.99 .29 .76 .29 .81	.33 .34 .91 .58 .93	.63 .14 .52 .32 .52
.07 .28 .59 .07 .48	.89 .64 .58 .89 .75	.83 .85 .62 .27 .89	.30 .14 .78 .56 .27	.86 .63 .59 .80 .02
.10 .15 .83 .87 .60	.79 .24 .31 .66 .56	.21 .48 .24 .06 .93	.91 .98 .94 .05 .49	.01 .47 .59 .38 .00
.55 .19 .68 .97 .65	.03 .73 .52 .16 .56	.00 .53 .55 .90 .27	.33 .42 .29 .38 .87	.22 .13 .88 .83 .34
.53 .81 .29 .13 .39	.35 .01 .20 .71 .34	.62 .33 .74 .82 .14	.53 .73 .19 .09 .03	.56 .54 .29 .56 .93
.51 .86 .32 .68 .92	.33 .98 .74 .66 .99	.40 .14 .71 .94 .58	.45 .94 .19 .38 .81	.14 .44 .99 .81 .07
.35 .91 .70 .29 .13	.80 .03 .54 .07 .27	.96 .94 .78 .32 .66	.50 .95 .52 .74 .33	.13 .80 .55 .62 .54
.37 .71 .67 .95 .13	.20 .02 .44 .95 .94	.64 .85 .04 .05 .72	.01 .32 .90 .76 .14	.53 .89 .74 .60 .41
.93 .66 .13 .83 .27	.92 .79 .64 .64 .72	.28 .54 .96 .53 .84	.48 .14 .52 .98 .94	.56 .07 .93 .89 .30
.02 .96 .08 .45 .65	.13 .05 .00 .41 .84	.93 .07 .54 .72 .59	.21 .45 .57 .09 .77	.19 .48 .56 .27 .44
.49 .83 .43 .48 .35	.82 .88 .33 .69 .96	.72 .36 .04 .19 .76	.47 .45 .15 .18 .60	.82 .11 .08 .95 .97
.84 .60 .71 .62 .46	.40 .80 .81 .30 .37	.34 .39 .23 .05 .38	.25 .15 .35 .71 .30	.88 .12 .57 .21 .77
.18 .17 .30 .88 .71	.44 .91 .14 .88 .47	.89 .23 .30 .63 .15	.56 .34 .20 .47 .89	.99 .82 .93 .24 .98
.79 .69 .10 .61 .78	.71 .32 .76 .95 .62	.87 .00 .22 .58 40	.92 .54 .01 .75 .25	.43 .11 .71 .99 .31
.75 .93 .36 .57 .83	.56 .20 .14 .82 .11	.74 .21 .97 .90 .65	.96 .42 .68 .63 .86	.74 .54 .13 .26 .94
.38 .30 .92 .29 .03	.06 .28 .81 .39 .38	.62 .25 .06 .84 .63	.61 .29 .08 .93 .67	.04 .32 .92 .08 .09
.51 .28 .50 .10 .34	.31 .57 .75 .95 .80	.51 .97 .02 .74 .77	.76 .15 .48 .49 .44	.18 .55 .63 .77 .09
.21 .31 .38 .86 .24	.37 .79 .81 .53 .74	.73 .24 .16 .10 .33	.52 .83 .90 .94 .76	.70 .47 .14 .54 .36
.29 .01 .23 .87 .88	.58 .02 .39 .37 .67	.42 .10 .14 .20 .92	.16 .55 .23 .42 .45	.54 .96 .09 .11 .06
.95 .33 .95 .22 .00	.18 .74 .72 .00 .18	.38 .79 .58 .69 .32	.81 .76 .80 .26 .92	.82 .80 .84 .25 .39
.90 .84 .60 .79 .80	.24 .36 .59 .87 .38	.82 .07 .53 .89 .35	.96 .35 .23 .79 .18	.05 .98 .90 .07 .35
.46 .40 .62 .98 .82	.54 .97 .20 .56 .95	.15 .74 .80 .08 .32	.16 .46 .70 .50 .80	.67 .72 .16 .42 .79
.20 .31 .89 .03 .43	.38 .46 .82 .68 .72	.32 .14 .82 .99 .70	.80 .60 .47 .18 .97	.63 .49 .30 .21 .30
.71 .59 .73 .05 .50	.08 .22 .23 .71 .77	.91 .01 .93 .20 .49	.82 .96 .59 .26 .94	.66 .39 .67 .98 .60

Figure 3

Back

Method of Test for Density and Air Voids of Asphalt Concrete by the Marshall Method

---

1. Scope:

This test is to determine the density and air void level of asphalt concrete mixtures.

2. Apparatus:

2.1 Slant foot (1° bevel) rotating base Marshall mechanical compaction machine mounted on a wooden pedestal secured to a concrete slab.

2.2 Compaction hammer conforming to AASHTO T 245.

2.3 Compaction molds conforming to AASHTO T 245.

2.4 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram. The scale or balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the weighing device.

Back

2.5 Thermometers, dial type, armored glass, or digital with a range of 50° to 400°F with a sensitivity of 5° F.

2.6 Thermometer sensitive to 0.5°F and readable to 1°F.

2.7 Miscellaneous. Insulated gloves, small trowel, filter paper discs, pails, shovel, pans, scoop or spoon, fuel oil, and rags.

2.8 Electric hot plate or roaster oven.

2.9 Water bath with an overflow outlet for maintaining a constant water level. An aquarium heater will suffice to control the temperature of the water bath at 77° ± 2°F. The water bath must be large enough to allow the suspension apparatus holder to be covered with water at all times. The sample and suspension apparatus must be completely covered with water during weighing. The wire suspending the suspension apparatus shall be the smallest practical size to minimize any possible effects of a variable immersed length.

2.10 A mechanical convection oven with a minimum chamber volume of 5.0 cubic feet capable of heating to 350°F.

3. Procedure:

3.1 Sampling uncompacted mix.

A. Material for the Marshall determinations shall be obtained from the same sample as obtained in SD 312.

B. Take approximately 70 to 80 lbs. of hot mix for the laboratory density determination - 110 to 120 lbs. when IA testing is required.

C. Transport the sample in a pail or box that is insulated or protected to help retain heat.

D. Place the sample in a clean pan where there will be neither loss of material nor the addition of foreign matter. Place the pan and material in an oven maintained at or slightly above the required compaction temperature.

3.2 Laboratory density determination.

Back

A. Preheat 3 molds, a flat bottom scoop, and a trowel or spatula in an oven or on a hot plate to the established mix compaction temperature recommended on the job mix formula. Preheat the tamping face of the hammer to 200° to 300° F on a hot plate. On non QC/QA projects compact the mix at the delivery temperature to the road ± 10°F.

B. Obtain by quartering or by using a heated flat bottom scoop a representative sample, from the same pan of material used in SD 312 Section 3.3 B. The material placed in the mold shall make a Marshall specimen with a compacted height of 2 1/2” ± 1/8”. Once the amount of material needed to make a compacted specimen the required height is established, material can be weighed into the compaction molds that have a paper disc in the bottom of the mold and placed in an oven. Monitor the temperature of the hot mix so that compacting will take place when the mix is at the established mix design compaction temperature recommended on the job mix formula. Thermometers should be calibrated and checked often to insure accurate temperature measurements.

C. Once the hot mix in the mold has reached the correct temperature, remove from the oven, rod 25 times (15 around the perimeter and 10 in the center) with the small trowel or spatula. After rodding, round off the top surface of the mixture. Measure and record the temperature of the mix in the mold.

D. Place a paper disc on the top of the mix in the mold and place the mold on the base of the mechanical compactor under the mold holder. Place the face of the hammer inside the mold and apply 50 blows, unless otherwise specified in the plans. Invert the mold and apply 50 blows or the number of blows specified in the plans to the opposite end of the specimen. After compaction, the base plate shall be removed and the paper discs discarded.

E. Repeat the procedure listed in paragraphs B., C., and D. above for the second and third specimens.

F. Cool the specimens in air. A fan may be used to aid in the cooling of the specimens. After a specimen has cooled enough to touch with the bare hand, remove it from the forming mold.

G. After removal, number each specimen and set aside. Avoid fracturing or deforming the specimens when handling. Rest specimens on a smooth, level surface until ready for testing. The height of each specimen shall be 2 1/2" ± 1/8”.

If the Marshall specimen doesn’t compact to a height of 2 1/2” ± 1/8”, use the following equation to correct the amount of material to be used:

A = Actual weight of the specimen

$$\frac{(2.5 \times A)}{B}$$

B = Actual height of the specimen

Back

H. After the specimen has cooled to room temperature, measure the height at four locations. Record the average height of the specimen to the nearest 1/16”.

I. Weigh the specimen in air and record the weight to the nearest 0.1 gram.

J. Suspend the specimen in a water bath at 77° ± 2° F for 3 to 3.5 minutes. Record the immersed weight to the nearest 0.1 gram. Maintain a constant level of water in the water bath at the overflow outlet through the entire test procedure.

K. Immediately after weighing under water, blot the specimen dry with a damp terry cloth towel and record the saturated surface dry weight to the nearest 0.1 gram.

L. Repeat H., I., J., and K. for the other two specimens.

NOTE: Cores and pucks shall be weighed individually.

4. Report:

4.1 Calculate the Marshall bulk specific gravity of the laboratory specimens in the following manner.

$$\text{Marshall bulk specific gravity} = \frac{A}{C - B}$$

A = Weight of sample in air.

B = Weight of the sample suspended in water.

C = Weight of saturated surface dry sample in air.

F = Marshall bulk specific gravity

4.2 Report the Marshall bulk specific gravity to the nearest 0.001 on the DOT-48

NOTE: Use all three of the specimens provided the difference between the high and low specimen does not exceed 0.020. When any specimen varies by more than 0.020 from any of the other specimens, that specimen will not be used in the calculations and will be discarded. If the remaining two specimens are within 0.010 of each other, use their average for the Marshall density data. If they are not, discard the specimens and obtain a new set of Marshall specimens.

Back

4.3 Calculate the percent of air voids in the following manner:

$$\%\text{ air voids} = \frac{(G - F)}{G} \times 100$$

G = Theoretical maximum specific gravity from SD 312.

F = Marshall bulk specific gravity.

H = % air voids.

4.4 Report the percent air voids to the nearest 0.1 on the DOT-48.

5. References:

AASHTO T 245
SD 312
DOT-48

MOISTURE SENSITIVITY REPORT - BITUMINOUS SURFACING

DOT - 48
3-19

FILE NUMBER ______________

PROJECT	P 3079(00)219	DESIGN LEVEL	I Q2	
PCN	5415	DESIGN AIR VOIDS	4.0	
COUNTY	Harding	DESIGN AC CONTENT	6.0	
DATE	09/27/2019			Spec.'s
ASPHALT BINDER	Cenex PG 58-28	AVERAGE AIR VOIDS	6.72	6-8
ADDITIVE & DOSAGE	0.75 percent hydrated lime	AVERAGE SATURATION LEVEL	65.0	55-80
METHOD OF ADDING	dry to aggregate with 3% H_2O	TENSILE STRENGTH RATIO	82	> 80
COMPACTION BLOWS	13 blows per side			

SPECIMEN NUMBER		1	2	3	4	5	6	7	8	9	10
DIAMETER (.01 in.)	D	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
THICKNESS (.01 in.)	t	2.53	2.57	2.61	2.57	2.57	2.59	2.56	2.58	2.59	2.66
DRY MASS IN AIR (0.1 g)	A	1169.4	1154.7	1177.4	1173.9	1163.5	1167.5	1181.4	1168.0	1175.8	1200.7
MASS IN WATER (0.1 g)	B	650.5	641.5	650.0	654.5	648.5	642.8	663.9	648.1	652.3	662.4
SSD MASS (0.1 g)	C	1170.6	1157.3	1179.1	1175.7	1164.9	1169.4	1182.6	1169.5	1177.7	1201.9
VOLUME (C - B)	E	520.1	515.8	529.1	521.2	516.4	526.6	518.7	521.4	525.4	539.5
BULK SP. GR. (A / E)	F	2.248	2.239	2.225	2.252	2.253	2.217	2.278	2.240	2.238	2.226
THEO. MAX SP. GR.	G	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403
% AIR VOIDS ((G-F)/G)x100	H	6.45	6.82	7.41	6.28	6.24	7.74	5.20	6.78	6.87	7.37
VOLUME AIR VOIDS (HE)/100	I	33.55	35.18	39.21	32.73	32.22	40.76	26.97	35.35	36.09	39.76
LOAD (LB.)	P	1105	1235				1235			1270	

AVERAGE AIR VOIDS OF DRY SUBSET 6.97

AVERAGE AIR VOIDS OF SAT. SUBSET 6.96

SATURATED 3 MIN. 19 "HG

19

Back

		1	2	3	4	5	6	7	8	9	10
MASS IN WATER (0.1 g)	B'			674.0	672.7				670.2		687.1
SSD MASS (0.1 g)	C'			1203.6	1194.0				1191.6		1226.6
VOLUME (C' - B')	E'			529.6	521.3				521.4		539.5
VOL. ABS. WATER (C' - A)	J'			26.2	20.1				23.6		25.9
% SATURATION (J'/ I) x 100				66.8	61.4				66.8		65.1
% SWELL ((E' -E) / E) x 100				0.09	0.02				0.00		0.00

CONDITIONED 24 HOURS IN 140 DEGREE F WATER

		1	2	3	4	5	6	7	8	9	10
THICKNESS (.01 in.)	t"			2.61	2.58				2.59		2.66
MASS IN WATER (0.1 g)	B"			681.9	680.1				678.2		695.5
SSD MASS (0.1 g)	C"			1217.4	1205.8				1206.3		1242.6
VOLUME (C" - B")	E"			535.5	525.7				528.1		547.1
VOL. ABS. WATER (C" - A)	J"			40.0	31.9				38.3		41.9
% SATURATION (J" / I) x 100				102.0	97.5				108.4		105.4
% SWELL((E" - E) / E) x 100				1.21	0.86				1.29		1.41
LOAD (LB.)	P"			1000	1030				950		1035
DRY STRENGTH ((2P) / tDπ)	Std	69.5	76.5				75.9			78.0	
WET STRENGTH ((2P") / t"Dπ)	Stm			61.0	63.5				58.4		61.9
VISUAL MOISTURE DAMAGE											
CRACK / BREAK DAMAGE											

π = 3.1416

TENSILE STRENGTH RATIO $\frac{\text{Average Wet Strength (psi)}}{\text{Average Dry Strength (psi)}}$ $\frac{\text{Stm1 + Stm2 + ... + Stmn}}{\text{Std1 + Std2 + ... + Stdn}} = \frac{61.2}{75.0} \times 100 = \boxed{81.6}$

Figure 1

Method for Field Determination of the Daily Asphalt Binder Content

---

1. Scope:

This test covers the procedure for calculating the daily asphalt binder content for an asphalt hot mix plant.

2. Apparatus:

2.1 Furnished charts showing the capacity per fractions of an inch for each oil storage tank.

2.2 A measuring device to measure the amount of asphalt in the storage tank. A calibrated stick or tape measure.

NOTE: The asphalt storage tanks must be level and remain level for measurements to be reliable.

3. Procedure:

Back

3.1 Measure the depth and take the temperature of the asphalt binder in the storage tank or tanks before the plant starts to produce hot mix.

3.2 Determine the number of gallons of asphalt binder at the storage temperature from the charts furnished for the storage tank capacity. Convert this gallon quantity to a weight quantity in pounds by using one of the formulas on the back of form DOT-89. (Figure 1) These formulas are used to determine the weight per gallon of asphalt binder at a particular temperature by using a multiplier for correcting oil volumes to the basis of 60° F. Multiply the weight per gallon of asphalt binder at the storage temperature by the number of gallons and divide by 2,000 lbs. to get the tons of asphalt binder in the storage tank.

The weight per gallon of asphalt binder at 60° F and/or the specific gravity of the asphalt binder can be found on the Certificate of Compliance or weight ticket furnished with each load of asphalt binder delivered to the project.

3.3 Add up the weight in tons of the truckloads of asphalt binder added to the storage tanks during the day.

3.4 Measure the depth and take the temperature of the asphalt binder in the storage tank or tanks after the plant finishes producing hot mix.

3.5 Convert the gallons of asphalt binder to tons by using the same procedure as used in 3.2 above.

3.6 Record the weight of all hot mix produced by the plant in tons.

4. Report:

4.1 Calculate the daily asphalt binder content in the following manner to the nearest 0.01% on a DOT-89.

$$\text{Daily asphalt binder content} = \frac{(A + B - C) \times 100}{D}$$

A = Tons of asphalt binder in the storage tanks at the start of the day.

B = Tons of asphalt binder added to storage tanks during the day.

C = Tons of asphalt binder in the storage tanks at the end of the day.

D = Tons of hot mix produced during the day.

4.2 Report the daily asphalt binder content to one decimal place.

5. References:

Back

DOT-66
DOT-89

Sample ID 2223389

Bitumen Content Determination

DOT-89
3-19

Report No. 14

County Aurora, Ziebach

PCN/PROJECT B015 PH 0066(00)15

Test Date 05/03/2019

Inspector Tester, One

Contractor Roads, Inc

Percent Bitumen Desired

Percent Used By Test 5.9

Bitumen Type 320E0008 - PG 64-34 Asphalt Binder

Back

TANK METHOD	Tank #1	Tank #2
A. Beginning Specific Gravity of Bitumen @ 60 F	1.033	1.03
B. Beginning Weight Per Gallon @ 60 F	8.6034	8.6034
C. Temperature of Bitumen in Tank When Check Starts	305	298
D. Weight Per Gallon of Bitumen at Temperature (*)	7.890	7.910
E. Gallons in Tank When Check Starts (calibrated stick)	18,495	18,465
Gallons at Start (at start of tank use)	☐	☐
F. Weight of Bitumen in Tank (start check) (D x E / 2000)	72.96	73.03
G. Weight of Bitumen Added to Tank(s)	282.20	
H. Temperature of Bitumen in Tank When Check Ends	301	298
I. Gallons in Tank When Check Ends (calibrated stick)	17,745	18,465
J. Ending Specific Gravity of Bitumen @ 60 F	1.033	1.033
K. Ending Weight Per Gallon @ 60 F	8.6034	8.6034
L. Weight Per Gallon at Temperature (*)	7.901	7.910
M. Weight of Bitumen in Tank (end check) (I x L / 2000)	70.10	73.03
Left in Storage (at end of tank use)	☐	☐
N. Weight of Bitumen Used (F + G - M)	285.06	
O. Weight of Mix Produced (Tons)	4,833.21	
P. Percent Bitumen in Mix (N / O x 100)	5.90	

G. Load #	Invoice #	Tons
032	184619	40.22
033	184620	40.49
034	184621	40.47
035	184622	40.21
036	184623	40.26
037	184623	40.26
038	184624	40.29

	Summary of Mix Produced		Bitumen	
To Road	4,827.21	Tons	284.71	Tons
Plant Waste	5.00	Tons	0.29	Tons
Road Waste	1.00	Tons	0.06	Tons
To Others		Tons		Tons
Produced	4,833.21	Tons		

REMARKS

Comments

Figure 1

DETERMINING POUNDS OF BITUMEN PER GALLON (Figure 1 cont.)
[Tank #1 Example]

1. **1.033** X **0.9171** **X 8.328 (1) =** **7.890** (Lbs. of Bitumen per Gallon @ Temp.) 23
(Spec. Gravity of Bitumen) (Temp. Factor)

2. **8.6034** X **0.9171** **=** **7.890** (Lbs. of Bitumen per Gallon @ Temp.)
(Wt. per Gallon @ 60°F) (Temp. Factor)

Back

Temp. ºF	Factor
225	0.9436
230	0.9419
235	0.9402
240	0.9385
245	0.9369
250	0.9352
255	0.9336
260	0.9319
265	0.9302
270	0.9286
275	0.9269
280	0.9253
285	0.9236
290	0.9220
295	0.9204
300	0.9187
305	0.9171
310	0.9154
315	0.9138
320	0.9122
325	0.9105
330	0.9089
335	0.9073
340	0.9057
345	0.9040
350	0.9024

(Table for converting pounds of bitumen per gallon – Applicable for DOT-89 & DOT-66)

Sample ID 2225780

File No.

Asphalt Plant Mix - Spot Check

DOT-66
7-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Field # 01 Date Sampled 07/03/2019 Date Tested 07/03/2019

Inspector Tester, One Contractor Roads, Inc

Back

TANK METHOD	Tank #1	Tank #2
A. Beginning Specific Gravity of Bitumen @ 60 F	1.320	1.032
B. Beginning Weight Per Gallon @ 60 F	8.5945	8.5945
C. Temperature of Bitumen in Tank When Check Starts	300	300
D. Weight Per Gallon of Bitumen at Temperature (*)	7.896	7.896
E. Gallons in Tank When Check Starts (calibrated stick)	3,685	6,304
Gallons at Start (at start of tank use)	☐	☐
F. Weight of Bitumen in Tank (start check) (D x E / 2000)	14.55	24.89
G. Weight of Bitumen Added to Tank(s)	184.92	
H. Temperature of Bitumen in Tank When Check Ends	300	300
I. Gallons in Tank When Check Ends (calibrated stick)	3,332	5,771
J. Ending Specific Gravity of Bitumen @ 60 F	1.320	1.032
K. Ending Weight Per Gallon @ 60 F	8.5945	8.5945
L. Weight Per Gallon at Temperature (*)	7.896	7.896
M. Weight of Bitumen in Tank (end check) (I x L / 2000)	13.15	22.78
Left in Storage (at end of tank use)	☐	☐
N. Weight of Bitumen Used (F + G - M)	188.43	
O. Weight of Mix Produced (Tons)	3,101.80	
P. Percent Bitumen in Mix (N / O x 100)	6.07	

METER METHOD

Q. Applied Temperature of Bitumen	300
R. Weight Per Gallon (D) of BItumen at Applied Temperature	7.896
S. Weight of Mix Produced (tons)	3,101.80

Meter Reads in Weight		Meter Reads in Gallons	
T. Stop (tons)		T. Stop (gallons)	
U. Start (tons)		U. Start (gallons)	
V. Net Weight		V. Net Weight	
V / S x 100 =	% bitumen in mix	R x (V / S)/2000 x 100 =	% bitumen in mix

Comments

Figure 2

Sample ID 2225789

File No.

Asphalt Plant Mix - Spot Check

DOT-66
7-19

PROJECT PH 0066(00)15
COUNTY Aurora, Ziebach
PCN B015
Field # 02
Date Sampled 07/03/2019
Date Tested 07/03/2019
Inspector Tester, One
Contractor Roads, Inc

TANK METHOD	**Tank #1**
A. Beginning Specific Gravity of Bitumen @ 60 F	
B. Beginning Weight Per Gallon @ 60 F	
C. Temperature of Bitumen in Tank When Check Starts	300
D. Weight Per Gallon of Bitumen at Temperature (*)	
E. Gallons in Tank When Check Starts (calibrated stick)	
Gallons at Start (at start of tank use)	☐
F. Weight of Bitumen in Tank (start check) (D x E / 2000)	
G. Weight of Bitumen Added to Tank(s)	0.00
H. Temperature of Bitumen in Tank When Check Ends	
I. Gallons in Tank When Check Ends (calibrated stick)	
J. Ending Specific Gravity of Bitumen @ 60 F	
K. Ending Weight Per Gallon @ 60 F	
L. Weight Per Gallon at Temperature (*)	
M. Weight of Bitumen in Tank (end check) (I x L / 2000)	
Left in Storage (at end of tank use)	☐
N. Weight of Bitumen Used (F + G - M)	
O. Weight of Mix Produced (Tons)	1,256.00
P. Percent Bitumen in Mix (N / O x 100)	

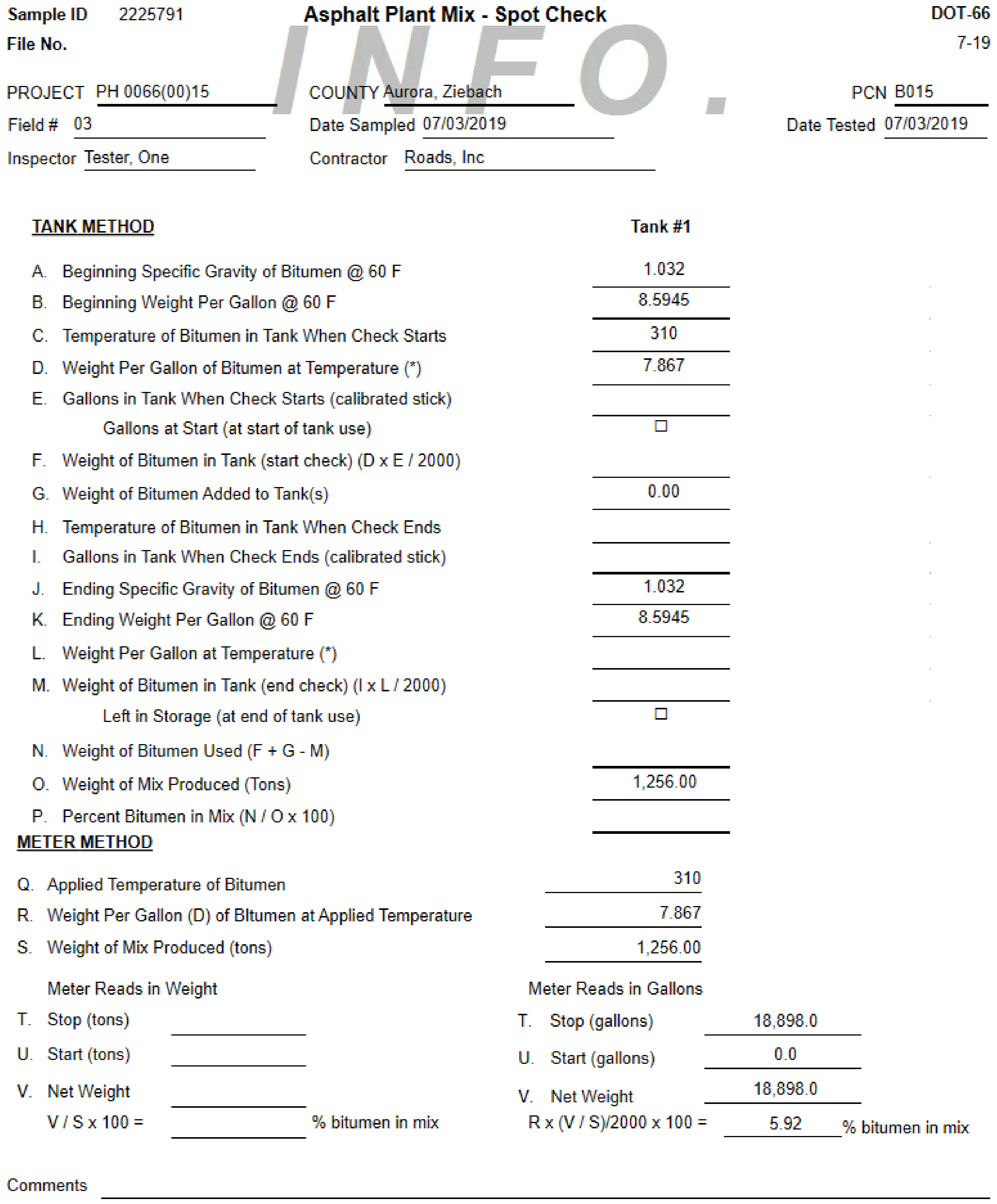
Back

METER METHOD	
Q. Applied Temperature of Bitumen	300
R. Weight Per Gallon (D) of BItumen at Applied Temperature	
S. Weight of Mix Produced (tons)	1,256.00

Meter Reads in Weight			Meter Reads in Gallons		
T. Stop (tons)	73.0		T. Stop (gallons)		
U. Start (tons)	0.0		U. Start (gallons)		
V. Net Weight	73.0		V. Net Weight		
V / S x 100 =	5.81	% bitumen in mix	R x (V / S)/2000 x 100 =		% bitumen in mix

Comments

Figure 3



Sample ID 2225791

File No.

Asphalt Plant Mix - Spot Check

DOT-66
7-19

PROJECT PH 0066(00)15
COUNTY Aurora, Ziebach
PCN B015
Field # 03
Date Sampled 07/03/2019
Date Tested 07/03/2019
Inspector Tester, One
Contractor Roads, Inc

Back

<u>TANK METHOD</u>	**Tank #1**
A. Beginning Specific Gravity of Bitumen @ 60 F	1.032
B. Beginning Weight Per Gallon @ 60 F	8.5945
C. Temperature of Bitumen in Tank When Check Starts	310
D. Weight Per Gallon of Bitumen at Temperature (*)	7.867
E. Gallons in Tank When Check Starts (calibrated stick)	
Gallons at Start (at start of tank use)	☐
F. Weight of Bitumen in Tank (start check) (D x E / 2000)	
G. Weight of Bitumen Added to Tank(s)	0.00
H. Temperature of Bitumen in Tank When Check Ends	
I. Gallons in Tank When Check Ends (calibrated stick)	
J. Ending Specific Gravity of Bitumen @ 60 F	1.032
K. Ending Weight Per Gallon @ 60 F	8.5945
L. Weight Per Gallon at Temperature (*)	
M. Weight of Bitumen in Tank (end check) (I x L / 2000)	
Left in Storage (at end of tank use)	☐
N. Weight of Bitumen Used (F + G - M)	
O. Weight of Mix Produced (Tons)	1,256.00
P. Percent Bitumen in Mix (N / O x 100)	

<u>METER METHOD</u>

Q. Applied Temperature of Bitumen	310
R. Weight Per Gallon (D) of BItumen at Applied Temperature	7.867
S. Weight of Mix Produced (tons)	1,256.00

Meter Reads in Weight		Meter Reads in Gallons	
T. Stop (tons)		T. Stop (gallons)	18,898.0
U. Start (tons)		U. Start (gallons)	0.0
V. Net Weight		V. Net Weight	18,898.0
V / S x 100 =	% bitumen in mix	R x (V / S)/2000 x 100 =	5.92 % bitumen in mix

Comments

Figure 4

In Place Density Determination of Asphalt Concrete by the Coring Method

---

1. Scope:

This procedure is for determining the density of in place asphalt concrete pavement.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram. The scale or balance will be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the weighing device.

2.2 Coring device capable of getting a minimum 4” diameter core from the pavement.

2.3 Diamond tipped blade cut off saw capable of sawing the 4" or larger core on the correct lift line without distortion and damage to the core.

Back

2.4 The water bath for immersing the sample will be equipped with an overflow outlet for maintaining a constant water level. An aquarium heater will suffice to control the temperature of the water bath at 77° ± 2° F. The water bath must be large enough to allow the suspension apparatus holder to be covered with water at all times. The sample and suspension apparatus must be completely covered with water during weighing. The wire suspending the suspension apparatus will be the smallest practical size to minimize any possible effects of a variable immersed length.

3. Procedure:

3.1 Randomly select 2 core sites per 1000 ton sublot and mark for the Contractor to core. Random core locations will be located within the pay factor asphalt mix being placed in the sublot. Core locations that fall within one foot from the edge of the paving sublot will be adjusted so that the core is taken one foot from the paving sublot edge line. Exercise care when removing the core from the pavement to prevent distortion or cracking. Label the core sample.

3.2 After removing the core, fill the hole in the pavement before the end of the next working day with mix and tamp to a density, which will be close to that of the surrounding pavement.

3.3 Transport the cores to the field laboratory site. Measure the core lift to the nearest .05 inch or 1/16” and record the measurements on a core dry back worksheet (DOT-42Q). Remove the pavement lift of interest from the core by using a cut off or masonry saw with a diamond tipped blade. Inspect the core for damage. Record the sawed core thickness on line (A) of the core dry back worksheet (DOT-42Q).

3.4 Weigh the core and record the apparent dry weight in air to the nearest 0.1 gram on line (B).

NOTE: Cores and pucks will be **weighed individually**.

3.5 Immerse each core in water at 77° ± 2° F for 3 to 3.5 minutes and record the submersed weight in water to the nearest 0.1 gram on line (C). Maintain a constant level of water in the water bath at the overflow outlet through the entire test procedure.

3.6 Remove each core from the water and surface dry by blotting with a damp terry cloth towel and record the saturated surface-dry weight in air to the nearest 0.1 gram on line (D).

3.7 Calculate the volume of the core (D - C). Record on line (E).

NOTE: Cores have taken on water from the coring and sawing process. The following procedure must be used to get the water out of the cores.

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3.8 Record the pan number on line (F).

3.9 Record the weight of the pan to the nearest 0.1 gram on line (G).

3.10 Place the core in the pan and place in an oven at 230 ± 9° F for 2 hours. Record the start time on the DOT-42Q.

3.11 After the 2 hour period, record the weight of the core and the pan to the nearest 0.1 gram on the first time space on line (J).

3.12 Place the core and pan back in the oven and weigh at 1 hour intervals until the core has reached a constant weight. Constant weight is attained when the weight loss is within 0.1 percent of the apparent dry weight. Calculate the amount of allowable loss (B x .001) to the nearest 0.1 gram. Record on line (M).

3.13 After a constant weight has been attained, cool the pan and core to room temperature. Record the weight of cooled core and pan to the nearest 0.1 gram on line (N).

3.14 Determine the actual dry weight of the core (N - G). Record on line (H).

3.15 Determine the core bulk specific gravity (H / E) to the nearest 0.001. Record on line (I).

3.16 Determine the moisture in the core (D - H). Record on line (K).

3.17 Calculate the percent water absorbed by volume (K / E x 100) to the nearest 0.1 percent. Record on line (L).

Example for determining coring locations using QC/QA stratified random sampling procedure:

Each 1000 ton sublot is divided into two 500 ton sections of pavement (one core per 500 ton). Using a random number table generate two random numbers to determine the location for each core. The first random number determines the tonnage into the sublot where the core will be taken. The second random number determines the offset distance from centerline or paving edge line where the core will be taken. The station of the random tonnage can be taken from the asphalt checkers weigh tickets. Round the longitudinal distances to the nearest foot and the offset distances to the nearest 0.5 foot.

The table shows a method using random numbers to determine the core stationing and offset distance from the beginning tonnage of the lot. The tonnage corresponds to the station, which is on the asphalt checkers weigh ticket. Cores to be used for IA testing will be taken at the same offset as the QA core. Note that the whole lot does not need to be completed prior to determining the coring locations for each individual core.

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Core			(Longitudinal location)				
site		Random #	Tonnage	Station	Distance from centerline		
1A	0 +	(500 x 0.57) =	285 ton;	83+86	12 x 0.82 = 9.8’	-	10’ Lt.
1B	500 +	(500 x 0.90) =	950 ton;	97+21	12 x 0.34 = 4.1’	-	4’ Lt.
2A	1,000 +	(500 x 0.47) =	1235 ton;	102+90	12 x 0.68 = 8.2’	-	8’ Lt.
2B	1,500 +	(500 x 0.07) =	1535 ton;	108+88	12 x 0.24 = 2.9’	-	3’ Lt.
3A	2,000 +	(500 x 0.87) =	2435 ton;	126+94	12 x 0.42 = 5.0’	-	5’ Lt.
3B	2,500 +	(500 x 0.90) =	2950 ton;	137+17	12 x 0.88 = 10.6’	-	10.5 Lt.
4A	3,000 +	(500 x 0.88) =	3440 ton;	146+95	12 x 0.97 = 11.6’*	-	11’ Lt.
4B	3,500 +	(500 x 0.19) =	3595 ton;	150+10	12 x 0.70 = 8.4’	-	8.5’ Lt.
5A	4,000 +	(500 x 0.34) =	4170 ton;	161+61	12 x 0.36 = 4.3’	-	4.5’ Lt.
5B	4,500 +	(500 x 0.85) =	4925 ton;	176+66	12 x 0.23 = 2.8’	-	3’ Lt.

* Any transverse distance closer than one (1) foot from either paving edge line is moved to one (1) foot from the paving edge line from typical section.

The Contractor will take cores with the quality assurance technician witnessing the sampling. The core will I be centered over the selected coring location and immediately transported to the QA Lab for testing. The cores will be measured and then separated on the lift line by means of sawing with a diamond blade cut off or masonry saw being careful not to damage the core. The density of each core is determined and the average core density for each 1,000 ton sublot is then determined. The average of the lot’s maximum specific gravity (Rice) tests is used to compute the lot average density.

4. Report:

4.1 Calculate the core bulk specific gravity to the nearest 0.001.

4.2 Calculate the core density percent of standard to the nearest 0.01 percent by dividing the core bulk specific gravity by the lot's average maximum theoretical specific gravity.

4.3 Calculate the average density percent of standard of the two cores in each sublot to the nearest 0.1 percent.

5. References:

DOT-42Q

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Sample ID: 2229719

Density Report - Bituminous Surfacing

DOT-42Q
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Class and Type Class Q2 Hot Mixed Asphalt Concrete Lift 1 of 1 Thickness 2"
% Asphalt Binder 5.1 Actual Finished Width 12.00 Station 665+10
Tested By Tester, Two Checked By Tester, One Date Tested 06/08/2019
Specification Requirement - Percent of Standard Required 92.0 - 96.0
Lot No. 1 Lot Location Sta. 623+15 to 482+50 Lt & 623+15 to 550+90 Rt
Core Site Length 21,290.00 Lot Width 24 Quantity Represented 5000 tons

Core Measurement Before Sawing	5 1/2	5 1/2	5 3/4	5 1/2	6	5 1/4	4 3/8	4 3/8	5	5 1/2								
Core Number	1 A	1 B	2 A	2 B	3 A	3 B	4 A	4 B	5 A	5 B	6 A	6 B	7 A	7 B	8 A	8 B	9 A	9 B
Lift Measured Thickness																		
21.80																		

A. Sawed core thickness	2 1/8	3	2 1/2	1 7/8	2 1/4	2 1/8	2 1/16	2 1/8	2 1/8	2 5/8								
B. Apparent dry weight in air	993.70	1,432.10	1,303.20	925.30	1,009.60	1,032.60	1,025.40	995.50	1,062.60	1,276.80								
C. Submersed weight in water	559.70	829.30	739.10	526.70	568.70	592.80	580.60	562.70	611.40	734.50								
D. SSD weight in air	994.20	1,439.90	1,303.80	925.80	1,010.10	1,033.20	1,026.00	995.90	1,063.00	1,277.30								
E. Volume of the core (D - C)	434.50	610.60	564.70	399.10	441.40	440.40	445.40	433.20	451.60	542.80								
F. Pan number	1	2	3	1	4	5	2	3	6	3								
G. Weight of pan	134.800	132.300	131.400	134.800	134.000	128.700	132.400	131.600	132.400	131.500								
H. Actual dry weight (N - G)	985.1	1,432.1	1,287.9	916.6	998.6	1,029.5	1,020.1	988.1	1,058.5	1,270.5								
I. Core bulk specific gravity (H / E)	2.267	2.345	2.281	2.297	2.262	2.338	2.290	2.281	2.344	2.341								
K. Moisture in core (D - H)	9.1	7.8	15.9	9.2	11.5	3.7	5.9	7.8	4.5	6.8								
L. Percent water absorbed by volume (K / E) * 100	2.1	1.3	2.8	2.3	2.6	0.8	1.3	1.8	1.0	1.3								
M. Maximum allowable weight loss in 1 hour (B x 0.001)	1.0	1.4	1.3	0.9	1.0	1.0	1.0	1.0	1.1	1.3								

Figure 1

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Core Drying Weigh Back Area

	Time (J)																		
After reaching constant weight, allow the core & pan to cool to room temp. before weighing for the final time (N)	8:30 am																		
	10:30 am	1,120.30	1,564.70	1,420.00															
	11:30 am	1,119.50	1,563.70	1,418.90															
	10:00 am																		
	12:00 pm				1,051.40	1,132.70	1,158.10	1,152.50	1,120.20	1,190.80									
	1:00 pm				1,051.30	1,132.60	1,157.80	1,152.30	1,119.50	1,190.60									
	9:15 am																		
	11:15 am										1,402.40								
	12:15 pm										1,402.00								
N. Weight of cooled core and pan		1,119.90	1,564.40	1,419.30	1,051.40	1,132.60	1,158.20	1,152.50	1,119.70	1,190.90	1,402.00								

Theoretical Maximum Specific Gravity

Sublot No.	1	2	3	4	5
Max. Sp. Gr.	2.479	2.478	2.477	2.473	2.468

Lot Average Maximum Specific Gravity (Standard) 2.475

In-Place Density Measurement

Percent of Standard = [(Core Bulk Specific Gravity / Lot Average Maximum Specific Gravity)] × 100

Core Sublot No.	Height	Rand. No.	Cumulative Tonnage	Station for Core	Rand. No.	Paving Width	Distance from C/L	Actual Dry Weight	Weight in Water	SSD Weight	Core Bulk Sp. Gr.	% of Stand.	**Avg. % Stand.**
1A	2 1/8	0.660	330	641+60	0.530	24	12.7 LT	985.1	559.7	994.2	2.267	91.60	93.2
1B	3	0.250	625	612+30	0.730	24	17.5 LT	1432.1	829.3	1439.9	2.345	94.75	
2A	2 1/2	0.820	1410	617+50	0.190	24	4.6 LT	1287.9	739.1	1303.8	2.281	92.16	92.5
2B	1 7/8	0.750	1875	587+20	0.090	24	2.2 LT	916.6	526.7	925.8	2.297	92.81	
3A	2 1/4	0.700	2350	570+40	0.600	24	14.4 LT	998.6	568.7	1010.1	2.262	91.39	92.9
3B	2 1/8	0.280	2640	550+90	0.450	24	10.8 LT	1029.5	592.8	1033.2	2.338	94.46	
4A	2 1/16	0.730	3365	582+80	0.550	24	13.2 LT	1020.1	580.6	1026.0	2.290	92.53	92.3
4B	2 1/8	0.510	3755	556+70	0.520	24	12.5 LT	988.1	562.7	995.9	2.281	92.16	
5A	2 1/8	0.620	4310	515+60	0.380	24	9.1 LT	1058.5	611.4	1063.0	2.344	94.71	94.7
5B	2 5/8	0.740	4870	482+50	0.810	24	19.4 LT	1270.5	734.5	1277.3	2.341	94.59	

Percent Density
93.1

Figure 1A

South Dakota Asphalt Concrete Marshall Mix Design Procedure

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1. Scope:

This standard practice for mix design evaluation uses aggregate and mixture properties to produce an asphalt concrete mix design formula that meets the specification requirements. This standard is for asphalt concrete hot mix that may or may not contain reclaimed asphalt pavement (RAP).

Contractors and consultants shall contact the Area Engineer when requesting to submit a mix design to the SDDOT Bituminous Mix Design Lab. Mix Designs will not be performed on samples that are not submitted through the Area Engineer and accompanied by the Area's properly filled out data sheet. The Engineer shall witness and/or take the sample. 50 percent of the plan quantity of material or 15,000 tons whichever is less shall be produced prior to material being submitted for a mix design. The Department may allow the Contractor to transport and deliver the RAP and aggregates samples for mix design and aggregate quality testing only when the Area office representative has sealed the samples with a tamper evident tag, with the DOT-1 attached.

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2. Apparatus:

2.1 Humboldt slant foot (1 degree bevel) rotating base hammer is kept in the South Dakota Central Office Mix Design Lab. All other hammers will be compared/calibrated against this hammer. Slant foot rotating base hammers can be used if results can be obtained which are comparable to those obtained in the South Dakota Central Office Mix Design Lab. The South Dakota Mix Design Lab's hammer has been calibrated to a hand-operated hammer.

2.2 All related equipment and/or apparatus to perform parts or all of tests including: SD 108, SD 201, SD 202, SD 206, SD 208, SD 209, SD 210, SD 211, SD 212, SD 213, SD 214, SD 217, SD 220, SD 221, SD 301, SD 306, SD 309, SD 312, SD 313, SD 316, SD 318, AASHTO T 164, and AASHTO T 308.

3. Procedure:

3.1 Preparation of aggregates.

The average gradation of each individual aggregate fraction shall be used when combining to form an aggregate composite. This average shall come from testing done on the individual fraction/stockpile prior to the asphalt concrete mix design being performed.

NOTE: When recycled asphalt pavement (RAP) is allowed, it will not be included in meeting the total aggregate requirements set forth in the plans, Special Provisions, and/or Specification Book.

A. The following are the minimum number of size fractions to use when recombining the gradation of each individual stockpile. The 3/4", 1/2", 3/8”, #4, #8, and all material passing the #8 are the minimum number of sizes required to be used when recombining the stockpiles.

B. Bulk specific gravity of the aggregate (G_{sb}) is determined by SD 209, and SD 210 for each fraction and combining to form a composite total G_{sb} and a - #4 G_{sb}. SDDOT Bituminous Office will determine both the total G_{sb} and the + #4 G_{sb} and - #4 G_{sb} on the total composite and not on individual fractions.

NOTE: When RAP is included in the plans, determine the asphalt binder content by conducting at least two extractions or ignition oven tests (Only if a correction factor is known). Determine the RAP aggregate gradation from the extractions (AASHTO T 164) or ignition oven tests (AASHTO T 308) and show the average RAP virgin aggregate only gradation on the mix design sheet. When 20 percent or less RAP is used in the mix design, use the G_{sb} from the old RAP mix design for the RAP virgin mineral aggregate G_{sb} or by conducting G_{sb} tests on the extracted or ignition oven aggregate samples using SD 209 and SD 210. If more than 20 percent RAP is used the G_{sb} shall be determined by conducting G_{sb} tests on the extracted or ignition oven aggregate samples using SD 209 and SD 210.

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C. Determine consensus virgin aggregate properties for the composite gradation including:

Crushed particles (SD 211), fine aggregate angularity (SD 217), flat & elongated particles (SD 212), and sand equivalent (SD 221). Also, determine source virgin aggregate properties for lightweight particles (SD 208, SD 214), sodium sulfate soundness (SD 220) (Optional), and Los Angeles abrasion loss (AASHTO T 96) (Optional), if have previous tests from pit history.

3.2 Determination of mixing and compacting temperatures.

A. Performance graded binder (PG); mixing temperature shall be 300° ± 10°F.

B. Performance graded binder (PG 58-28, PG 64-22); compaction temperature shall be 270° ±5° F, (PG 58-34, PG 64-28) compaction temperature shall be 275° ±5° F., (PG 64-34, PG 70-28) compaction temperature shall be 280° ±5° F.

3.3 Preparation of mixtures.

A. Adjust the laboratory sample gradations to meet the average stockpile gradations down to the #8 and recalculate the laboratory - #8 gradation to reflect the changes. Weigh into pans material from each fraction to form a composite. Heat aggregate composite samples in an oven overnight or for a minimum of four hours to a temperature not exceeding 50° F above the mixing temperature.

NOTE: If recycled asphalt pavement is allowed, heat the RAP in an individual oven for a period of no more than two hours at 230° ± 5° F and add soon after heating to the mixture of aggregate and binder. Also, when RAP is added, care must be taken to thoroughly mix all components.

B. Following mixing immediately put the mixture in a covered container in an oven maintained at the compaction temperature for a period of two hours. At least three sets of specimens are to be made at 0.5% oil increments. This will include 3 Marshall samples made using SD 313. Two G_{mm} (SD 312) samples are to be made at the center oil increment. The oil content will be based on the total weight of the bituminous mixture.

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NOTE: This total weight of mixture would include RAP if it is allowed in the mixture. An example of combining virgin aggregate, RAP, lime, and 4.5% virgin binder is as follows for a total sample of 4750 grams:

Virgin aggregate = 3591.0 g (80%) + RAP = 897.7 g (20%) + 47.5 g (1.00%) hydrated lime + 213.8 g (4.50%) virgin binder = 4750.0 g. The RAP contains 6.00% binder content from the average of two extractions. 53.9 g is from the RAP binder. The total asphalt binder content of the sample is (213.8 g + 53.9 g) / 4750 x 100 = 5.64%. 4.50% added from the new virgin binder is a contribution of 79.9% to the total binder content and 1.13% from the RAP binder is a contribution of 20.1% to the total binder content.

3.4 Compaction of specimens.

Combining elements of 3.1, 3.2 and 3.3 compact the specimens with a Marshall hammer using SD 313. The number of Marshall blows is included in the plans, plan notes, Standard Specification book and/or Special Provision for a specific project. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with SD 313.

3.5 Determine the air voids (V_a), voids in the mineral aggregate (VMA), voids filled with asphalt (VFA), dust to effective binder ratio, Marshall stability, and Marshall flow for each binder percent increment in accordance with the formulas and calculations in Asphalt Institute MS-2 or SD 318.

4. Report:

4.1 The Contractor’s material and data submitted to the SD DOT Mix Design Lab in Pierre must meet all of the specifications and requirements as shown in the plans, plan notes, Standard Specifications book and the Special Provision Regarding quality control/quality assurance specifications that apply to the project.

4.2 The Contractor’s mix design submittal will include the source of the binder, bin splits selected to use along with the legal pit descriptions of all the materials, average gradation of the stockpiles, and the recommended JMF gradation values to be used for the mix design.

4.3 The SD DOT Mix Design Lab will complete the mix design submitted by the Contractor/Area and conduct all necessary mix design quality tests required on the mineral aggregate, RAP, and asphalt concrete mixture. When the mix design is completed by the Department’s Bituminous Mix Design Lab, an approved mix design report (DOT-64) will be provided to the Area Engineer and the Contractor prior to production.

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5. References:

AASHTO T 245
Listed in 2.2 above

Procedure for Evaluating Quality Control Test Results of Aggregate Gradations, Theoretical Maximum Specific Gravity, and Bulk Specific Gravity of Asphalt Concrete Mixes

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1. Scope:

To provide a procedure for comparing the Contractor's quality control (QC) test results with the Department of Transportation's quality assurance (QA) test results for the lot. This procedure is for aggregate gradation and specific gravities of hot mix asphalt concrete and should be used by Area personnel to determine if the QC and QA samples are similar or dissimilar. The similar/dissimilar test should be used to verify that sampling and testing methods are giving comparable test results for the lot tested.

2. Procedure:

2.1 Immediately after the completion of a lot, determine the average of the QC test results for that individual lot. Determine the average percent passing for each sieve size and the average of the theoretical maximum (Rice) and bulk (Marshall) specific gravities of the hot mix asphalt concrete.

2.2 Determine the range (R) of the QC samples from the lot by subtracting the smallest test value from the largest value. The range will be calculated for each sieve size, theoretical maximum (Rice) and bulk (Marshall) specific gravities.

2.3 Determine the upper and lower interval (I) of the QC test results by using the following equation:

$$I = \text{Average} \pm \text{Constant} \times \text{Range}$$

Number of QC samples used in calculating average	Constant
9	0.97
8	1.05
7	1.17
6	1.33
5	1.61

2.4 Compare the quality assurance sample tests with the calculated interval (I). A comparison will be made on each sieve size. The comparison will also be made for the theoretical maximum and bulk specific gravities.

2.5 Determine if the results are similar or dissimilar. If all the test results of the QA sample coincide with, or lie between, the upper and lower limits of their interval, the QC samples will be considered similar to the QA sample. If the QA sample has any sieve size or specific gravity in which a result does not coincide with or lie between the upper and lower limits of their interval, the QC samples will be considered dissimilar to the QA sample.

2.6 If the results are dissimilar, action must be taken to determine the reason for the dissimilar results. Review the QA and QC sampling procedures. Review the QA and QC testing procedures. Check scales and all other testing equipment. Review computations and the reporting procedure. Perform any additional investigation that may clarify the reason for the dissimilarity. The Region Materials Engineer should be involved in the review and investigation. Region Materials IA test results may be used to help identify the reason for the dissimilar test result.

2.7 Perform additional testing if any test result is found to be dissimilar until the reason for the dissimilar test result is found and documented. Document the results of the additional testing and findings in the field diary and the similar/dissimilar worksheet.

3. Report:

Report the results on the similar/dissimilar worksheet. Report the similarity as (Yes) similar or (No) dissimilar on the DOT 3 or DOT 42QA and include the signature of the individual determining if the results are similar or dissimilar. The following computer spread sheet can be used for determining similar/dissimilar results. The spread sheet is available from the SDDOT Bituminous Engineer or from the DOT U drive (U:\ms\Qcqa). The spreadsheet will be available in the MS&T system to record the results.

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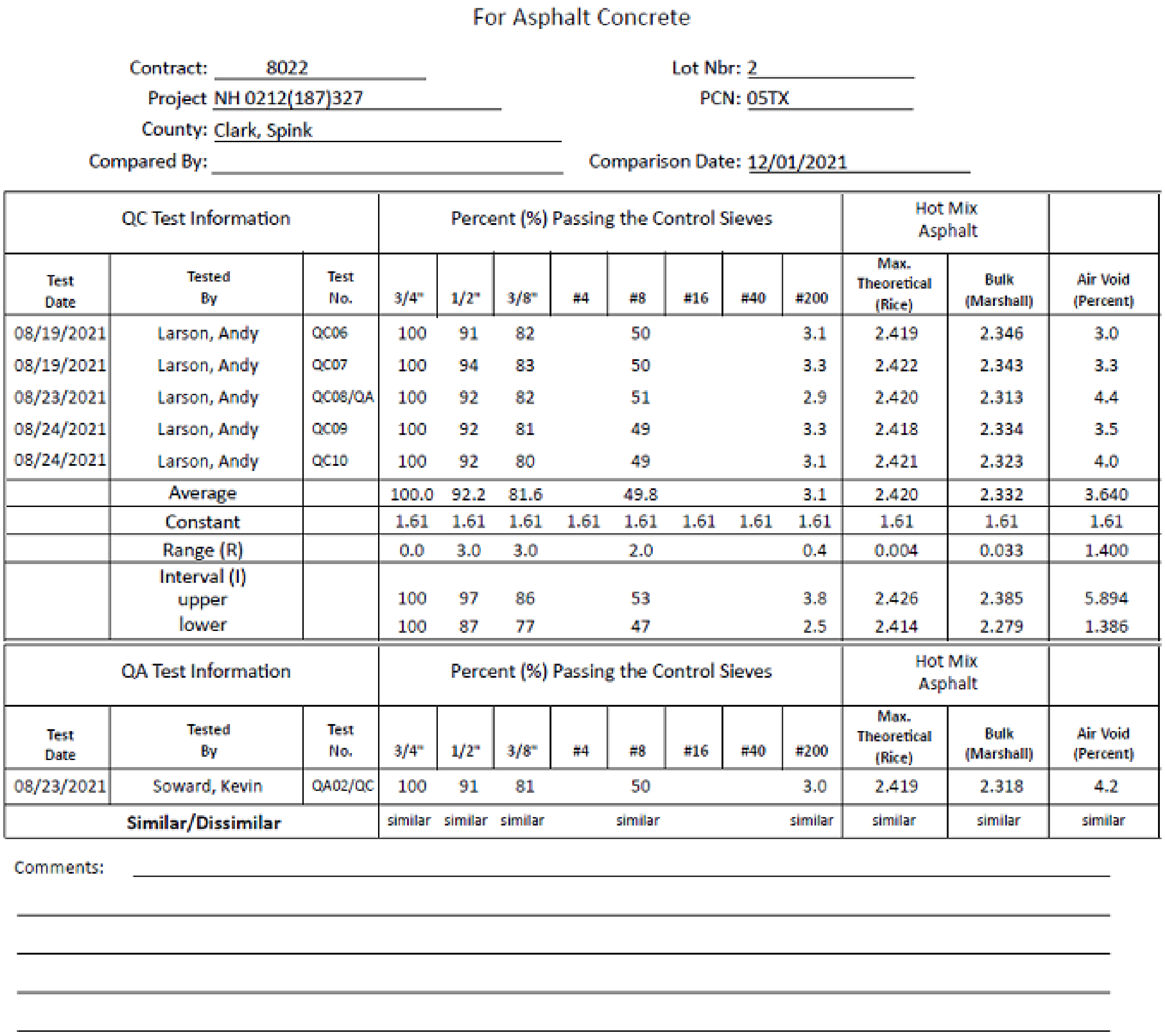
4. References:

Similar/dissimilar worksheet



For Asphalt Concrete

Contract: 8022
Lot Nbr: 2
Project NH 0212(187)327
PCN: 05TX
County: Clark, Spink
Compared By:
Comparison Date: 12/01/2021

QC Test Information			Percent (%) Passing the Control Sieves								Hot Mix Asphalt		
Test Date	Tested By	Test No.	3/4"	1/2"	3/8"	#4	#8	#16	#40	#200	Max. Theoretical (Rice)	Bulk (Marshall)	Air Void (Percent)
08/19/2021	Larson, Andy	QC06	100	91	82		50			3.1	2.419	2.346	3.0
08/19/2021	Larson, Andy	QC07	100	94	83		50			3.3	2.422	2.343	3.3
08/23/2021	Larson, Andy	QC08/QA	100	92	82		51			2.9	2.420	2.313	4.4
08/24/2021	Larson, Andy	QC09	100	92	81		49			3.3	2.418	2.334	3.5
08/24/2021	Larson, Andy	QC10	100	92	80		49			3.1	2.421	2.323	4.0
	Average		100.0	92.2	81.6		49.8			3.1	2.420	2.332	3.640
	Constant		1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
	Range (R)		0.0	3.0	3.0		2.0			0.4	0.004	0.033	1.400
	Interval (I)												
	upper		100	97	86		53			3.8	2.426	2.385	5.894
	lower		100	87	77		47			2.5	2.414	2.279	1.386

QA Test Information			Percent (%) Passing the Control Sieves								Hot Mix Asphalt		
Test Date	Tested By	Test No.	3/4"	1/2"	3/8"	#4	#8	#16	#40	#200	Max. Theoretical (Rice)	Bulk (Marshall)	Air Void (Percent)
08/23/2021	Soward, Kevin	QA02/QC	100	91	81		50			3.0	2.419	2.318	4.2
Similar/Dissimilar			similar	similar	similar		similar			similar	similar	similar	similar

Comments:

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Figure 1

Method of Test for Density and Air Voids of Asphalt Concrete by the Gyratory Method

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1. Scope:

This test is to determine the density and air void level of asphalt concrete mix by using the gyratory compactor.

2. Apparatus:

2.1 Gyratory compactor conforming to the requirements of AASHTO T 312.

2.2 Gyratory molds & plates conforming to the requirements of AASHTO T 312.

2.3 Thermometers, dial type, armored glass, or digital with a range of 50° to 400°F with a sensitivity of 5°F.

2.4 Thermometer sensitive to 0.5°F and readable to 1°F.

2.5 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure, accurate and readable to the nearest 0.1 gram. The scale or balance will be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the weighing device.

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2.6 Mechanical convection oven with a minimum chamber volume of 5.0 cubic feet capable of heating to 350°F.

2.7 Flat bottom metal pan, flat bottom scoop, containers, large mixing spoon or small trowel, large spatula, gloves, paper disks, WD-40 lubricant, and grease.

2.8 Water Bath with an overflow outlet for maintaining a constant water level. An aquarium heater will suffice to control the temperature of the water bath at 77° ± 2°F. The water bath must be large enough to allow the suspension apparatus holder to be covered with water at all times. The sample and suspension apparatus must be completely covered with water during weighing. The wire suspension apparatus will be the smallest practical size to minimize any possible effect of a variable immersed length.

3. Procedure:

3.1 Sampling uncompacted mix.

A. Material for the gyratory testing will be obtained from the same sample as will be used for SD 312 but a larger sample must be obtained.

B. Take approximately 160 to 180 lbs. of hot mix for the laboratory density determination, 240 to 260 lbs. when IA testing is required.

C. Transport the sample in a pail or box that is insulated or protected to help retain heat.

D. Place the hot mix in a clean pan where there will be neither loss of material nor the addition of foreign matter. Place the pan and material in an oven maintained at or slightly above the required compaction temperature.

3.2 Gyratory machine preparation.

NOTE: Before operating the gyratory, it's important to make sure that it's ready for operation. The steps below need to be completed prior to operating the Pine Brovold portable (AFGB1A) gyratory. Other gyratory compactors can be used and must be operated according to the manufacturer's recommendations.

A. Make sure the gyratory compactor has been calibrated to an internal angle of (1.16 ± 0.02°) or if using a Pine RAM calibration device, calibrated to a cold internal angle of (1.19 ± 0.03°) and the calibration records are available. SD DOT machines are calibrated by the SD DOT Central Lab.

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B. Make sure that the gyratory is properly lubricated. There are several spots that require a regular application of grease, including:

- a. The ring at the top of the cylinder which controls the angle of the gyration. This should be done prior to running a set of two gyratories.
- b. The ram head on the top of the gyratory. Grease the outer portion of the ram head prior to running a set of three gyratories. This head causes the cylinder to gyrate.
- c. The ram pressure head at the bottom of the cylinder. This is the head that pushes up the plate. This should get a coating of grease prior to running every gyratory, before the mold is put in place.
- d. Once the material is loaded and leveled, put in the paper disk and top plate and grease the top of the plate. This is to be done on every gyratory.
- e. The spherical bearing that contacts the bottom of the mold. The spherical bearing is located below the ram pressure plate. The best way to lubricate it is to use a brush with grease. This should be done once every two gyratories.

C. The gyratory mold needs to be cleaned inside and out with WD-40 at the end of each day to avoid HMA buildup. This is easiest when the molds are hot.

D. Turn the machine on and wait for it to run through the startup routine.

E. Make sure all the “Set Points” on the machine are correct. This is done by going into the “Setup” program on the machine. Most of these, like the dwell and the pressure, are constant and shouldn’t require adjustment. However, the number of gyrations will need to be changed when switching from the design gyration number to the maximum gyration number. This is done in the “Set Gyrations” category at the top of the “Setup” page. The gyrations are specified in the plans and shown on the mix design DOT-64 form. To change any of the settings, using the arrow keys scroll the cursor down to the desired attribute. Type in the number you want and press ↵ “Enter”.

F. Make sure that all pertinent points are lubricated (See gyratory machine preparation, step B)

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3.3 Laboratory density determination.

A. Preheat molds, a flat bottom scoop and a trowel or spatula in an oven to the established mix compaction temperature recommended on the job mix formula (JMF) from the DOT-64 mix design form.

B. Obtain by quartering or by using a heated flat bottom scoop a representative sample from the pan of material used in SD 312 Section 3.3 B. The material placed in the mold will make a specimen 4.5 ± 0.2 inches high and 6 inches in diameter (Approximately 4500-4800 grams of material) and be compacted at established mix design compaction temperature on the JMF.

If the gyratory specimen doesn’t compact to a height of 115 mm ± 5 mm use the following equation to correct the amount of material to put in the mold.

A = Actual weight of the specimen (grams)

(115 X A) ÷ B

B = Actual height of the specimen

C. Heat the hot mix so that compaction takes place when the mix is at the established mix design compaction temperature recommended on the JMF. Thermometers will be calibrated and checked often to insure accurate temperature measurements.

D. Once the hot mix, tools, and mold have reached the correct temperature recommended on the JMF, prepare to make a specimen.

E. Apply grease to bottom ram head. Place a cylinder plate in the bottom of the mold with the beveled end toward the bottom that is heated to compaction temp prior to being placed in the gyratory machine. Put a paper disk in on top of the plate.

F. Place the mold into the gyratory compactor using the tongs, lowering it into the compactor until it reaches bottom, and then rotate the mold clockwise until it stops. Put the funnel on the top of the mold and load the mold with HMA mix in one lift (Usually about 4500-4700 grams of mix), which should only be loaded at the proper mix compaction temperature. Remove funnel, lightly level out the mix with spatula and put paper disk on top. Do not pack the mix. The temperature should be within ± 5° of the mix design compaction temperature shown on the DOT-64 JMF.

G. Place the plate on top of mix, with the beveled edge away from the mix, grease the top of the plate and swing the gyratory head on top of the cylinder and lower the head into place. Lock the gyratory head onto the machine using the three levers.

Back

H. Press "Run" on the machine to get into the "Run Mode", and then press "Start", which will begin the process. As the gyratory is running, keep an eye on the gyrations, pressure, and angle. The gyrations are as specified in the Standard Specifications or plan notes. The pressure should be 600 ± 18 kPa. If the angle goes out (External angle range from calibration) make sure the molds are clean on the outside and the mold and material is at the correct compaction temperature. Call the Central Materials Lab on a SDDOT gyratory before making any adjustments to the machine angle.

I. Once the specified number of gyrations is complete and the ram head returned to its original position, then loosen the three levers on the side of the machine, lift the gyratory head and swing it out of the way.

J. Place the funnel on the top of the machine, press "Unload" twice, and as the gyratory breaks free of the mold, remove the funnel quickly to prevent injury to the gyratory specimen.

K. Once the specimen is completely extruded, remove the top paper disk and carefully remove the specimen from the machine, inverting it before you set it down to allow removal of the bottom paper disk. Set the specimen in front of a fan to cool on a smooth flat surface and cool to room temperature.

L. After the specimen has cooled to room temperature, measure the height at four locations. Record the average height of the specimen to the nearest 0.1 mm.

M. Weigh the specimen in air and record the weight to the nearest 0.1 gram.

N. Suspend the specimen in a water bath at 77° ± 2° F for 3 to 3.5 minutes. Record the immersed weight to the nearest 0.1 gram. Maintain a constant level of water in the water bath at the overflow outlet through the entire test procedure.

O. Immediately after weighing under water, blot the specimen dry with a damp terry cloth towel and record the saturated surface dry weight to the nearest 0.1 gram.

P. Press the "Main Menu" button, and then press "Result". This will bring up a menu with "Select", "Print", and "Send". Press "Print", and the machine will ask you if you want to "Print Report" - "Yes". Press "Enter" to print.

Q. Once the gyratory is unloaded and results printed, grease the machine as needed and ready it for the next test.

R. Make sure to label the gyratory correctly and label the printout sheet the same way.

S. Repeat steps for the other specimen.

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* For more detailed instructions or to solve any problems that might arise, contact the Central Materials Lab (605-773-6994) if problem is not resolved.

4. Report:

Calculations to be completed on the DOT-86:

- G_{mm} - The maximum specific gravity will be determined according to SD 312 to the nearest 0.001.

- ***Put in the plant settings values for "% binder Pb" and "lime" until the actual cutoff values are obtained.

- % Binder P_b - Binder content calculation value determined on DOT-89 to the nearest 0.1 percent.

  For RAP (Recycled Asphalt Pavement) mixes, the Total binder estimate is calculated using the example on the DOT-64 mix design form (Just below the gradation chart).

  The calculated RAP binder content needs to be added to the virgin binder content that was determined on the DOT-89 form to account for the oil that is being added to the mix by the RAP and recorded to the nearest 0.1 percent.

- G_{sb} – Aggregate Composite G_{sb}, found on the DOT-64 mix design JMF reported to the nearest 0.001.

- Binder G_b – Designated on the oil tickets from the supplier reported to the nearest 0.001.

- Dust (- #200) – On the gradation DOT-69 form total / combined - #200 or from the (Acc % passing #200 sieve rounded) column if a + #4 sample was not washed reported to the nearest 0.1 percent.

- Lime – Lime content determination from the DOT-33Q reported to the nearest 0.01 percent.

- Add the dust (-#200) and the lime together and report to the nearest 0.1 percent.

- Obtain the number of gyrations needed for the type of mix design from the Standard Specifications or project plan notes (Field gyration values will be shown on the DOT-64 mix design form).

Complete the following calculations in order as follows:

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1. Effective Specific Gravity of the Mineral Aggregate (Gse).

$$Gse = \left(\frac{100 - Pb}{\left(\frac{100}{Gmm}\right) - \left(\frac{Pb}{Gb}\right)} \right) \qquad [Report\ to\ nearest\ 0.001]$$

2. Percent Asphalt Absorption (Pba).

$$Pba = 100 \times \left(\frac{Gse - Gsb}{Gse \times Gsb}\right) \times Gb \qquad [Report\ to\ nearest\ 0.01\%]$$

3. Percent Aggregate Content of the Mixture (Ps).

$$Ps = 100 - Pb \qquad [Report\ to\ nearest\ 0.1\%]$$

4. Percent Effective Asphalt Content (Pbe).

$$Pbe = Pb - \left(\frac{Pba \times Ps}{100}\right) \qquad [Report\ to\ nearest\ 0.1\%]$$

5. Bulk Specific Gravity, measured (Gmb measured). *(Report to nearest 0.001)*

$$Gmb\ (measured) = \frac{Weight\ in\ Air}{SSD\ Weight - Weight\ in\ Water}$$

6. Bulk Specific Gravity, calculated (Gmb calculated). *(Report to nearest 0.001)*

$$Gmb\ (calculated) = \frac{Gmb\ (measured) \times Height\ (@\ N_{des})}{Height\ @\ N_{ini}}$$

7. Make sure that the Rice Specific Gravity (Gmm) testing is completed using SD 312. Average the two Gmm values and record to the nearest 0.001.

8. Calculate the Average Gmb for $N_{initial}$ and N_{design} to the nearest 0.001.

9. % Of Rice Specific Gravity (Gmm).

$$\%\ of\ Gmm = \left(\frac{Gmb}{Gmm}\right) \times 100 \qquad [Report\ to\ nearest\ 0.1\%]$$

10. % Air Voids (Va).

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$$Va = \left(\frac{Gmm - Gmb}{Gmm}\right) \times 100 \qquad [Report\ to\ nearest\ 0.1\%]$$ 23

11. % Voids in the Mineral Aggregate (VMA).

$$VMA = 100 - \left(\frac{Gmb \times Ps}{Gsb}\right) \qquad [Report\ to\ nearest\ 0.1\%]$$

12. % Voids Filled with Asphalt (VFA).

$$VFA = \left(\frac{VMA - Va}{VMA}\right) \times 100 \qquad [Report\ to\ nearest\ whole\ \%]$$

13. Dust to Binder Ratio. *(Report to nearest 0.1)*

$$Dust\ to\ Binder\ Ratio = \frac{(\%\ dust\ (-\#200) + (\%\ lime))}{Pbe}$$

Do not forget to compare calculated values with the QC/QA specification requirements.

5. References

AASHTO R 35
AASHTO T 312
ANSI B46.1 (Note 2)
SD 312
DOT-33Q
DOT-64
DOT-69
DOT-86
DOT-89

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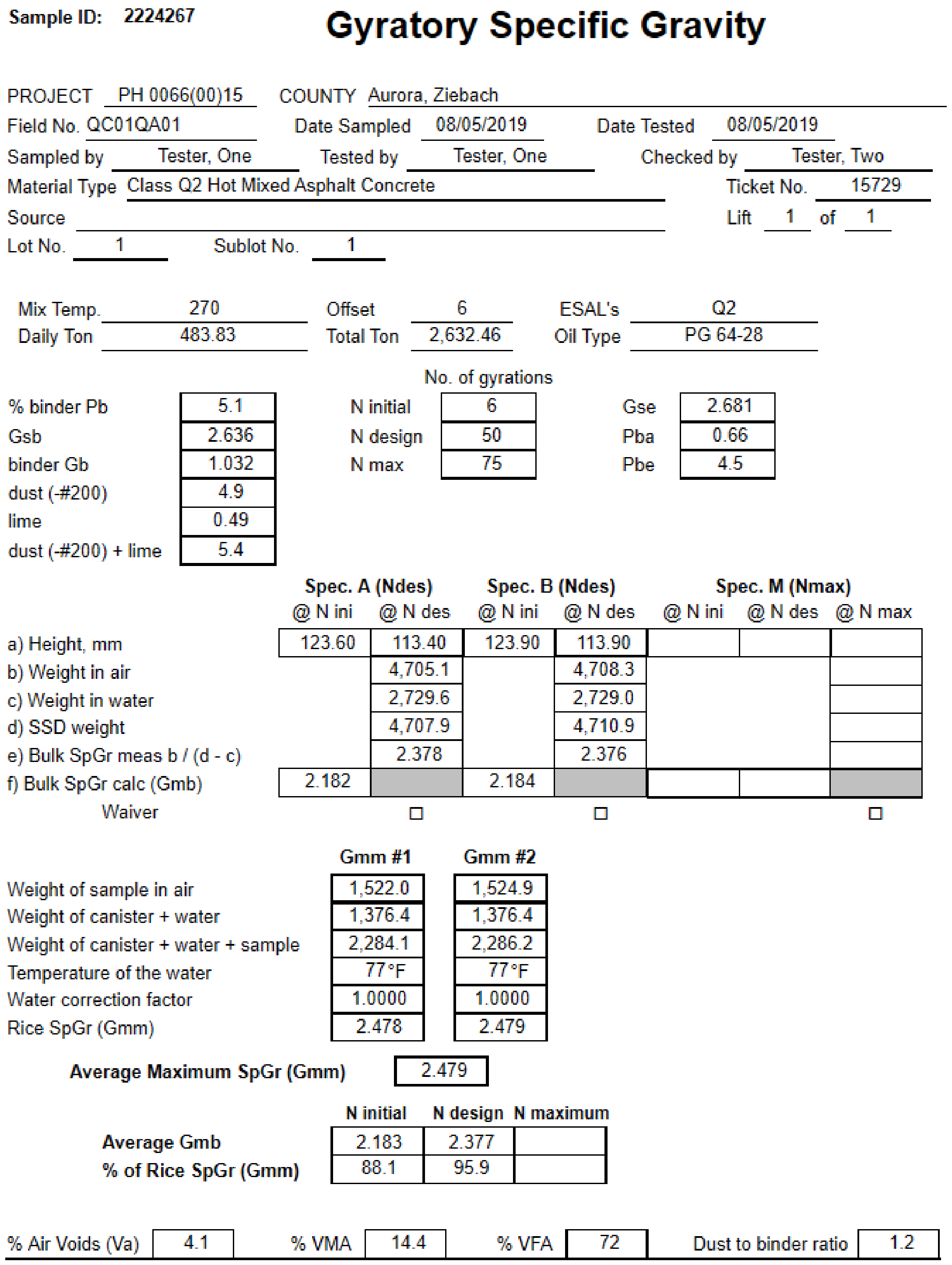

Sample ID: 2224267

Gyratory Specific Gravity

DOT-86
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Field No. QC01QA01 Date Sampled 08/05/2019 Date Tested 08/05/2019
Sampled by Tester, One Tested by Tester, One Checked by Tester, Two
Material Type Class Q2 Hot Mixed Asphalt Concrete Ticket No. 15729
Source Lift 1 of 1
Lot No. 1 Sublot No. 1

Mix Temp. 270 Offset 6 ESAL's Q2
Daily Ton 483.83 Total Ton 2,632.46 Oil Type PG 64-28

			No. of gyrations		
% binder Pb	5.1	N initial	6	Gse	2.681
Gsb	2.636	N design	50	Pba	0.66
binder Gb	1.032	N max	75	Pbe	4.5
dust (-#200)	4.9				
lime	0.49				
dust (-#200) + lime	5.4				

	Spec. A (Ndes)		**Spec. B (Ndes)**		**Spec. M (Nmax)**		
	@ N ini	@ N des	@ N ini	@ N des	@ N ini	@ N des	@ N max
a) Height, mm	123.60	113.40	123.90	113.90			
b) Weight in air		4,705.1		4,708.3			
c) Weight in water		2,729.6		2,729.0			
d) SSD weight		4,707.9		4,710.9			
e) Bulk SpGr meas b / (d - c)		2.378		2.376			
f) Bulk SpGr calc (Gmb)	2.182		2.184				
Waiver		☐		☐			☐

	Gmm #1	**Gmm #2**
Weight of sample in air	1,522.0	1,524.9
Weight of canister + water	1,376.4	1,376.4
Weight of canister + water + sample	2,284.1	2,286.2
Temperature of the water	77°F	77°F
Water correction factor	1.0000	1.0000
Rice SpGr (Gmm)	2.478	2.479

Average Maximum SpGr (Gmm) 2.479

	N initial	**N design**	**N maximum**
Average Gmb	2.183	2.377	
% of Rice SpGr (Gmm)	88.1	95.9	

% Air Voids (Va) 4.1 % VMA 14.4 % VFA 72 Dust to binder ratio 1.2

Figure 1

South Dakota Asphalt Concrete Gyratory Mix Design Procedure

---

1. Scope:

This standard practice for mix design evaluation uses aggregate and mixture properties to produce an asphalt concrete mix design formula that meets the specification requirements. This standard is for asphalt concrete hot mix that may or may not contain reclaimed asphalt pavement (RAP).

2. Apparatus:

2.1 Gyratory compactor and support equipment (Including height recording device, specimen molds, ram heads, and mold bottoms) meeting requirements of AASHTO T 312.

2.2 All related equipment and/or apparatus to perform parts or all of tests including: SD 108, SD 201, SD 202, SD 204 SD 206, SD 208, SD 209, SD 210, SD 211, SD 212, SD 213, SD 214, SD 217, SD 220, SD 221, SD 301, SD 306, SD 309, SD 312, SD 313, SD 316, SD 318, SD 319, AASHTO T 164, AASHTO T 308, & AASHTO T 312.

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3. Procedure:

3.1 Preparation of aggregates.

The average gradation of each individual aggregate fraction will be used when combining to form an aggregate composite. This average will come from testing done on the individual fraction/stockpile prior to the asphalt concrete mix design being performed.

NOTE: When recycled asphalt pavement (RAP) is allowed, it will not be included in meeting the total aggregate requirements set forth in the plans, Special Provisions, and/or Specification book.

A. The following are the minimum number of size fractions to use when recombining the gradation of each individual stockpile. The 3/4", 1/2", 3/8”, #4, #8, and all material passing the #8 are the minimum number of sizes required to be used when recombining the stockpiles.

B. Bulk specific gravity of the aggregate (G_{sb}) is determined by SD 209, and SD 210 for each fraction and combining to form a composite total G_{sb} and a - #4 Gsb. SDDOT Bituminous Office will determine both the total G_{sb} and the - #4 G_{sb} on the total composite and not on individual fractions.

NOTE: When RAP is included in the plans, determine the asphalt binder content by conducting at least two extractions or ignition oven tests (Only if a correction factor is known). Determine the RAP aggregate gradation from the extractions (AASHTO T 164) or ignition oven tests (AASHTO T 308) and show the average RAP virgin aggregate only gradation on the mix design sheet. When20 percent or less RAP is used in the mix design, use the G_{sb} from the old RAP mix design for the RAP virgin mineral aggregate G_{sb} or by conducting G_{sb} tests on the extracted or ignition oven aggregate samples using SD 209 and SD 210. If more than 20 percent RAP is used to determine the RAP aggregate G_{sb} by conducting G_{sb} tests on the extracted or ignition aggregate samples using SD 209 and SD 210.

C. Determine consensus virgin aggregate properties for the composite gradation including:

Crushed particles (SD 211), fine aggregate Angularity (SD 217), flat and elongated particles (SD 212), and sand equivalent (SD 221). Also, determine source virgin aggregate properties for lightweight particles (SD 208, SD 214), sodium sulfate soundness (SD 220) (Optional), and Los Angeles abrasion loss (SD 204) (Optional), if have previous tests from pit history.

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3.2 Determination of mixing and compacting temperatures.

A. Performance graded binder (PG); mixing temperature will be 300° ± 10° F.

B. Performance graded binder (PG 58-28, PG 64-22); compaction temperature will be 270° ± 5° F, (PG 58-34, PG 64-28) compaction temperature will be 275° ± 5° F. (PG 64-34, PG 70-28) compaction temperature will be 280° ± 5° F.

3.3 Preparation of mixtures.

A. Adjust the laboratory sample gradations to meet the average stockpile gradations down to the #8 and recalculate the laboratory - #8 gradation to reflect the changes. Weigh into pans material from each fraction to form a composite. Heat aggregate composite samples in an oven overnight or for a minimum of four hours to a temperature not exceeding 50° F above the mixing temperature.

NOTE: If recycled asphalt pavement is allowed, heat the RAP in an individual oven for a period of no more than two hours at 230° ± 5° F and add soon after heating to the mixture of aggregate and binder. Also, when RAP is added, care must be taken to thoroughly mix all components.

B. Following mixing immediately put the mixture in a covered container in an oven maintained at the compaction temperature for a period of two hours. At least three sets of specimens are to be made at 0.5% oil increments. This will include (2) G_{mb} samples at N_{des} and (1) G_{mb} sample at N_{max} using SD 318. Two G_{mm} (SD 312) samples are to be made at the center oil increment. The oil content will be based on the total weight of the bituminous mixture.

NOTE: This total weight of mixture would include RAP if it is allowed in the mixture and should make a gyratory specimen to the required height of 115 ± 5 mm. An example of combining virgin aggregate, RAP, lime, and virgin binder is as follows:

If 4750 grams is the target weight; hydrated lime at 1.00% = 47.5g, virgin aggregate = 3598.6g (80%), RAP = 899.6g (20%) and 4.3% new binder = 204.3g for a total of 4750 grams. The RAP contains 6.00% binder content from the average of the two extraction tests. 54.0g of binder is coming from the RAP. 54.0g + 204.3g = 258.3g of total binder in the sample for a total asphalt content of 258.3 / 4750 x 100 = 5.44%. The old asphalt binder at 1.14% is contributing 20.9% to the total binder content with a 79.1% contribution to the total binder content from the new binder at 4.30% added. 21

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3.4 Compaction of specimens.

Combining elements of 3.1, 3.2, and 3.3 referenced from above, compact the specimens with a gyratory compactor at the gyration levels for N_{des}, and N_{max} and calculate the N_{ini} using SD 318. The specified gyration levels are included in the plans, plan notes, Standard Specification book and/or Special Provision for a specific project. Determine the bulk specific gravity (G_{mb}) of each of the compacted specimens in accordance with SD 313.

3.5 Determine the air voids (V_a), voids in the mineral aggregate (VMA), voids filled with asphalt (VFA), and dust to effective binder for each binder percent increment in accordance with SD 318. Also include the percent of G_{mm} at N_{ini} and N_{max} for each binder increment.

4. Report:

4.1 Contractor and consultants can use and submit mix design data and calculations on their own forms and charts as long as all pertinent mix design data is included with the material sent to the SD DOT Mix Design Lab. Aggregate stockpile gradation averages including the legal pit descriptions for the materials, and the + #4 and - #4 bulk specific gravity of each individual stockpile are data which needs to be included with the mix design submittal. The asphalt binder supplier and grade of binder to be used will be listed. A completed DOT 48 form for moisture sensitivity (SD 309) will also be included with the mix design data submitted (If not adding 1.00% hydrated lime) The

Contractor's material and data submitted to the SD DOT Mix Design Lab in Pierre must meet all of the specifications and requirements as shown in the plans, plan notes, Standard Specifications book and the Special Provision regarding quality control/quality assurance specifications that apply to the project.

4.2 The Contractor's mix design submittal will include a single percentage of binder recommended, the source of the binder, bin splits selected to use along with the legal pit descriptions of all the materials, average gradation of the stockpiles, and the recommended JMF to be used for the mix design along with a signed JMF mix design sheet including all the required mix design test results.

4.3 The SD DOT Mix Design Lab will verify the mix design submitted by the Contractor/Area and conduct all necessary mix design quality tests required on the mineral aggregate, RAP, and asphalt concrete mixture. When the mix design verification is completed by the Department's Bituminous Mix Design Lab, an approved mix design report (DOT-64) will be provided to the Area Engineer and the Contractor prior to production.

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5. References

Listed in 2.2 above

Procedure for Texture of Cold Milled and Micro-Milled Asphalt Concrete Surfaces

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1. Scope:

This test is for measuring the ridge to valley depth of cold milled and micro-milled asphalt concrete surfaces.

2. Apparatus:

2.1 A gauge marked in 1/32” increments and capable of measuring to a depth of at least 1/2”. An ordinary tire tread depth gauge meeting these requirements may be used.

2.2 Miscellaneous: 12” rule, 100’ tape, broom or wire brush.

3. Procedure:

3.1 Randomly select 5 sites within the lot. If a random site falls within an area of pavement distress (e.g., fatigue cracking, transverse cracking, block cracking), move the site up to a maximum of 5’ ahead or back to an area of sound pavement.

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3.2 Remove all loose material from the site to be measured by brush or air pressure.

3.3 Determine and record the depth of 10 consecutive grooves in a straight line. Measure the deepest part of the groove within ± 1/2” of the straight line.

3.4 Perform calculations according to Section 4.

3.5 Verify if milling spacing is within specification and document on DOT-55A.

4. Report:

4.1 Calculations.

A. Calculate the “Ave. depth” for each location to the nearest 1/32”.

Average depth = Site Total / 10

B. Calculate the lot average by averaging the 5 “Site total” numbers from each location to the nearest 1/32”.

Lot average = Sum of site totals / 50

4.2 Report the test as being satisfactory, provided all the following conditions are met for each lot.

A. The lot average is within specification (0” to 4/32” for micro-milling, 0” to 8/32” for cold milling.)

5. References:

DOT-55A

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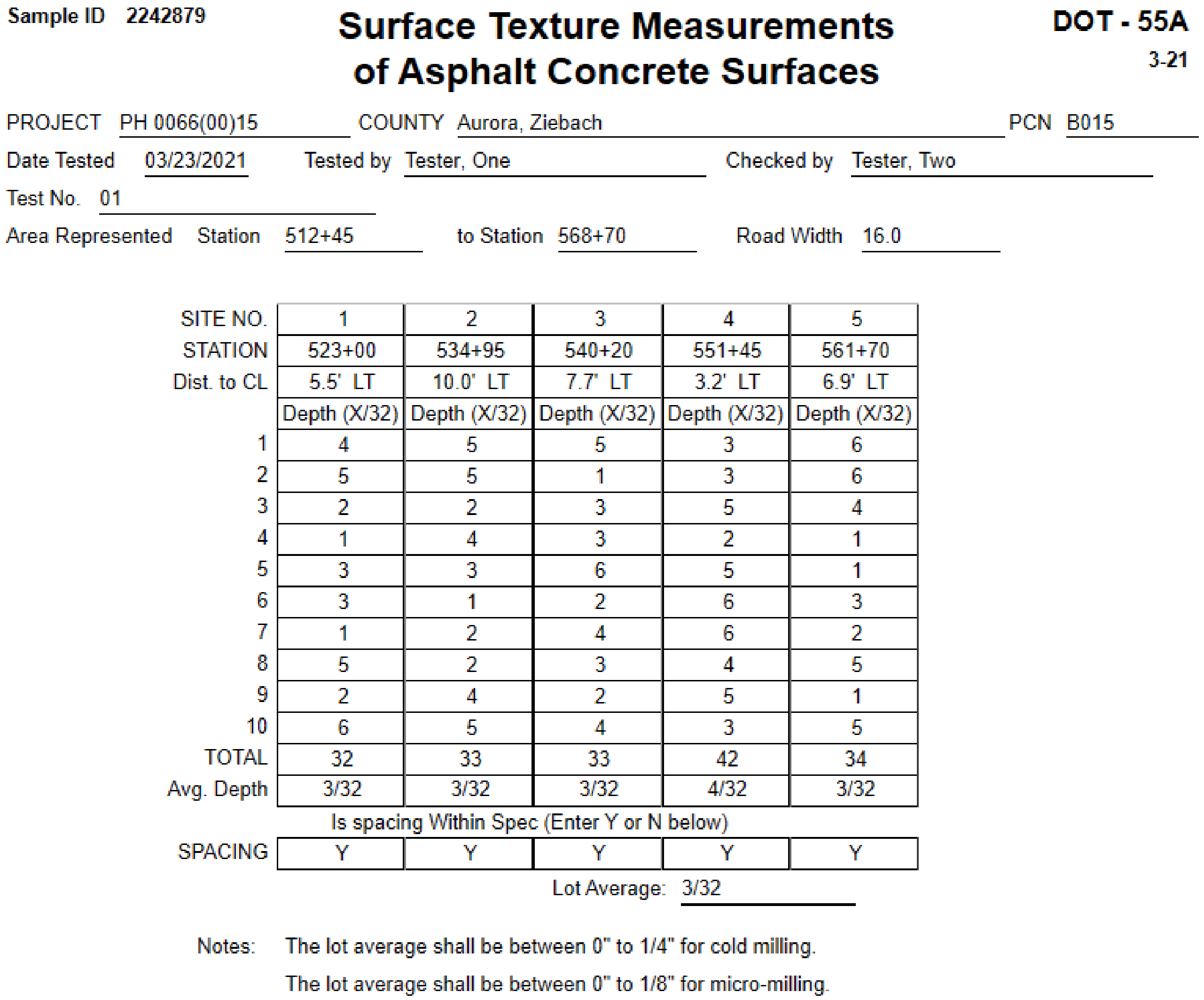

Sample ID **2242879**

Surface Texture Measurements of Asphalt Concrete Surfaces

DOT - 55A
3-21

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Date Tested 03/23/2021 Tested by Tester, One Checked by Tester, Two

Test No. 01

Area Represented Station 512+45 to Station 568+70 Road Width 16.0

SITE NO.	1	2	3	4	5
STATION	523+00	534+95	540+20	551+45	561+70
Dist. to CL	5.5' LT	10.0' LT	7.7' LT	3.2' LT	6.9' LT
	Depth (X/32)	Depth (X/32)	Depth (X/32)	Depth (X/32)	Depth (X/32)
1	4	5	5	3	6
2	5	5	1	3	6
3	2	2	3	5	4
4	1	4	3	2	1
5	3	3	6	5	1
6	3	1	2	6	3
7	1	2	4	6	2
8	5	2	3	4	5
9	2	4	2	5	1
10	6	5	4	3	5
TOTAL	32	33	33	42	34
Avg. Depth	3/32	3/32	3/32	4/32	3/32
	Is spacing Within Spec (Enter Y or N below)				
SPACING	Y	Y	Y	Y	Y

Lot Average: 3/32

Notes: The lot average shall be between 0" to 1/4" for cold milling.
The lot average shall be between 0" to 1/8" for micro-milling.

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Method of Test for Calculating Percent Reclaimed Asphalt Pavement (RAP) in the Mix

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1. Scope:

This test is for calculating the percent Reclaimed Asphalt Pavement (RAP) in the mix as a percent of the total aggregate.

2. Apparatus:

NONE

3. Procedure:

<u>Weigh Ticket Entries</u>

3.1 Record the total tons of hot mix produced for the day from the tickets (**A**) (nearest 0.01 ton).

3.2 Record the Moisture in the mix percentage from the most recent one tested (**B**) (nearest 0.1 percent). (DOT-35)

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3.3 Calculate the Moisture in the mix in tons (**C**) (nearest 0.01 ton):

$$\mathrm{C} = \frac{\mathbf{A} \times \left(\frac{\mathbf{B}}{\mathbf{100}}\right)}{\left[\mathbf{1} + \left(\frac{\mathbf{B}}{\mathbf{100}}\right)\right]}$$

3.4 Calculate the Total dry amount of hot mix produced for the day in tons (**D**) (nearest 0.01 ton).

$$\mathrm{D} = \mathbf{A} - \mathbf{C}$$

3.5 Record the Added binder percentage by cutoff from the DOT-89 (**E**) (nearest 0.01 percent).

3.6 Calculate the Total amount of added binder in tons ($\boldsymbol{F}$) (nearest 0.01 ton):

$$\mathrm{F} = \mathbf{A} \times \left(\frac{\mathbf{E}}{\mathbf{100}}\right)$$

3.7 Record the Added lime percentage by cutoff from the DOT-33Q (**G**) (nearest 0.01 percent).

3.8 Calculate the Total amount of added lime in tons (**H**) (nearest 0.01 ton):

$$\mathrm{H} = \mathbf{A} \times \left(\frac{\mathbf{G}}{\mathbf{100}}\right)$$

3.9 Calculate the Total dry Virgin MA and RAP from tickets and cutoffs in tons (**I**) (nearest 0.01 ton):

$$\mathrm{I} = \mathbf{D} - (\mathbf{F} + \mathbf{H})$$

Weigh Bridge Entries

3.10 Record the Weight of Virgin MA from weight bridge totalizer in tons. This should be the wet amount of aggregate not including the hydrated lime going into the dryer drum (**J**) (nearest 0.01 ton).

3.11 Record the Percent moisture in Virgin MA (Average of QC tests for the day) (**K**) (nearest 0.1 percent). (DOT-69)

3.12 Calculate the Weight of water in Virgin MA in tons (**L**) (nearest 0.01 ton):

$$\mathrm{L} = \frac{\mathbf{J} \times \left(\frac{\mathbf{K}}{\mathbf{100}}\right)}{\left[\mathbf{1} + \left(\frac{\mathbf{K}}{\mathbf{100}}\right)\right]}$$

Back

3.13 Calculate the Weight of dry Virgin MA in tons (**M**) (nearest 0.01 ton):

$$\mathrm{M} = \mathbf{J} - \mathbf{L}$$

3.14 Record the Weight of RAP from weigh bridge totalizer in tons (**N**) (nearest 0.01 ton).

3.15 Record the Percent moisture in the RAP from most recent test for moisture in the RAP material (DOT-35) (**O**) (nearest 0.1 percent).

3.16 Calculate the Weight of water in the RAP mixture in tons (**P**) (nearest 0.01 ton):

$$\mathrm{P} = \frac{\mathbf{N} \times \left(\frac{\mathbf{O}}{\mathbf{100}}\right)}{\left[\mathbf{1} + \left(\frac{\mathbf{O}}{\mathbf{100}}\right)\right]}$$

3.17 Calculate the Weight of dry RAP from weigh bridge totalizer in tons (**Q**) (nearest 0.01 ton):

$$\mathrm{Q} = \mathbf{N} - \mathbf{P}$$

3.18 Calculate the Total dry Virgin MA and RAP from weigh bridges in tons (**R**):

$$\mathrm{R} = \mathbf{M} + \mathbf{Q}$$

<u>RAP percentages</u>

3.19 Calculate the Percentage of RAP based on weigh bridges (**S**) (nearest 0.01 percent):

$$S = \left(\frac{\mathbf{Q}}{\mathbf{R}}\right) \times \mathbf{100}$$

3.20 Calculate the Percentage of RAP based on weigh tickets (**T**) (nearest 0.01 percent):

$$T = \left(\frac{\mathbf{Q}}{\mathbf{I}}\right) \times \mathbf{100}$$

3.21 Calculate the % Difference between scale tickets and weigh bridges (**U**) (nearest 0.01 percent):

$$U = \left(\frac{\mathbf{I - R}}{\mathbf{I}}\right) \times \mathbf{100}$$

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4. Report:

4.1 Record all data and findings on test report (DOT-93) and the percent RAP by test (**S**) to the nearest whole percent on line at top of (DOT-93) test report.

5. References:

DOT-33Q
DOT-35
DOT-69
DOT-89
DOT-93

23

Sample ID: 2242952

Percent Reclaimed Asphalt Pavement (RAP) in the Mix as Percent of Total Aggregate

DOT-93
3-19

Report No 8

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Date 10/25/2016 Inspector Tester, One

Contractor Roads, Inc

Percent RAP Desired 15 - 25 Percent RAP by Test 21 Material Type Q3R

Weigh Ticket Entries

A. Total of hot mix produced by tickets (tons)	545.95
B. Moisture in the mix percentage (most recent one tested)	0.10
C. Moisture in the mix (tons)	0.55
D. Total dry amount of hot mix produced for the day (tons)	545.40
E. Added binder percentage by cutoff (DOT-89)	4.94
F. Total amount of added binder (tons)	26.97
G. Added lime percentage by cutoff (DOT-33Q)	1.03
H. Total amount of added lime (tons)	5.62
I. Total dry Virgin MA and RAP from tickets & cutoffs (tons)	512.81

Weigh Bridge Entries

J. Weight of Virgin MA from weight bridge totalizer (tons)	434.13
K. Percent moisture in Virgin MA	3.30
L. Weight of water in Virgin MA (tons)	13.87
M. Weight of dry Virgin MA (tons)	420.26
N. Weight of RAP from weigh bridge totalizer (tons)	113.22
O. Percent moisture in RAP	0.70
P. Weight of water in the RAP mixture (tons)	0.79
Q. Weight of dry RAP from weigh bridge totalizer (tons)	112.43
R. Total dry Virgin MA and RAP from weigh bridges (tons)	532.69

RAP Percentages

S. Percentage of RAP based on weigh bridges	21.11
T. Percentage of RAP based on weigh tickets	21.92
U. % difference between scale tickets and weigh bridges	-3.88

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Method of Test for Determining Compatibility of Cover Aggregates

---

1. Scope:

This test covers the procedure for determining the compatibility of emulsified asphalt with aggregate to be used for asphalt surface treatments.

2. Apparatus:

2.1 Drying oven capable of maintaining a temperature of 230º ± 9ºF.

2.2 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

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2.3 Pans, scoops, brushes, etc., for handling materials.

2.4 Spatula with a blade 4 in. long.

2.5 Beaker, paper cup or plastic container suitable for hot liquid, 8-oz. capacity.

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3. Procedure:

3.1 Obtain a sample of cover aggregate to test from contractor or storage.

3.2 Determine the type of emulsified asphalt to be used and identify the supplier.

3.3 Weigh approximately 2000 grams of aggregate into a pan.

3.4 Dry the sample to a constant weight in an oven and cool to room temperature.

3.5 Add water to the aggregate to reach the required 2.0 percent moisture level.

3.6 Weigh 50 grams of the wetted aggregate into the 8-oz. container.

3.7 Add, immediately, 5.0 grams of the test emulsion to the aggregate. Stir sample with the spatula to achieve maximum coating. Continue stirring for approximately 10 seconds.

NOTE: Take care so that stirring is not continued after the emulsion breaks.

3.8 Spread sample onto absorbent paper towel to determine the degree of coating.

3.9 Photograph the sample on the paper towel with the project information.

4. Report:

4.1 Acceptance (complete coating) or incomplete coating shall be noted. Additional tests such as boiling water and/or sweep tests or a small test strip will be required if incomplete coating occurs. Changing the aggregate and/or emulsion and completing a new compatibility test may be required.

5. References:

None

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Table of Contents

Concrete Section

Back

Method of Sampling Portland Cement and Fly Ash in the Field

---

1. Scope:

This is the procedure for sampling Portland cement and fly ash in the field for use in Portland cement concrete.

The sampling of Portland cement for certification of plants shall be in accordance with SD 416.

2. Apparatus:

2.1 Tube sampler.

2.2 Shovel.

2.3 Sample cans - 4 lb.

3. Procedure:

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3.1 Sample size.

A. The samples shall consist of two full cans for cement and one can for fly ash.

3.2 Sampling.

A. Packaged.

1. Randomly select 3 packages from the load.

2. Obtain approximately equal amounts from each package, using the tube sampler and place the material in the can making sure it is full.

B. From bulk storage (Train cars / truck transports).

1. Obtain a sample by inserting the full length of a sampling tube vertically into the material at various well distributed locations over the entire area of the bulk storage container (A minimum of 3 locations).

2. The openings in the sampling tube shall be closed when it is inserted into the material. Following insertion to the tubes full length, allow the material to flow into the orifices of the tube by turning the inside tube on the top of the device 90 degrees or as required to completely open the orifices for the applicable device.

3. Remove the tube from the material and place the contents directly into the sample container.

C. From bulk storage at points of discharge.

1. Draw sufficient material from the discharge openings to obtain a representative sample.

D. From conveyor delivering to bulk storage.

1. Take the sample from material passing over the conveyor with a shovel or can. This may be accomplished by taking the entire sample in a single operation, known as the “Grab method” or by combining several approximately equal portions, (Minimum of three) taken at regular intervals known as the “composite method”.

3.3 Seal the sample container by taping the lid to the can.

4. Report:

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4.1 Prepare Sample Data Sheet (DOT-1) and attach to the container(s) of the sample.

5. References:

SD 416
DOT-1

Method of Sampling Fresh Concrete

---

1. Scope:

This test covers the procedure for obtaining samples of fresh concrete.

2. Apparatus:

2.1 Shovel.

2.2 Wheelbarrow or other container.

3. Procedure

3.1 Obtain sample large enough to complete all necessary testing. Use the most appropriate procedure.

A. Stationary mixers and continuous mixers (volumetric mixers used for low slump overlays).

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1. Obtain a sample by passing a receptacle completely through the discharge stream of the mixer or diverting the stream completely so that it discharges into a wheelbarrow or other container. Do not obtain sample from the very first or last part of the discharge.

B. Revolving truck mixers.

1. Wait to obtain the sample until after all the water and admixtures have been added to the mixer. Do not obtain the sample from the very first or last part of the discharge. Pass a receptacle through the entire discharge stream, or by diverting the stream completely to discharge into a wheelbarrow or other container. Regulate the discharge of the batch by the rate of revolution of the drum and not by the size of the opening.

NOTE: For concrete placements consisting of 4 yd3 or less, the sampling of the concrete will be at the beginning of the batch after 5 gallons ± of concrete have been discharged from the mixing drum.

Drilled Shafts:
The sampling of the concrete will be at the beginning of the batch after 5 gallons ± of concrete have been discharged from the mixing drum.

Self-consolidating Concrete:
Sampling of concrete will be at the beginning of the batch after 5 gallons have been discharged from the mixing drum.

2. Sampling may be in accordance with paragraph 3.1.C.

C. Dump trucks or open top truck mixers (agitators).

1. Discharge the contents of the truck and collect the sample from at least 5 different locations of the pile.

   The sampling of the concrete for PCC paving train operations will be obtained from at least 5 different locations immediately ahead of the paver. 24

D Pumps.

1. Take the sample from the discharge end of the pump. Collect the sample from at least 5 different locations of the pile. Discharge will not be directly into a sampling bucket. Sample will be taken at same location where discharge is being incorporated into the structures. Pump should not be shut off or angle of discharge changed.

2. When sampling from end of discharge hose is not possible, sample according to 3.1.B.1.

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3.2 Testing the sample.

A. Procedures for obtaining a composite sample will be completed within 15 minutes.

B. The sample will be transported to the place where tests are to be made and will be remixed with a shovel to insure uniformity. Expeditiously obtain and use the sample and protect the sample from the sun, wind, and other sources of rapid evaporation, and from contamination

C. Start tests for air content, temperature, unit weight, and slump within 5 minutes after obtaining the final portion of the composite sample. For SCC, slump flow, visual stability index, and J-ring will be performed in lieu of slump test. Start molding specimens for strength tests within 15 minutes after fabricating the composite sample.

NOTE: Volumetric mixer (used for low slump overlays); immediately after obtaining the sample, cover the wheelbarrow or container for five minutes. Following the elapsed time remix with a shovel, the sample will then be tested immediately.

4. Report:

None required.

5. References:

None.

Back

Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method

---

1. Scope:

This test is for determining air content in fresh concrete by the pressure method.

2. Apparatus:

2.1 Air Meter conforming to AASHTO T 152. (Type B)

2.2 Tamping Rod - A round smooth straight 5/8 in. diameter steel rod with the tamping end or both ends rounded to a hemispherical tip of 5/8 in. diameter. The minimum length shall be 18 in.

2.3 Mallet - A mallet (with a rubber or rawhide head) having a mass of 1.25 ± 0.50 lb.

2.4 Strike-off Plate - A flat rectangular metal plate at least 1/4 in. thick or a glass or acrylic plate at least 1/2 in. thick with a length and width at least 2 in. greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within a tolerance of 1/16 in**.**

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2.5 Strike-off Bar - A flat straight bar of steel at least 1/8 in. thick and 3/4 in. wide by 12 in. long.

2.6 Scoop - A scoop of a size large enough so a representative amount of concrete is obtained and small enough that concrete is not spilled during placement in the measure.

3. Procedure:

3.1 Air Meter Calibration – Method A.

A. Fill the measuring bowl with water.

B. Screw the short piece of straight tubing into the threaded petcock hole on the underside of the cover. Clamp the cover assembly onto the measuring bowl with the tube extending down into the water.

C. With both petcocks open, add water with a syringe through the petcock having the pipe extension below, until all the air is forced out the opposite petcock.

D. Pump the pressure to a little beyond the initial calibration pressure. Use the initial pressure provided by the manufacturer or as marked on the gauge. Wait a few seconds for compressed air to cool to normal temperature and then stabilize the gauge needle at the initial calibration pressure by pumping or bleeding off air as needed to get the exact initial pressure. Lightly tap the pressure gauge by hand to stabilize the needle.

E. Close both petcocks and immediately press down on the thumb lever exhausting the air into the measuring bowl. Wait a few seconds until the hand is stabilized. Lightly tap the pressure gauge by hand to stabilize the needle. If all the air was eliminated and the initial calibration pressure was correctly selected, the gauge should read zero. If two or more tests show a consistent variation of ±0.1%, change the initial calibration pressure to compensate for the variation. Use the newly established initial calibration pressure for subsequent tests. The initial calibration pressure should be marked on the gauge for reference on subsequent tests. 23

F. Screw the curved tube into the outer end of the same petcock having the straight tubing below. By pressing on the thumb lever and controlling the flow with the petcock lever, fill the 5% calibration vessel level full of water from the meter. The 5% of water may also be determined by weight.

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G. Release the air at the free petcock. Open the other petcock and let the water in the curved pipe run back into the measuring bowl. There is now the equivalent of 5% air in the measuring bowl.

H. With the petcocks open, pump up the air pressure in the same manner as outlined in paragraph D. Close the petcocks and immediately press the thumb lever. Wait a few seconds for exhaust air to warm to normal temperature, and for the needle to stabilize.

Lightly tap the pressure gauge by hand to aid in stabilizing the needle. The dial should read 5.0%.

I. If two or more consecutive readings are more than 0.1% above or below 5%, remove the gauge glass and reset the needle to 5% by turning the re-calibration screw located on the needle assembly. If the re-calibration screw is adjusted, the initial pressure must be checked again. If the initial pressure changes, then the 5% reading should also be rechecked. 23

J. The meter may be calibrated for higher air contents, if deemed necessary. This is accomplished by withdrawing additional water at 5% increments using the calibration vessel or at other values by weight and repeating the steps outlined in paragraphs G., H., and I. above.

3.2 Air Meter Calibration – Method B (Field Check Only)

A. Fill the measuring bowl with water.

B. Place the internal calibration cylinder at the bottom of the filled measuring bowl. (Keep the cylinder upright as you place it.)

C. Clamp the cover assembly on the measuring bowl.

D. With both petcocks open, add water with a syringe through one petcock until all air is forced out and water emerges from the opposite petcock.

E. Pump the pressure to slightly beyond the initial calibration pressure that is marked on the gauge. Wait a few seconds for compressed air to cool to normal temperature and then stabilize the gauge needle at that initial pressure by pumping or bleeding off air as needed to get the exact initial pressure. Lightly tap the pressure gauge by hand to stabilize the needle.

F. Close both petcocks and immediately press down on the thumb lever exhausting the air into the measuring bowl. Lightly tap the gauge by hand and wait a few seconds until the gauge needle is stabilized. If the gauge is calibrated correctly, the gauge should read 5.0%. If two or more tests show a consistent variation greater than ± 0.1% in the result, the air meter should be calibrated as per Method A at the earliest convenience. 23

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G. Keep the small hole at the bottom of the internal calibration cylinder unobstructed. Usually, a very slight amount of water may be left in the cylinder after a test. Shake this water out before making another test or putting the internal calibration cylinder into storage. Use two internal calibration cylinders if you wish to calibrate at 10%.

3.3 Air test: Type B Meter.

A. Obtain a sample of fresh concrete in accordance with SD 402.

NOTE: Samples of volumetric mixed low slump dense concrete will be placed in a covered container for 5 minutes prior to testing.

B. Dampen the interior of the empty measuring bowl and remove any standing water from the bottom. Place the measuring bowl on a flat, level, and firm surface.

C. Fill the measuring bowl with concrete in 3 approximately equal layers. Rod each layer 25 times. Distribute the strokes uniformly over the cross section of the layer being rodded.

Rod the lower layer throughout its depth, but the rod must not forcibly strike the bottom of the measuring bowl so as to cause excessive vibration. Rod the second and third layers with the rod penetrating slightly (Approximately 1 inch) into the layer below.

Add concrete to the final layer in a manner to avoid excessive overfilling. Add additional concrete as required to keep the surface above the measuring bowl as it is rodded.

After each layer is rodded, tap the outside of the measuring bowl 10 to 15 times with the mallet. Tap with enough force to close any holes left by rodding and to release any large air bubbles that may have been trapped. For concrete with a slump of less than 2” the number of taps may be increased to achieve consolidation.

Self-Consolidating Concrete (SCC) – Slightly overfill the measure and fill in one continuous lift. Rodding, tapping the side of the measure, and vibrating of SCC is prohibited.

D. Use a strike-off plate or strike-off bar to strike off the concrete flush with the top of the measuring bowl. Removal of 1/8” of material during strike off is optimum.

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Strike-off plate will be used for strike-off on all unit weight determinations. Use the following procedure for striking off the measure. Press the strike-off plate on top of the measuring bowl to cover approximately 2/3 of the measuring bowl. Withdraw the strike-off plate with a sawing motion. Place the strike-off plate on the measuring bowl in the original position to cover the same 2/3 of the measuring bowl. Advance the strike-off plate with downward pressure and a sawing motion until it slides completely off the measuring bowl. Finish the surface with several strokes of the strike-off plate at an inclined angle. 23

When the strike-off bar is used, strike off the top surface of the measuring bowl with a sawing motion until the bowl is level full.

E. Thoroughly clean the rim of the measuring bowl. The internal surface of the cover assembly and seal must be clean and should be wet prior to placing it on the measuring bowl. Clamp the cover assembly on securely and open both petcocks.

F. Using the syringe supplied, inject water through one petcock until all of the air is displaced and expelled through the opposite petcock. Jar the meter gently with the hand to expel trapped air.

G. Apply air pressure with the pump until the gauge reading equals the initial calibration pressure that is marked on the gauge.

H. Wait a few seconds and stabilize the needle at the initial calibration pressure by pumping up or bleeding off with the air release valve. Lightly tap the pressure gauge by hand to stabilize the needle

Close both petcocks, then press down on the thumb lever to release air into the measuring bowl. While holding the thumb lever down smartly tap the measuring bowl with a mallet to relieve local restraints and then lightly tap the pressure gauge by hand to stabilize the needle. 23

I. Read the percent of air in the concrete on the dial and then release the thumb lever.

J. Release the pressure in the measuring bowl by opening the petcocks. Clean the measuring bowl and the cover assembly thoroughly with running water.

4. Report:

Report the percent of air to the nearest 0.1% on a DOT-23.

Back

5. References:

AASHTO T 152
SD 402
DOT-23

Method of Test for Slump of Portland Cement Concrete

---

1. Scope:

The test is for determining the slump of fresh concrete.

2. Apparatus:

2.1 Mold conforming to AASHTO T 119.

2.2 Tamping rod. A round smooth 5/8” steel rod with the tamping end rounded to a hemispherical tip of 5/8” diameter. The minimum length shall be 18”.

2.3 Small scoop or shovel.

2.4 Measuring tape capable of measuring to 1/4”.

3. Procedure:

Back

3.1 Obtain a sample of fresh concrete in accordance with SD 402.

NOTE: Samples of volumetric mixed low slump dense concrete shall be placed in a covered container for 5 minutes prior to testing.

3.2 Dampen the inside of the mold and the base it will sit on, just prior to use.

3.3 Place the mold on a flat, level, rigid non-absorbent surface and hold it firmly in place.

3.4 Fill the mold in 3 layers of approximately equal volume. One-third of the volume of the slump mold fills it to a depth of 2 5/8”, two-thirds of the volume fills it to a depth of 6 1/8". Rod each layer 25 times. Distribute the strokes uniformly over the cross section of the layer being rodded. For the bottom layer this will necessitate inclining the rod slightly and making approximately half the strokes near the perimeter and then progressing with vertical strokes spirally toward the center.

Rod the lower layer to its total depth, but the rod shall not forcibly strike the bottom of the base so as to cause excessive vibration. Rod the second and third layers with the rod penetrating slightly (Approximately 1 inch) into the layer below.

Heap the concrete above the top of the mold for the final layer, adding additional concrete, as required, to keep the surface above the mold as it is rodded.

3.5 After rodding the final layer, strike off the surface with a tamping rod and remove all excess concrete from the base of the cone.

3.6 Remove the mold immediately from the concrete by raising it carefully in a vertical direction. Raise the mold a distance of 12" in 5 ± 2 seconds by a steady upward lift with no lateral or torsional motion. Complete the entire test from the start of the filling through removal of the mold without interruption within an elapsed time of 2 1/2 minutes.

3.7 Set the mold next to the specimen. Use the tamping rod as a level line to measure the vertical difference between the top of the mold and the displaced original center of the top surface of the concrete.

4. Report:

Report the slump to the nearest 1/4” on a DOT-23.

5. References:

AASHTO T 119
SD 402
DOT-23

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Method of Making and Curing Concrete Specimens in the Field for Compression Tests

---

1. Scope:

This is the procedure for making and curing concrete specimens to be used for compression tests.

2. Apparatus:

2.1 Cylinder mold - Inside measurements will be 6” in diameter by 12” high or 4” in diameter by 8” high meeting AASHTO M205 with the following modifications.

A. Reusable molds metallic split type held together by clamps and have a rigid base that can be attached by clamps.

B. Single use molds will be plastic and have a tightly fitting plastic top cap used that will maintain the circular shape at the top of the cylinder.

C. The diameter of the molds used for 28 day cylinders will not differ from the normal diameter by more than ± 0.02 inches.

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All 28 day and 28 day backup cylinders will be cast using 6” x 12” metallic molds or 4” x 8” plastic single use molds with a matched tightly fitting plastic top cap. When the nominal maximum size of the coarse aggregate is greater than 1 inch, 6” x 12” molds will be required.

Early break cylinders will be cast using 6” x 12” or 4” x 8” plastic or metallic molds. When the nominal maximum size of the coarse aggregate is greater than 1 inch, 6” x 12” molds will be required.

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In RCP pipe, precast, and prestressed concrete, an alternate curing system requiring metal molds may be approved by the Concrete Engineer.

2.2 Tamping rods - A round smooth straight steel rod with diameter conforming to the following table, having both ends rounded to a hemispherical tip of the same diameter as the rod. The length of the tamping rod will be at least 4 inches greater than the depth of the mold in which rodding is being performed, but not greater than 24 inches.

Cylinder Size	Rod Diameter (in.)
4" X 8"	3/8 ± 1/16
6" X 12"	5/8 ± 1/16

2.3 Mallet - A mallet (with a rubber or rawhide head) having a mass of 1.25 ± 0.50 lb.

2.4 Scoop - A scoop of a size large enough so a representative amount of concrete is obtained and small enough that concrete is not spilled during placement in the measure.

2.5 Finishing Tools – Straightedge, handheld float, or trowel.

3. Procedure:

3.1 Molding specimens.

A. Obtain a sample of concrete in accordance with SD 402.

B. Mold the specimens in layers as indicated in the following table:

Cylinder Size	Number of Layers of Approximately Equal Depth	Number of Roddings per Layer
6" X 12"	3	25
4" X 8"	2	25

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Rod the lower layer to its total depth, but the rod must not forcibly strike the bottom of the bucket so as to cause excessive vibration. Rod the second and third layers with the rod penetrating slightly (Approximately 1 inch) into the layer below. Distribute the strokes uniformly over the cross section of the layer being rodded.

After each layer is rodded, tap the outsides of the mold 10 to 15 times with the mallet. Tap with enough force to close any holes left by rodding and to release any large air bubbles that may have been trapped. For concrete with a slump of less than 2 in. the number of taps may be increased to achieve consolidation.

Heap the concrete above the top of the mold for the final layer, adding additional concrete, as required, to keep the surface above the mold as it is rodded.

Self-Consolidating Concrete – Mold the specimens as described in 3.1.B without layers or consolidation.

C. Strike off surface with a straightedge or trowel.

D. Curing and Transporting the Cylinders.

(1) Cover each cylinder individually with non-absorbent material (Plastic) and seal to prevent moisture loss.

(2) If it is necessary to move the cylinders a short distance (carrying distance), do so immediately while the concrete is still in a plastic state. Prevent damage to the top of the concrete surface, the top of cylinders must be flat.

(3) Store specimens where they are not subject to vibration or being moved for 24 ± 8 hours after molding. Schedule moving of the cylinders as close to the 24 hour time frame as possible.

To check for excess vibration, drive a 2” x 2” stake into the ground and place a glass of water on top. If ripples are visible in the glass of water, vibration is excessive.

(4) Cylinders should never be exposed to the direct rays of the sun or be in direct contact with radiant heating or radiant cooling devices. Pavement surfaces act as a radiant heater or radiant cooler. Therefore, cover the cylinders use insulating material between the pavement and cylinders or choose a more acceptable location. 24

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(5) If extra cylinders are made, they can be field cured until tested to determine when to put concrete into service, protection/curing of the concrete, or form removal timing. The temperature and moisture of field cured cylinders will be kept as close as possible to the represented concrete. Leave the specimens in the molds until tested or forms or blankets are removed from the represented concrete whichever comes first. Where the cylinders can be stored under the blankets, field curing extra cylinders may be desirable for pavement repair or fast track concrete.

(6) The temperature surrounding the cylinders (except for field curing) should be maintained as closely as practical between 60° and 80°F. If additional measures are needed for temperature control, the below hot or cold weather options will be used:

A. Hot weather concreting.

The following are possible options depending on forecasts and current weather conditions.

- Cover all cylinders with ample wet burlap and white plastic. Use weight (aggregate, rocks, etc.) to keep plastic against the surface and not blow off when windy. 24

- Move the plastic specimens a short distance (carrying distance) and place them in a temperature controlled job facility immediately after molding.

- Place individually covered cylinders in a cool shady area and cover with wet burlap and white plastic.

- Fill a 5-gal. bucket or comparable container to within 1/2" of the top of the cylinders with cool water. Cover container to reduce temperature changes and water evaporation. Consider drilling a hole in the bucket at the high water mark to prevent water from contacting the top of the cylinder until after initial set.

- Make a small pit in the ground or sand to accommodate the cylinders. After the cylinders are placed in the pit, cover the top of the pit area with wet burlap and white plastic or wet sand.

B. Cold weather concreting.

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The following are possible options depending on forecasts and current weather conditions.

- Move the plastic specimens a short distance (carrying distance) and place them in a temperature controlled job facility immediately after molding.

- Use a large cooler or other suitable insulated container and close the top to retain the heat from the cylinders.

- Place individually covered cylinders in a sunny area and cover with wet burlap and black plastic.

- Place specimens adjacent to the freshly placed concrete under blankets or other insulating material to utilize the heat from the freshly placed concrete in maintaining the temperature of the cylinders, provided the cylinders will not be subjected to vibration.

(7) Transport the cylinders in the mold, within 24 ± 8 hours after casting, to a facility with lime (calcium hydroxide) water tank.

Schedule moving of the cylinders as close to the 24 hour time frame as possible. Remove cylinders from the mold and place in lime water solution.

The lime water in the curing tank should have a concentration of 1 teaspoon of lime to 1 gallon of water and will be maintained at a temperature range of 70° to 77°F. Stir the lime water daily.

In lieu of a lime water curing tank, a moist room may be used. The moist room will maintain a temperature range of 70° to 77°F and a relative humidity of not less than 95%.

NOTE: Before placing the cylinders into the lime water solution, make sure the necessary identification data has been written on the top and side of each cylinder (Figure 2 and 3).

(8) Cylinders will be placed in plastic cylinder bags for transporting to Area or Central Office to keep cylinders moist at all times. Cylinders must be protected from jarring or excessive bumps while in vehicle. Transporting may also be done by placing the specimen in a bed of sand.

If a cylinder is dropped or mishandled in any way (curing problems, excessive heat or cold, dryness, etc.) make a note on the DOT-23.

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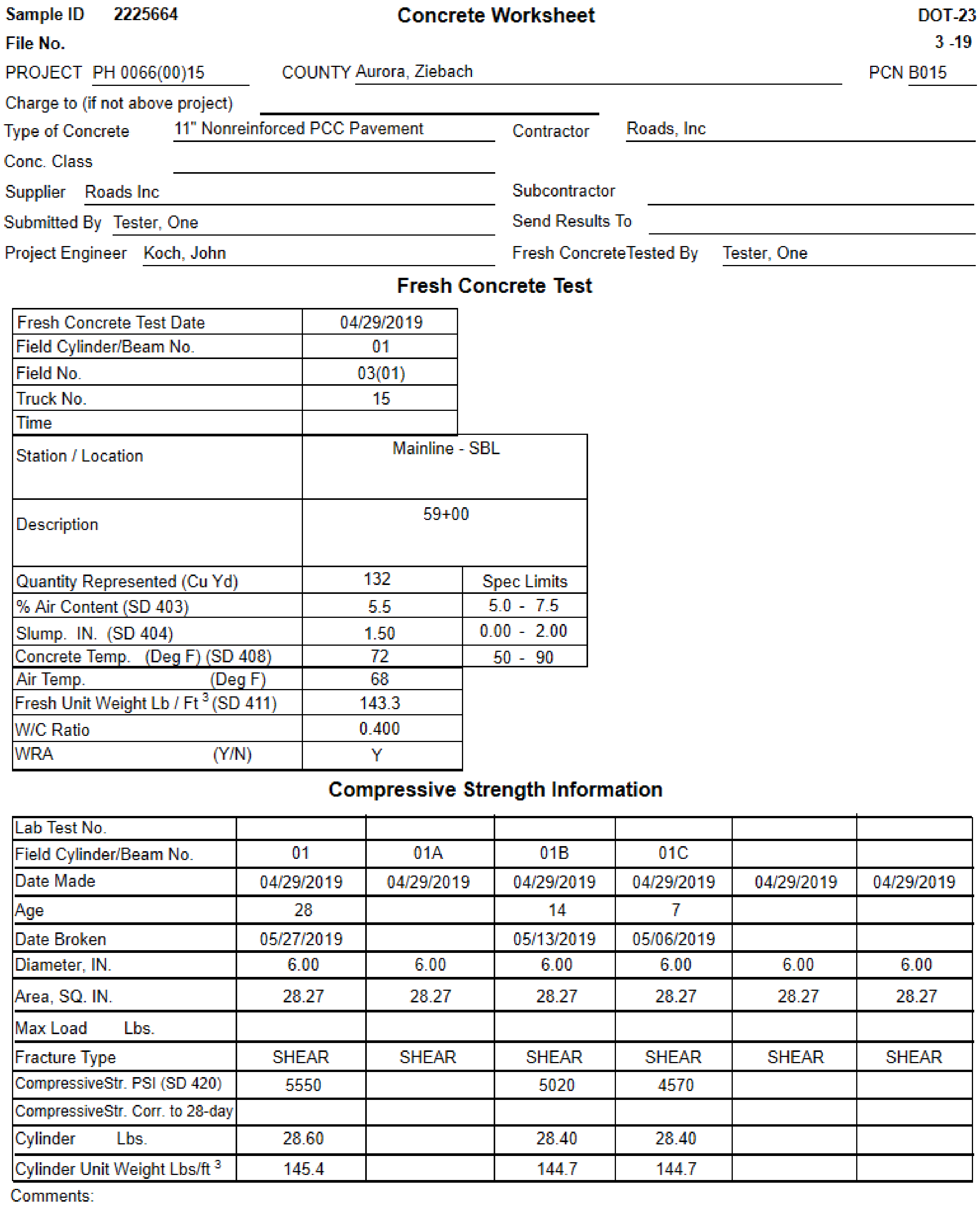
Only one cylinder is to be sent to the Central Laboratory for the 28 day test. The 28 day cylinder will be sent in between 15 and 21 days. In the event that the 14 day cylinder fails to meet strength, the backup cylinder will be sent in with the original.

4. Report:

DOT-7 (Central Office)
DOT-23

5. References:

AASHTO M 205
SD 402
DOT-7
DOT-23



Sample ID 2225664

Concrete Worksheet

DOT-23
3 -19

File No.

PROJECT PH 0066(00)15

COUNTY Aurora, Ziebach

PCN B015

Charge to (if not above project)

Type of Concrete 11" Nonreinforced PCC Pavement

Contractor Roads, Inc

Conc. Class

Supplier Roads Inc

Subcontractor

Submitted By Tester, One

Send Results To

Project Engineer Koch, John

Fresh Concrete Tested By Tester, One

Fresh Concrete Test

Fresh Concrete Test Date	04/29/2019	
Field Cylinder/Beam No.	01	
Field No.	03(01)	
Truck No.	15	
Time		
Station / Location	Mainline - SBL	
Description	59+00	
Quantity Represented (Cu Yd)	132	Spec Limits
% Air Content (SD 403)	5.5	5.0 - 7.5
Slump. IN. (SD 404)	1.50	0.00 - 2.00
Concrete Temp. (Deg F) (SD 408)	72	50 - 90
Air Temp. (Deg F)	68	
Fresh Unit Weight Lb / Ft ^{3} (SD 411)	143.3	
W/C Ratio	0.400	
WRA (Y/N)	Y	

Compressive Strength Information

Lab Test No.						
Field Cylinder/Beam No.	01	01A	01B	01C		
Date Made	04/29/2019	04/29/2019	04/29/2019	04/29/2019	04/29/2019	04/29/2019
Age	28		14	7		
Date Broken	05/27/2019		05/13/2019	05/06/2019		
Diameter, IN.	6.00	6.00	6.00	6.00	6.00	6.00
Area, SQ. IN.	28.27	28.27	28.27	28.27	28.27	28.27
Max Load Lbs.						
Fracture Type	SHEAR	SHEAR	SHEAR	SHEAR	SHEAR	SHEAR
CompressiveStr. PSI (SD 420)	5550		5020	4570		
CompressiveStr. Corr. to 28-day						
Cylinder Lbs.	28.60		28.40	28.40		
Cylinder Unit Weight Lbs/ft ^{3}	145.4		144.7	144.7		

Comments:

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Figure 1

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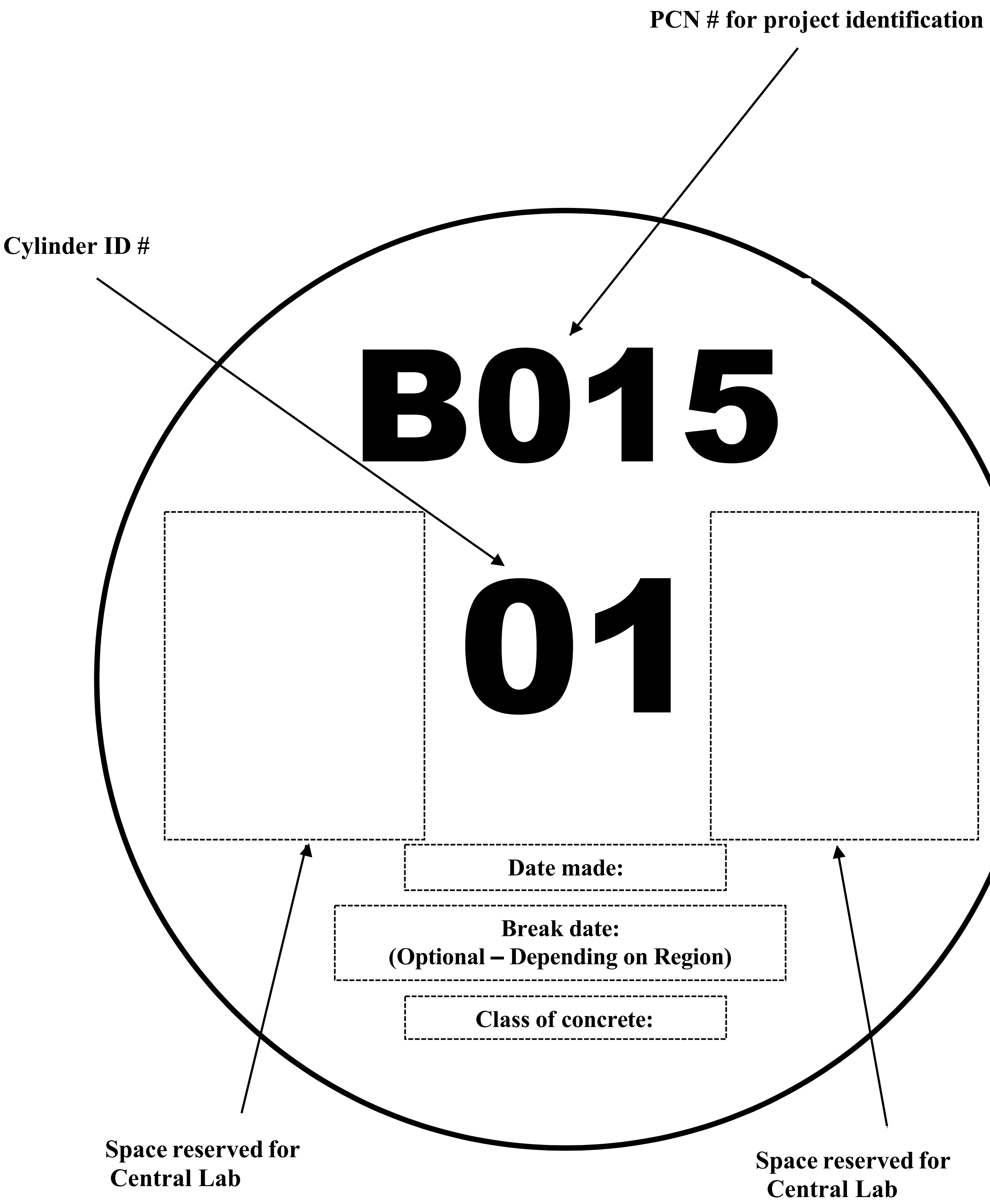

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Figure 2

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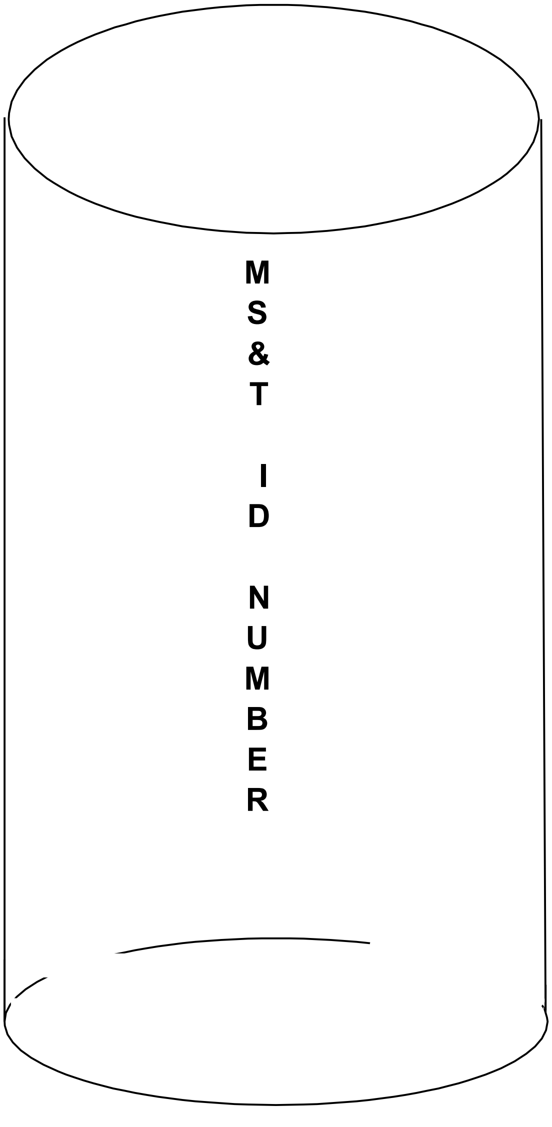

Figure 3

Method of Test for Air Entraining Admixtures for Concrete

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1. Scope:

This test is for materials proposed for use as air entraining admixtures.

2. Apparatus:

As specified in AASHTO T 157.

3. Procedure:

3.1 The procedure shall be the same as specified in AASHTO T 157 with the following exceptions:

A. Design of concrete mixtures for standards shall be those shown on job mix design sheets without entrained air.

B. Freezing and thawing and length change tests are to be omitted from routine control work.

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C. For control purposes, 7 day strength shall be considered sufficient.

4. Report:

As required by AASHTO T 157.

5. References:

AASHTO T 157

Method of Test for Slump Flow and Visual Stability Index of Self-Consolidating Concrete

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1. Scope:

The test is for determining the slump flow and visual stability index (VSI) of self-consolidating concrete (SCC).

2. Apparatus:

2.1 Slump Cone Mold conforming to AASHTO T 119.

2.2 Base plate of stiff non-absorbing material, at least 32 inches square and marked with both a circle indicating the central location for the slump cone and a concentric circle with a diameter of 20 inches.

2.3 Strike-off Bar - A flat straight bar of steel at least 1/8 in. thick and 3/4 in. wide by 12 in. long.

2.4 Measuring tape capable of measuring to 1/4”.

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2.5 Scoop or shovel.

3. Procedure:

3.1 Obtain a sample of fresh concrete in accordance with SD 402.

3.2 Dampen the inside of the mold and the base plate just prior to use.

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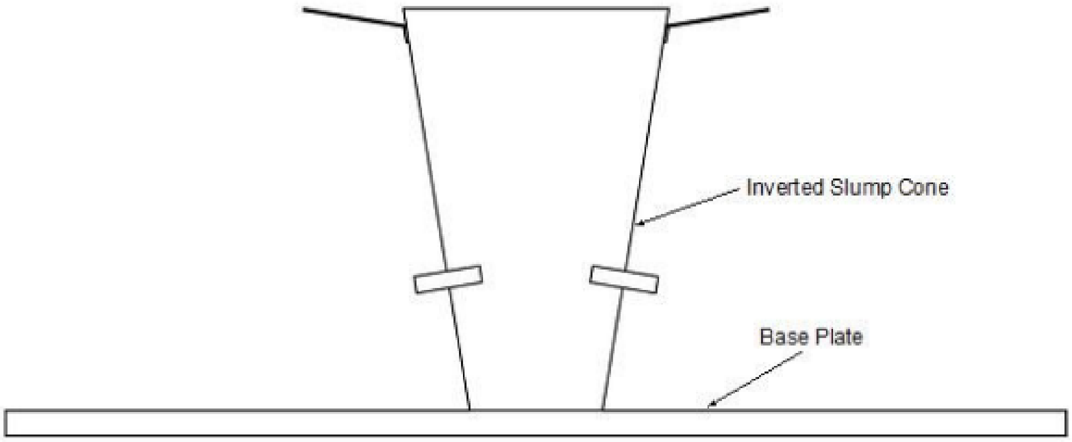
3.3 Place the base plate on a level, stable surface.

3.4 Invert the mold and place it in the center of the base plate (Figure 1). Hold firmly in place.

Figure 1- Mold (Inverted) and Base Plate



3.5 Using a shovel or hand scoop, fill the mold in one lift without vibrating, rodding, or tamping.

3.6 Use the strike-off bar to strike off the SCC level with the top of cone.

3.7 Remove any concrete from around the base of the cone.

3.8 Raise the cone in a vertical direction 9 in. 3 ± above the base plate with no lateral or torsional motion within 3 ± 1 seconds.

Complete the entire test from the start of the filling through removal of the mold without interruption within an elapsed time of 2 1/2 minutes.

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3.9 After the concrete flow has stopped, measure the diameter in two directions, the largest diameter (d_1) and the diameter perpendicular to the largest diameter (d_2), to the nearest ¼”. Include any border without coarse aggregate or a bleed water ‘halo’ in the diameter measurement. the slump flow diameter. The average of the two measurements will be the slump flow.

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If the diameter of the two measurements differs by more than 2 inches, the test will be considered invalid and must be repeated.

Slump Flow = $(d_1 + d_2) / 2$

3.10 By visual examination, rate the visual stability index (VSI) of the SCC using the criteria in Table 1 and the illustrations in Figures 2 thru 8.

Table 1
Criteria of Visual Stability Index

Rating	Criteria
0	No evidence of segregation in slump flow patty or mixer drum or wheelbarrow
1	No border of mortar without coarse aggregate in the slump flow patty, but some slight bleed or air popping on the surface of the concrete in the mixer drum or wheelbarrow.
2	A slight border of mortar without coarse aggregate (<10 mm (3/8 in.)) or aggregate pile in the slump flow patty, or both, and highly noticeable bleeding in the mixer drum or wheelbarrow.
3	Clearly segregating by evidence of a large border of mortar without coarse aggregate (>10 mm (3/8 in.)) or large aggregate pile in the center, or both, of the slump flow patty and a thick layer of paste on the surface of the resting concrete in the mixer drum or wheelbarrow.

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Figure 2
Visual Index = 0

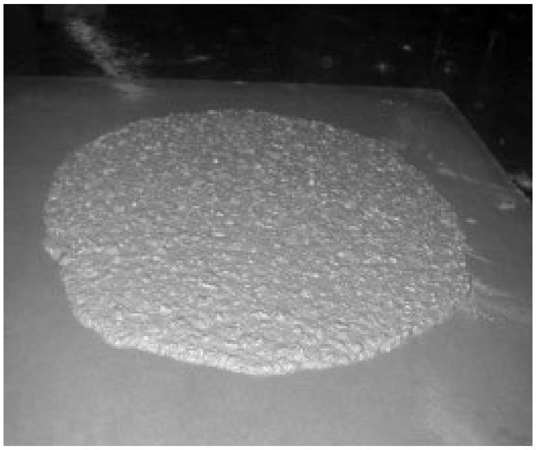
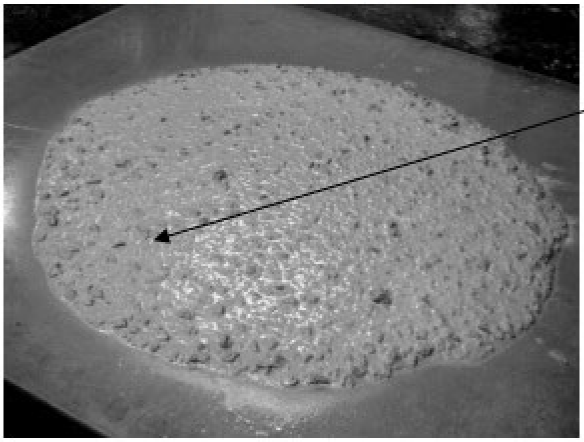


Figure 3
Visual Stability Index = 1

Some slight bleed or air popping on the surface

Figure 4
Visual Stability Index = 1



Some slight bleed or air popping on the surface

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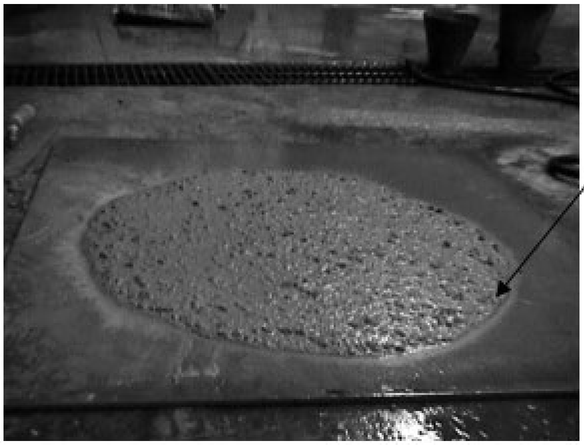
Figure 5
Visual Stability Index = 2



Border of mortar without coarse aggregate and bleeding

Figure 6
Visual Stability Index = 2

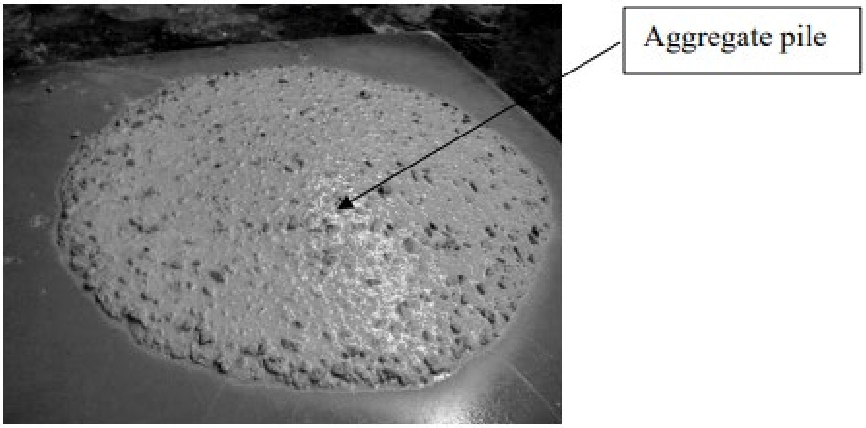
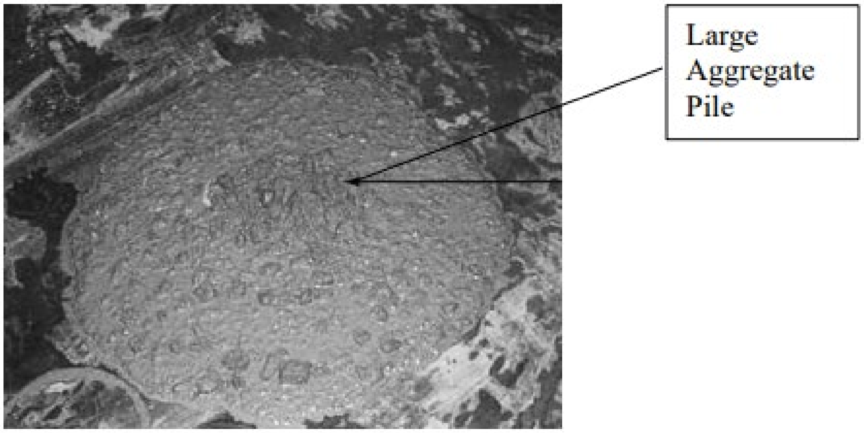


Figure 7
Visual Stability Index = 3



Back

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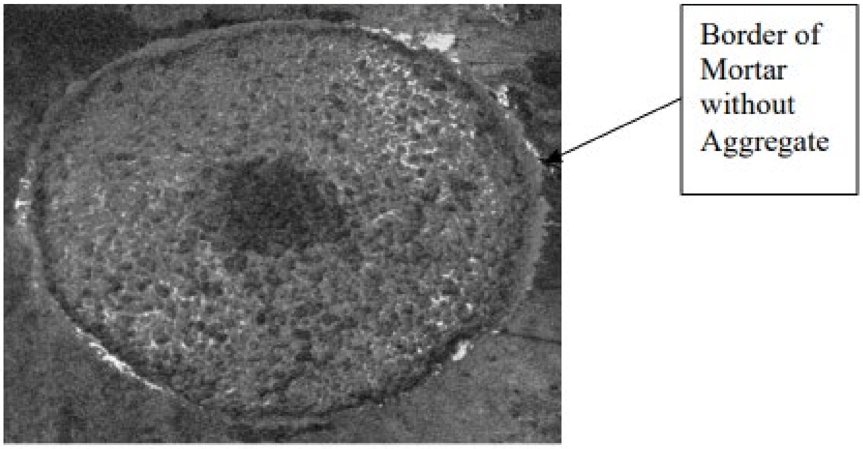
Figure 8
Visual Stability Index = 3



4. Report:

Report the slump flow to the nearest 1/4” and the VSI rating on a DOT-23.

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5. References:

AASHTO T 119
SD 402
DOT-23

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Method of Test for Temperature of Freshly Mixed Portland Cement Concrete

---

1. Scope:

This test method covers the determination of temperature of freshly mixed Portland cement concrete.

2. Apparatus:

2.1 Temperature measuring device. A temperature measuring device capable of measuring the temperature of the freshly mixed concrete to ± 1°F, having a range from 30 to 120°F. The design shall be such that it allows 3” or more of immersion during operation.

2.2 Container. The container shall be made of non-absorptive material and large enough to provide at least 3" of concrete in all directions around the sensor of the temperature measuring device.

3. Procedure:

Back

3.1 Place the temperature measuring device in the freshly mixed concrete so that the temperature sensing portion is submerged a minimum of 3". Gently press the concrete around the temperature measuring device at the surface of the concrete so that ambient air temperature does not affect the reading.

3.2 Leave the temperature measuring device in the freshly mixed concrete for a minimum of 2 minutes or until the temperature reading stabilizes, record temperature.

3.3 Complete the temperature measurement of the freshly mixed concrete within 5 minutes after obtaining the sample. For volumetric mixed concrete complete within 10 minutes after obtaining sample.

NOTE: Samples of volumetric mixed (Low slump) concrete shall be placed in a covered container for 5 minutes prior to testing.

4. Report:

4.1 Record the measured temperature of the freshly mixed concrete to the nearest 1°F on a DOT-23. 23

5. References:

DOT-23
ASTM C1064

Method of Test for Compressive Strength of Concrete Using the Rebound Test Hammer

---

1. Scope:

This test is for determining the approximate compressive strength of concrete in-place.

2. Apparatus:

2.1 Test hammer with carborundum stone.

3. Procedure:

3.1 Calibration.

A. The rebound test hammer is calibrated at the Central Laboratory. Send the test hammer to the Central Laboratory when it is malfunctioning or after approximately 2000 impacts.

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3.2 Field Checks.

A. Prior to using the test hammer for informational purposes, verify the Central Lab calibration chart by performing the test procedure on concrete with a similar mix design that has a known strength. Compare the known strength to the test hammer result and consider this information in any decisions that will be made based on the test hammer results. Whenever possible, a more accurate field correction factor (G) should be calculated according to 3.2(B) and applied to test results.

B. Field correction factor (G) calculation.

(1) When possible, use a cylinder of the same mix design and age of the in place concrete to be tested. If possible, perform the calibration with the test hammer in the same orientation (Horizontal, vertical up, or down) it will be used in the field. The moisture condition on the surface of the cylinder should be similar to what is going to be tested in the field.

(a) If calibrating in the horizontal position, place the cylinder in a compressive strength-testing machine and apply 10,000 to 15,000 pounds force (Enough to keep the cylinder stationary).

(b) If calibrating in the vertical down position, place the cylinder on a firm surface and secure it from movement.

(2) Perform the test hammer procedure on the cylinder as per 3.3B through 3.3H.

(3) Perform the compressive strength test on the cylinder according to SD 420 and record the cylinder compressive strength (A).

(4) Compare the compressive strength of the cylinder (A) to the orientation corrected compressive strength (F) determined by the test hammer in 3.2B(2). Calculate the field correction factor (G) = (A) / (F).

(5) When possible, apply this correction factor to field tests of the same concrete according to 3.3I.

3.3 Field tests.

A. Operate the test hammer in a horizontal position, whenever feasible.

B. If the concrete surface is rough, grind points to be tested with the carborundum stone.

Back

C. Press the test hammer plunger at exactly right angles to the surface of the concrete being tested. Press the plunger slowly and uniformly until released. Do not jerk or try to anticipate the plunger release.

D. After impact, press the lock button and read the rebound value shown on the rider. Record the reading.

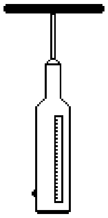
E. Take a minimum of 15 rebound readings. Take only one reading at a given point. Very high readings may be caused by rock or steel near the surface at the point of impact, and very low readings may be caused by trapped air pockets near the surface at the point of impact.

F. Discard the highest reading, the lowest reading, and any that are obviously in error. Calculate the sum of the remaining readings (B) and the average of the remaining readings (C).

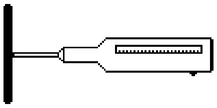
G. Convert the average of remaining reading (C) to compressive strength (D) in PSI by using the Central Lab calibration chart for that particular test hammer. (Do not use the calibration curves on the test hammer.)

H. Calculate the orientation corrected compressive strength by adding the appropriate orientation correction factor (E) according to the orientation of the test hammer during the testing. (F) = (D) + (E)

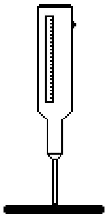
Horizontal: Correction – None
Vertical Up: Correction – Minus 500 PSI
Vertical Down: Correction – Plus 500 PSI



Vertical Up



Horizontal



Vertical Down

I. Calculate the final compressive strength (H) by multiply the orientation corrected compressive strength (F) by the field correction factor (G) that was calculated in 3.2B(4).

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(H) = (F) x (G)

NOTE: During the concrete cylinder comparison calibration test this should equal the initial compressive strength of the cylinder (A) ± 0.5%.

4. Report:

Report final compressive strength (PSI) on a DOT-9.

5. References:

SD 420
DOT-9

Sample ID: 2229731

Rebound Hammer Test Worksheet

DOT-9
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Tested By Tester, One Test Date 06/13/2019
Location Box Culvert located at Sta. 125+30 Age of Concrete 7 days
Description MATERIALS MANUAL
Hammer Identity P-15 Date of Calibration 03/02/2019 Approximate # of impacts since calibration 56

Concrete Cylinder Comparison Calibration Cylinder ID # 5
(A) Cylinder Compressive Strength 3,920 Date Made 06/06/2019

Location of Test		Calibration	Top Slab	Top Slab	Bottom Slab	East Wall
Position of Hammer Vert. Up - Horiz. - Vert. Down		Horizontal	Vertical Up	Vertical Up	Vertical Down	Horizontal
HAMMER READINGS (strike through highest and lowest reading and any other that is an obvious error)	1	22	21	23	19	20
	2	21	~~26~~	23	20	21
	3	24	~~17~~	22	~~26~~	21
	4	24	23	~~20~~	18	~~17~~
	5	~~19~~	22	21	~~28~~	19
	6	22	22	23	20	18
	7	22	~~29~~	23	17	20
	8	23	24	21	~~14~~	22
	9	21	23	24	17	22
	10	~~27~~	20	22	19	19
	11	24	23	22	20	20
	12	22	22	21	~~13~~	21
	13	21	21	24	21	~~25~~
	14	23	20	23	21	21
	15	23	24	~~31~~	20	23
	16	22	20	24	20	19
	17	22	23	22	19	21
(B) Sum of Remaining Readings		336	308	338	251	307
(C) Average of Remaining Readings		22	22	23	19	20
(D) Compressive Strength (PSI) (from Central Lab Calibration		4,340	4,340	4,370	3,480	3,810
(E) Test Hammer Orientation Correction Factor (PSI)		0	-500	-500	500	0
(F) Orientation Corrected Compressive Strength (PSI) =		4,340	3,840	3,870	3,980	3,810
(G) Field Correction Factor for Cylinder Calibration = A/F		0.90	(G) from calibration column	(G) from calibration column	(G) from calibration column	(G) from calibration column
(H) Final Compressive Strength (PSI) = FxG		3,906	3,456	3,483	3,582	3,429

Comments:

Figure 1

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Method of Test for Flexural Strength of Concrete

---

1. Scope:

This test is for determining flexural strength of concrete with third point loading.

2. Apparatus:

2.1 Beam breaker. (AASHTO T 97)

2.2 Rule with 1/16” divisions at least 8” in length.

2.3 Recording charts.

3. Procedure:

3.1 Turn the test specimen on its side, with respect to its position as molded, and center on the bearing blocks.

Back

3.2 Bring the load-applying blocks in contact with the surface of the specimen.

If full contact is not obtained at no load between the specimen and the load-applying blocks, grind the contact surfaces of the specimen or shim with leather strips.

3.3 Load at a rate of 125 to 175 psi/min.

3.4 Measure the beam at the breaking point to obtain the width and depth to nearest 1/16" with respect to its position when tested.

3.5 Record the load in lbs.

NOTE: If the break occurs outside the middle third of the span, contact the Central Laboratory for instructions.

4. Report:

4.1 Calculations.

$$R = Pl / bd^2$$

Where:

R = Modulus of rupture, psi,
P = Maximum applied load indicated by the testing machine, lbf,
l = Span length, in.,
b = Average width of specimen, in., and
d = Average depth of specimen, in.

4.2 Report the flexural strength to the nearest 5 psi.

5. References:

AASHTO T 97

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Method of Test for Density (Unit Weight) of Concrete

---

1. Scope:

This test is for determining the density (unit weight) of freshly mixed concrete

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 lb.

2.2 Tamping rod. A round, smooth, straight 5/8 in. diameter steel rod with the tamping end or both ends rounded to a hemispherical tip of 5/8 in. diameter. The minimum length will be 18 in.

2.3 Measure. A cylindrical rigid metal measure with a capacity of approximately 0.5 ft.^{3} or the measuring bowl of the air meter may be used (SD 403).

2.4 Mallet. A mallet (with a rubber or rawhide head) having a mass of 1.25 +/- 0.50 lb.

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2.5 Scoop. A scoop of a size large enough so a representative amount of concrete is obtained and small enough that concrete is not spilled during placement in the measure.

2.6 Strike-Off Plate. A flat rectangular metal plate at least 1/4 in. thick or a glass or acrylic plate at least 1/2 in. thick with a length and width at least 2 in. greater than the diameter of the measure with which it is to be used. The edges of the plate will be straight and smooth within a tolerance of 1/16 in**.**

3. Procedure:

3.1 Calibrate the measure as described in SD 205, paragraph 3.3 C to determine the volume of the measure to the nearest 0.001 ft^3.

3.2 Obtain a sample of concrete in accordance with SD 402.

NOTE: Samples of volumetric mixed low slump dense concrete will be placed in a covered container for 5 minutes prior to testing.

3.3 Dampen the interior of the empty measure and remove any standing water from the bottom. Weigh the empty measure to the nearest 0.1 lb. Place the measure on a flat, level and firm surface.

3.4 Fill the measure with concrete in 3 approximately equal layers. Rod each layer 25 times. Distribute the strokes uniformly over the cross section of the layer being rodded.

Rod the lower layer its total depth, but the rod will not forcibly strike the bottom of the measure so as to cause excessive vibration. Rod the second and third layers with the rod penetrating slightly (Approximately 1 inch) into the layer below.

Add concrete to the final layer in a manner to avoid excessive overfilling. Add additional concrete as required to keep the surface above the measure as it is rodded.

After each layer is rodded, tap the outside of the measure 10 to 15 times with the mallet. Tap with enough force to close any voids left by rodding and to release any large air bubbles that may have been trapped. For concrete with a slump of less than 2”, the number of taps can be increased to achieve consolidation.

3.5 After consolidation of the concrete, strike off the top surface of the concrete and finish it smoothly using the strike-off plate, so the measure is level full.

Press the strike-off plate on top of the measure to cover approximately 2/3 of the measure. Withdraw the strike-off plate with a sawing motion. Place the strike-off plate on the measure in the original position to cover the same 2/3 of the measure. Advance the strike-off plate with downward pressure and a sawing motion until it slides completely off the measure. Finish the surface with several strokes of the strike-off plate at an inclined angle

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3.6 Clean all excess concrete from the measure and weigh to the nearest 0.1 lb.

4. Report:

4.1 Calculations.

A. Subtract the weight of the empty measure from the total weight to determine the weight of the concrete to fill the measure.

B. Density (unit weight) of concrete lb./ft^3 = Weight of the concrete to fill the measure divided by the volume of the measure.

Example:

Total weight of measure & fresh concrete (0.1 lb.)		Weight of empty measure (0.1 lb.)		Weight of fresh concrete (0.1 lb.)
44.3 lb.	-	8.0 lb.	=	36.3 lb.

Volume of measure = 0.251 ft^3

Density (unit weight) of concrete = 36.3 lb. / 0.251 ft^3 = 144.6 lb./ft^3

Report to the nearest 0.1 lb./ft^3 on a DOT-23. 23

5. References:

DOT-23
SD 205
SD 402
SD 403

Back

Method of Test for Passing Ability of Self-Consolidating Concrete by J-Ring

1. Scope:

The test is for determining the passing ability of self-consolidating concrete (SCC).

2. Apparatus:

2.1 J-Ring apparatus conforming to AASHTO T 345.

2.2 Slump Cone Mold conforming to AASHTO T 119.

2.3 Base Plate – Base plate of stiff non-absorbing material, at least 32 inches square and marked with both a circle indicating the central location for the slump cone and a concentric circle with a diameter of 20 inches.

2.4 Strike-off Bar - A flat straight bar of steel at least 1/8 in. thick and 3/4 in. wide by 12 in. long.

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2.5 Measuring tape capable of measuring to 1/4”.

2.6 Scoop or shovel.

3. Procedure:

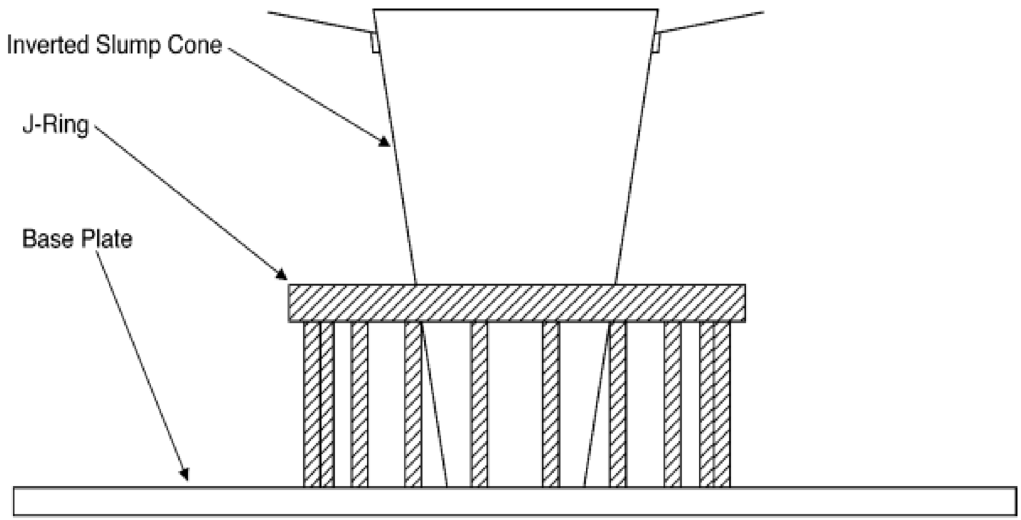
3.1 Obtain a sample of fresh concrete in accordance with SD 402. Complete this test within six minutes of starting SD 424.

3.2 Dampen the inside of the mold and the base plate just prior to use.

3.3 Place the base plate on a level, stable surface.

3.4 Place the J-Ring centrally on the base place and the inverted slump cone centrally inside it (Figure 1). Hold the slump cone firmly in place.

Figure 1



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3.5 Using a shovel or hand scoop, fill the mold in one lift without vibrating, rodding, or tamping.

3.6 Use the strike-off bar to strike off the SCC level with the top of cone.

3.7 Remove any concrete from around the base of the cone. 23

3.8 Raise the cone in a vertical direction 9 in. 3 ± above the base plate with no lateral or torsional motion within 3 ± 1 seconds.

Complete the entire test from the start of the filling through removal of the mold without interruption within an elapsed time of 2 1/2 minutes.

3.9 After the concrete flow has stopped, measure the diameter in two directions, the largest diameter (j_1) and the diameter perpendicular to the largest diameter (j_2), to the nearest ¼”. Include any border without coarse aggregate or a bleed water ‘halo’ in the diameter measurement. The average of the two measurements will be the J-Ring flow.

If the diameter of the two measurements differs by more than 2 inches, the test will be considered invalid and must be repeated.

J-Ring Flow = (j_1 =+ j_2) / 2

3.10 The J-Ring value is the difference between the slump flow (SD 424) and the J-Ring flow.

J-Ring Value = J-Ring Flow – Slump Flow

4. Report:

Report the J-Ring Value to the nearest 1/4” on a DOT-23.

5. References:

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AASHTO T 119
AASHTO T 345
SD 402
SD 424
DOT-23

Back

Procedure for Checking Contractor's 25 Foot California Style Profilograph

---

1. Scope:

This test covers the procedure for checking the Contractor's 25' California style profilograph machine to the Department's 25' California style profilograph to assure that the Contractor's machine is producing pavement smoothness results similar to the Department's machine.

2. Apparatus:

2.1 25 Foot California style profilograph – SDDOT.

3. Procedure:

3.1 Assemble the profilograph machine as per manufacturer's recommendations.

3.2 Perform the vertical calibration a minimum of once per day or after each re-assembly.

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3.3 Tire pressure shall be as per manufacturer's recommendations, (Cox or McCracken - 25 psi, Ames - 30 psi). Check the tire pressure at least once per 3 hours of use.

3.4 Perform the horizontal calibration annually, unless a discrepancy is noted. This shall be accomplished on a pre-measured test distance of 500 to 1000'. The tolerance should be at ± 0.2% of the measured distance.

3.5 Observe the Contractor's profilograph vertical calibration.

3.6 Operate the profilographs at a walk approximately 3 mph in one or more wheel paths for approximately one mile with the Contractor. Compare the machine horizontal measurements with the Contractor's. The horizontal measurements should compare with ± 0.2%.

3.7 The average results of the contractor's machine should be within 1 inch/mile for a 0.2" blanking band and within 2 inches/mile for a 0 blanking band of the average results of the SDDOT machine.

3.8 Repeat the above steps until an acceptable comparison is obtained. The Contractor shall make whatever adjustments necessary to his machine to achieve an acceptable comparison.

4. Report:

4.1 The Central Office Materials Lab shall report the results of the comparison in a letter to the Area Engineer, Region Engineer, Concrete Engineer and the Project File.

5. References:

SDDOT Training Manual for concrete paving

Back

Method of Making and Curing Concrete Specimens in the Field for Flexural Tests

---

1. Scope:

This is the procedure for making and curing concrete specimens to be used for flexural tests.

2. Apparatus:

2.1 Beam Mold. Inside measurements will be 6” x 6” x 22”. They will be collapsible for easy removal of the specimen.

2.2 Tamping Rod - A round smooth straight 5/8 in. diameter steel rod with the tamping end or both ends rounded to a hemispherical tip of 5/8 in. diameter. The length of the tamping rod will be at least 4 inches greater than the depth of the mold, but not greater than 24 inches.

2.3 Finishing Tools – Straightedge, handheld float, or trowel.

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2.4 Miscellaneous - Small scoop or shovel, and mallet.

3. Procedure:

3.1 Molding Specimens.

A. Obtain a sample of concrete in accordance with SD 402.

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B. Fill the mold with concrete in 2 approximately equal layers.

Rod each layer sixty-six strokes, once for each 2 square inches of surface area.

Rod the lower layer its total depth, but the rod must not forcibly strike the bottom of the mold so as to cause excessive vibration. Rod the second layer with the rod penetrating slightly (approximately 1 inch) into the layer below.

Heap the concrete above the top of the mold for the final layer, adding additional concrete, as required, to keep the surface above the mold as it is rodded.

After each layer is rodded, tap the outsides of the mold 10 to 15 times with the rubber mallet. Tap with enough force to close any holes left by rodding and to release any large air bubbles that may have been trapped. For concrete with a slump less than 2” the number of taps may be increased to achieve consolidation.

Self-Consolidating Concrete – Mold the specimens as described in 3.1.B without layers or consolidation.

D. After tapping, spade the concrete along the sides and ends of the beam mold with a trowel.

E. Strike off and finish with a straightedge and trowel to produce a flat even finish.

F. Curing.

(1) Immediately after molding, place the specimen in a storage box or completely cover with plastic, sealing it to prevent moisture loss.

(2) Store the specimens where they are not subject to vibration or being moved for 24 ± 8 hours after molding.

(3) Do not remove the specimen from the mold until 24 hours after molding.

Back

(4) Cure and transport specimens in accordance with SD 405 3.1.D.(6).

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(5) Transport the beam to be cured in the mold or place the specimen in a bed of sand.

(6) After removing from the mold, store the specimens in lime water (calcium hydroxide) at a temperature between 70° and 77°F.

The lime water in the curing tank should have a concentration of at least 1 teaspoon of lime to 1 gallon of water. Stir the lime water monthly. Lime will be calcium hydroxide.

In lieu of a lime water curing tank, a moist room may be used. The moist room will maintain a temperature range of 70° to 77°F and a relative humidity of not less than 95%.

NOTE: Before placing the beams into the lime water solution, make sure the necessary identification data has been provided on each at a location that is clearly visible.

4. Report:

DOT-7 (Central Office)

5. References:

None.

Method of Test for Determining the Dissolved Solids in Water

---

1. Scope:

This test is for determining the dissolved solids in water used for concrete mix, cement stabilization or lime stabilization.

2. Apparatus:

2.1 Digital conductivity meter with automatic temperature compensation.

2.2 Glass and platinum dip cell.

3. Procedure:

3.1 Completely submerge the dip cell in the sample.

3.2 Read the dissolved solids in parts per million from the LED on the meter.

4. Report:

Back

Report the dissolved solids in parts per million.

5. References:

AASHTO T 26

Portland Cement Mill Certification

1. Scope:

Mills furnishing Portland cement to South Dakota Department Transportation projects shall be classified by the Chief Materials and Surfacing Engineer as certified mills or non-certified mills in accordance with this procedure.

2. Apparatus:

2.1 The apparatus for sampling cement shall be as shown in SD 401.

3. Procedure:

3.1 Certified mill.

A. Basis for qualification.

(1) A certified mill is any mill that furnishes Portland cement on a relatively continuous basis or a volume sufficient to justify the sampling and testing necessary to qualify and maintain a "Certified" status. The mill shall:

(a) Have an acceptable quality history based upon the manufacturer's data or Department of Transportation test records, as required by the Chief Materials and Surfacing Engineer.

(b) Maintain mill laboratory facilities which are periodically inspected by the Bureau of Standards Cement and Concrete Reference Laboratory (CCRL); or by an authorized representative of the Office of Materials and Surfacing.

(c) Maintain a record of cooperative test results conducted with the CCRL or the Department of Transportation Laboratory.

(d) As production warrants, and as directed by the Chief Materials and Surfacing Engineer, at the beginning of each month, make available to the local Region Materials Engineer a minimum of one random composite sample for each type of cement produced during the previous month. This sample will be tested by the Department.

Back

Additional samples may be requested as deemed necessary, to determine the quality of cement being produced.

(e) In addition to making a sample available as specified in (d) above, the certified mill shall also furnish the Region Materials personnel a copy of the most current Certificate of Compliance to represent each type of cement obtained that day.

Results of the following tests shall be reported on the Certificate of Compliance:

1. Physical tests (All types of cement):

   Fineness (Specified surface).
   Soundness (Autoclave expansion).
   Time of setting.
   Air content of mortar.
   Compressive strength, Types I-II, and V, 3 day and 7 day.
   Compressive strength, Type III, 1 day and 3 day.

Back

2. Chemical analysis (All types of cement):

   Silicone dioxide (SiO_2).
   Aluminum oxide ($A1_2 O_3$).
   Ferric oxide (Fe_2O_3).
   Calcium oxide (CaO).
   Magnesium oxide (MgO)
   Sulfur trioxide (SO_3).
   Loss on ignition.
   Insoluble residue.
   Tricalcium silicate ($3 CaO.SiO_2$).
   Dicalcium silicate ($2 CaO.SiO_2$).
   Tricalcium aluminate ($3 CaO.A1_2O_3$).
   Sodium oxide (Na_2O).
   Potassium oxide (K_2O).
   Equivalent alkali ($NaO+0.658K_2O$).

The Certificate of Compliance shall accompany the sample and Sample Data Sheet (DOT-1) to the laboratory.

(f) If any individual sample fails to meet requirements of the applicable specification, the mill may be removed from the certified list, by letter from the Chief Materials and Surfacing Engineer.

Certification may be reinstated at the discretion of the Chief Materials and Surfacing Engineer when sufficient sampling and testing has determined that cement meeting specifications is being maintained.

3.2 Non-certified mills.

A. Basis for qualification.

(1) Any mill not currently identified as a certified mill shall be a non-certified mill.

(a) The manufacturer and appropriate Department of Transportation personnel will be notified by the Office of Materials and Surfacing when a mill is certified and when there is a change in a mill's certification.

3.3 Portland cement delivery.

A. From a certified mill.

Back

(1) A Certificate of Compliance for each conveyance will not be required.

(2) Samples shall be obtained in accordance with SD 401 at the minimum frequency prescribed.

B. From a non-certified mill.

(1) Two copies of a properly executed Certificate of Compliance shall be submitted by the cement manufacturer for each conveyance, prior to or at time of delivery. Information required by the Certificate may be included as part of the standard bill of lading, loading or weight ticket, or shipping invoice.

The original shall be placed in the project file. The copy shall be forwarded to the Office of Materials and Surfacing.

(2) Sampling shall be in accordance with SD 401, at the minimum frequency prescribed.

C. Portland cement deliveries without required documentation.

(1) Shipments of Portland cement received without the required certification shall not be used until the Engineer in charge of the project has obtained the documents or has received satisfactory test results on samples of the cement.

4. Report:

Report the test results as set forth in AASHTO M 85.

5. References:

AASHTO M 85
SD 401

Back

Method of Test for Determining Surface Deviations of PCC Pavement and Bridge Decks

---

1. Scope:

This test is for determining longitudinal and transverse surface deviations of PCC Pavement and bridge decks.

2. Apparatus:

2.1 10’ straightedge

2.2 Steel shims of 1/16”, 1/8”, 3/16”, and 1/4” with an allowable tolerance of ±0.010” in thickness. The shims will be a minimum size of approximately 1 1/4” wide and 3” long.

2.3 10’ High-Low Detector

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3. Procedure:

Determine if the High-Low Detector will be used or if only the straightedge will be used. If only the straightedge will be used, follow section 3.3.

The High-Low Detector is used to determine the general location of possible deficient areas (Bumps/dips) to be checked with a 10’ straightedge. If the area to be checked is small the location of deficient areas may be determined with the straightedge without first identifying areas using the High-Low Detector.

3.1 Verification of the High-Low Detector.

A Prior to use.

(1) Place the High-Low Detector on a flat, straight surface. The surface should be checked with the 10’ straightedge prior to verification.

(2) Verify the High-Low Detector using shims of 1/16”, 1/8”, 3/16”, and 1/4” or a combination of 1/16” and 1/8” shims. Place these shims longitudinally under the wheels.

The High-Low Detector should be verified through the entire range of 1/16”, 1/8”, 3/16”, and 1/4” for both the high and low positions.

(3) Mark the new height and depths accurately on the indicator plate of the detector. Narrow strips of colored adhesive tape

are suggested for use in making the marks, as they can readily be removed and replaced when further verification requires slight changes on the indicator plate.

3.2 Operation of the High-Low Detector.

A. The High-Low Detector should be pushed in a longitudinal direction over the approximate center of the wheel paths in each travel lane. The detector should be kept in an upright position, approximately perpendicular to the pavement surface.

B. A deviation of 1/8” exists when the needle of the High-Low Detector swings just past the 1/8” mark of the indicator plate on either the high or low side. Also, when the indicator needle is riding on the high side and swings to the low side (or vice versa) with a total movement indicating a change of 1/8” or more, within a longitudinal distance of less than 10’, the questionable areas should be marked for checking with the 10’ straightedge.

3.3 Straightedging.

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The areas in question will be checked with a 10’ straightedge positioned either parallel or perpendicular to the centerline of the roadway. Lay shim flat on the pavement surface approximately perpendicular to the straightedge.

During the checking operation, the straightedge will be at rest and supported by only its own weight on the narrow side.

A surface deviation is considered to exist when the shim resting on the surface of the concrete can be freely passed under the straightedge.

Determine if the 1/8” or 1/4” shim will be used to determine the permissible deviation. This is based on location and standard specifications.

A. Test locations.

(1) Longitudinal surface tests will be completed on each wheel path on travel lanes and acceleration lanes. Tests will be completed at ramp entrances, shoulders, and other similar areas that visually indicate a deviation may exist.

(2) Transverse surface tests will be completed at locations that visually indicate a transverse deviation may exist. Edge slump at the pavement edge is one example.

B. Determine the Maximum Depth of the deficient area.

(1) The maximum depth of the deviation is determined by the largest shim or combination of shims that can pass freely under the straightedge, using examples in Figures 1a, 1b and 2.

Example: If the permissible deviation is 1/8” (2/16”) and the 1/8" shim will freely slide under the straightedge, but 3/16" shim will not, then report as 1/8" (2/16") under “Depth of Deviation – Total”.

C. Determining the Length of deviation in the deficient areas.

(1) Longitudinal surface test

The length of the deviation is determined using examples in Figures 1a, 1b and 2.

(2) Transverse surface test.

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The length of the deviation is measured in the longitudinal direction.

D. Determine the Width of the deficient area.

(1) Longitudinal surface test

The width will be the total width of the travel lane (12 feet or less) or shoulder.

(2) Transverse surface test.

The width will be the total width of the travel lane or shoulder. This is regardless of the actual measured width of the deviation.

4. Report:

Document the Maximum Depth of Deviation at locations that exceed the permissible deviation. The Maximum Depth of Deviation reported will be to the nearest 1/16". The wheel path with the larger maximum depth of deviation will be used for determination.

4.1 Calculate the "Deficient Area" of longitudinal surface deviation.

The length used for computation of the area will be the length measured at the wheel path with the larger maximum depth of deviation.

Deficient Area = (L * W) / 9
L = Length of deviation (nearest 0.1')
W = Width (nearest 1')

Report only the deficient area of the wheel path with the larger deviation to the nearest 0.1 yd² on the DOT-29.

4.2 Calculate the "Deficient Area" of transverse surface deviation.

Deficient Area = (L * W) / 9

L = Length of deviation (nearest 0.1 ft.)
W = Width (nearest 1')

Report the deficient area to the nearest 0.1 yd² on the DOT-29.

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5. References:

DOT-29

Sample ID 2412195

Longitudinal Surface Deviation

DOT-29
1-24

File No.

PROJECT NH-PS 0012(187)106 COUNTY Corson PCN 04FL

Field Nbr 01R McIntosh Date 12/21/2023 Tested By Armfield, Kelly

Location McIntosh Deck/Approache Type Of Material Class A45 Concrete, Bridge Deck

Station	Direction Tested	WIDTH (1 ft) W	Length (0.1 ft) L	Area (0.1 yd$_2$) (W X L)/9	Maximum Depth	Spec. Max (380.2.O or 460.3.L.4)	Remarks
1344+94.5	L	6.0	2.0	1.3	4/16	2/16	Grind R-L Wheel Track
1345+55.5	L	6.0	3.0	2.0	4/16	2/16	Grind R-L Wheel Track
1346+86.5	L	6.0	4.0	2.7	4/16	2/16	Grind R-L Wheel Track
1346+92.5	L	6.0	6.0	4.0	4/16	2/16	Grind R-L Wheel Track
1346+98.5	L	6.0	6.0	4.0	4/16	2/16	Grind R-L Wheel Track
1344+90.5	L	6.0	4.0	2.7	4/16	2/16	Grind R-R Wheel Track
1345+21.5	L	6.0	4.0	2.7	3/16	2/16	Grind R-R Wheel Track
1345+43.5	L	6.0	8.0	5.3	3/16	2/16	Grind R-R Wheel Track
1346+17.5	L	6.0	11.0	7.3	3/16	2/16	Grind R-R Wheel Track
1346+81.5	L	6.0	8.0	5.3	4/16	2/16	Grind R-R Wheel Track
1346+89.5	L	6.0	11.0	7.3	4/16	2/16	Grind R-R Wheel Track
1347+02.5	L	6.0	5.0	3.3	4/16	2/16	Grind R-R Wheel Track
1344+84.5	L	6.0	4.0	2.7	3/16	2/16	Grind Rt Outside Shldr
1344+90.5	L	6.0	1.0	0.7	4/16	2/16	Grind Rt Outside Shldr
1346+17.5	L	6.0	11.0	7.3	3/16	2/16	Grind Rt Outside Shldr
1346+80.5	L	6.0	3.0	2.0	3/16	2/16	Grind Rt Outside Shldr
1346+83.5	L	6.0	7.0	4.7	4/16	2/16	Grind Rt Outside Shldr
1346+90.5	L	6.0	9.0	6.0	4/16	2/16	Grind Rt Outside Shldr
1347+01.5	L	6.0	4.0	2.7	4/16	2/16	Grind Rt Outside Shldr
1347+09.5	L	6.0	3.0	2.0	4/16	2/16	Grind Rt Outside Shldr

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Direction Tested = longitudinal (L) or transverse (T)
Lane or Shoulder Width = affected width to nearest 0.5'
Length Deviation = nearest 0.1'
Depth of Deviation Total = max measured under straightedge to nearest 1/16"
Depth of Deviated Permissible = specification

Sq Yd= (Length x Width)/9

Comments This DOT-29 Test is for the McIntosh Deck/Approaches - Right Side. This Tests in accordance with Per Standard Specific

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LONGITUDINAL SURFACE DEVIATION

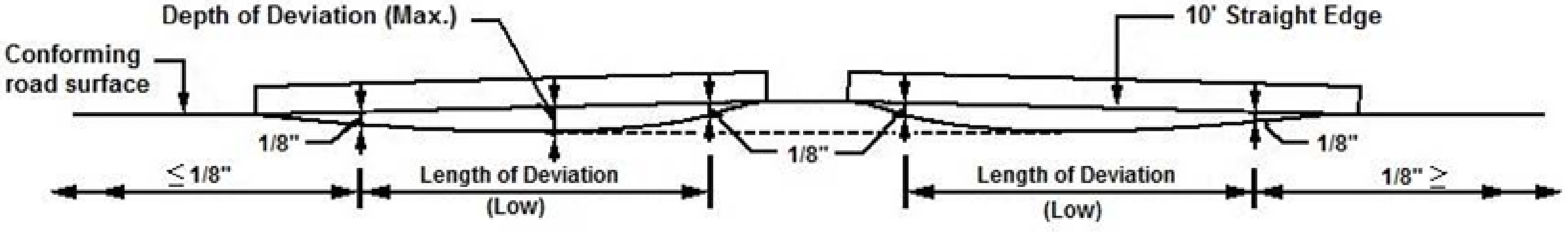

Figure 1A

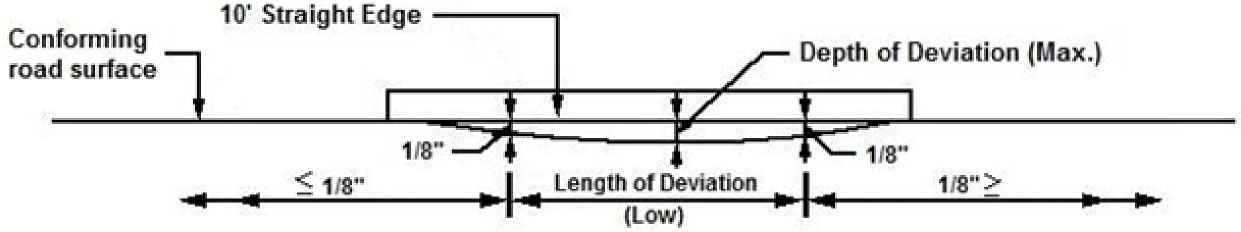

Figure 1B

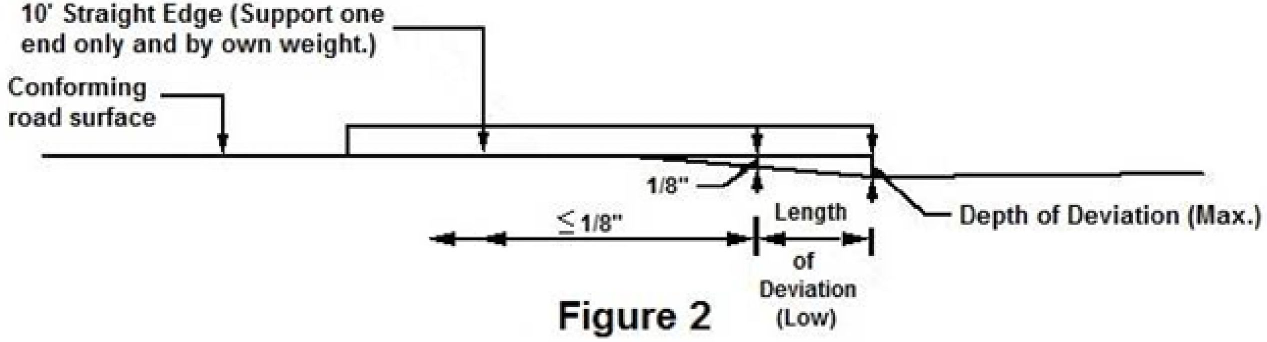

Figure 2

Procedure for Groove Depth and Spacing Measurements of Concrete Surfaces

---

1. Scope:

This test is for determining the depth of the grooving or texturing of tined surfaces.

Definitions:

Grooving: The mechanical cutting of mortar and aggregates in hardened pavement with center-to-center spacing of a nominal 1”. Grooves must have a uniform width and a uniform minimum depth. The grooves should be straight with a continuous configuration to provide rapid dispersal routes for surface water drainage.

Plastic grooving: A means of meeting the above definition by manipulation of fresh concrete pavement at the specified spacing.

Texturing: The mechanical cutting of patterns in hardened pavement with a center-to-center spacing. Indentations should produce a rough, even or uneven pattern of specified width and depth.

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Plastic texturing: The means of meeting the above definition by manipulation of concrete while it is in the plastic state.

Measurement: A specified individual determination of dimension, quality or quantity; by device or by comparison with standard or specified values.

2. Apparatus:

2.1 A gauge marked in 1/32” increments and capable of measuring to a depth of at least 1/2”. An ordinary tire tread depth gauge meeting these requirements may be used.

2.2 Miscellaneous: 12” rule, 100’ tape, broom or wire brush.

3. Procedure:

3.1 Randomly select 5 sites within the lot.

3.2 Remove all loose material from the site to be measured by brush or air pressure.

3.3 Determine and record the depth of 10 consecutive grooves in a straight line. Measure the deepest part of the groove within ± 1/2” of the straight line.

3.4 Perform calculations according to section 4.

3.5 Verify if tining spacing is within specification and document on DOT-55.

4. Report:

4.1 Calculations.

A. Calculate the "Ave. depth" for each location to the nearest 1/32".

Average depth = Site Total/10

B. Calculate the lot average by averaging the 5 "Site total" numbers from each location to the nearest 1/32".

Lot average = Sum of site totals/50

4.2 Report the test as being satisfactory, provided all the following conditions are met for each lot.

A. The lot average is within specification (4/32" to 8/32")

B. None of the individual site averages are outside individual site limitations (3/32" to 10/32").

C. No more than 2 of the individual site averages are outside specifications (4/32" to 8/32")

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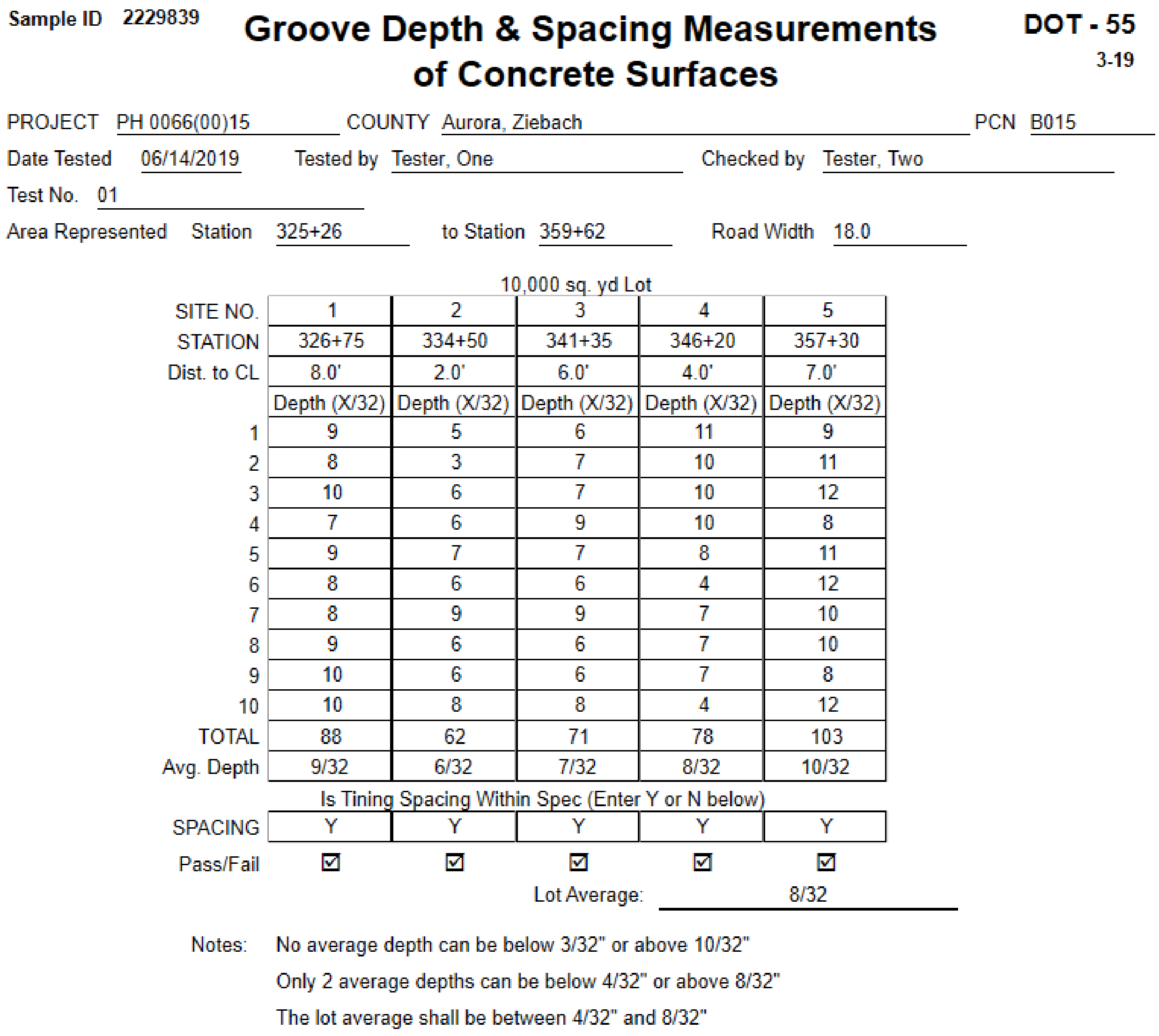
5. References:

DOT-55



Sample ID 2229839

Groove Depth & Spacing Measurements of Concrete Surfaces

DOT - 55
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Date Tested 06/14/2019 Tested by Tester, One Checked by Tester, Two

Test No. 01

Area Represented Station 325+26 to Station 359+62 Road Width 18.0

10,000 sq. yd Lot

SITE NO.	1	2	3	4	5
STATION	326+75	334+50	341+35	346+20	357+30
Dist. to CL	8.0'	2.0'	6.0'	4.0'	7.0'
	Depth (X/32)	Depth (X/32)	Depth (X/32)	Depth (X/32)	Depth (X/32)
1	9	5	6	11	9
2	8	3	7	10	11
3	10	6	7	10	12
4	7	6	9	10	8
5	9	7	7	8	11
6	8	6	6	4	12
7	8	9	9	7	10
8	9	6	6	7	10
9	10	6	6	7	8
10	10	8	8	4	12
TOTAL	88	62	71	78	103
Avg. Depth	9/32	6/32	7/32	8/32	10/32
	Is Tining Spacing Within Spec (Enter Y or N below)				
SPACING	Y	Y	Y	Y	Y
Pass/Fail	☑	☑	☑	☑	☑

Lot Average: 8/32

Notes: No average depth can be below 3/32" or above 10/32"
Only 2 average depths can be below 4/32" or above 8/32"
The lot average shall be between 4/32" and 8/32"

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Figure 1

Method of Test for Determining the In-Place Density of Low Slump Dense Concrete Using the Nuclear Gauge

---

1. Scope:

This test is for determining the in-place density of freshly mixed low slump dense concrete using the nuclear gauge.

Definitions:

Adjusted Unit Weight Determination: Field determination of unit weight using the calibrated measuring bowl of an air meter and adjusting the results to an air content of 6% (Or otherwise specified air content).

In-Place Density Measurement: A specific individual measurement of in-place nuclear gauge wet density (One of three measurements made for a lot).

Lot: A quantity of material from the same source, using the same mix, placed the same day, representing a specific segment of construction.

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Percent of Standard Density: Relationship of the in-place density measurement to the standard density.

Standard Density: Average of the three most recent adjusted unit weight determinations.

2. Apparatus:

2.1 Nuclear density-moisture gauge capable of determining densities by the direct transmission method and conforming to the requirements of AASHTO T 310.

2.2 2" snap-on source rod protection plate.

2.3 A reference standard block for taking standard counts.

2.4 A manufacturer’s instruction manual for the nuclear gauge.

2.5 A nuclear gauge information book, transportation documents book, and nuclear badge.

2.6 A supply of rags, a can of WD-40 for cleaning the base and a can of spray lubricant containing teflon to keep the gauge base and probe lubricated.

When the gauge base is cleaned with WD-40, all residue must be completely wiped from the base before applying the spray lubricant.

NOTE: Silicone spray will not be used.

2.7 Miscellaneous. A measuring tape, chalk or other marking materials (For referencing pre-selected sites), test forms, etc.

2.8 An apparatus for determining the percent of air, SD 403.

2.9 An apparatus for determining the unit weight, SD 411.

3. Procedure:

3.1 Calibration and standardization of the nuclear gauge:

A. Calibration and performing the standard count of the nuclear gauge will be in accordance with SD 114, paragraphs 3.1 and 3.2.

3.2 Selecting density measurement locations.

A. Record the location of the lot to be tested by indicating the beginning and ending stationing. Record the length, width and quantity represented by the lot in square yards.

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B. During surface preparation operations, pre-selected sites will be chipped out as required to provide for a 3” minimum depth of overlay at the measurement site at least 18” x 18” in area. Five such sites should be prepared for each lot to provide standby locations in the event a site cannot be measured for density for some reason or in the event additional density measurements are desired. Ordinarily only three of the sites will be used for each lot. The center of each site will be at least 18” from the edge of the lot.

C. The pre-selected sites will be referenced by measurements in such a manner that they can easily be located for density measurement after placement of the overlay.

3.3 Adjusted Unit Weight Determination.

A. The unit weight of the concrete will be determined by SD 411, with the following exceptions:

(1) The measuring bowl of the air meter will be used as the measure. After the unit weight determination has been completed, the top will be placed on the air meter and the percentage of air determined (SD 403).

(2) The unit weight will then be adjusted for an air content of 6.0%. This adjustment is determined by multiplying the unit weight times 94.0% and dividing that result by 100.0% minus the percent of air in the concrete.

3.4 Standard Density.

A. The moving average concept will be employed. A minimum of two adjusted unit weight determinations will be made on the first lot and then a minimum of one adjusted unit weight determination per lot thereafter. The standard density will be based on the first two determinations, then on the average of the first three determinations. After the first three tests the average of the three most recent adjusted unit weight determinations will be used as the standard density. The moving average may include more than one project when the same source, mix and mixing equipment are being used.

B. The validity of the sample is questionable when the adjusted unit weight determination varies by more than 1.5 lbs./ft^3 from the previous adjusted unit weight. Another sample will be obtained immediately and an adjusted unit weight determination made to verify or replace the sample in question.

3.5 In-Place Density Measurements.

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A. After the concrete has been placed, struck off, and consolidated by the finish machine prior to final texturing and tining, locate the pre-selected site. Seat the gauge with the 2" snap-on source rod protection plate attached on the plastic concrete. Extend the source rod to the 2" direct transmission position and take a 1 minute density reading. Record the wet density to the nearest 0.1 lbs./ft^3 on DOT 56. Remove the gauge from the test site and thoroughly clean all concrete from the bottom of the gauge. After cleaning, lightly coat with the lubricant spray and wipe dry.

B. Repeat the procedure for the other two selected sites.

4. Report:

4.1 Calculations.

A. Standard Density determinations.

(1) The adjusted unit weight will be calculated as follows:

$$\text{Adjusted Unit Weight} = \frac{\text{Unit Wt. x } 94.0}{100.0 - \text{Determined Air Content}}$$

Example:

Obtained Unit Weight = 143.6 lbs./ft^3

Determined Air Content = 5.0%

$$\text{Adjusted Unit Weight} = \frac{143.6 \text{ x } 94.0}{100.0 - 5.0}$$

$$= \frac{143.6 \text{ x } 94.0}{95.0} = 142.1 \text{ lbs./ft}^3$$

B. In-Place Density Measurements.

(1) Determine the wet density in lbs./ft^3 with the gauge.

NOTE: 3.0 lbs./ft^3 correction will be subtracted from the wet density reading when limestone aggregate is used in the mix. There is no correction for quartzite or granite used in the mix.

(2) The resulting corrected density is the wet density at that site and is the density to be averaged with that of the other two sites to determine the density for the lot. Since the standard density is also a wet density, it is not necessary to determine moisture content or dry density.

(3) Percent of Standard Density for each density measurement.

$$\text{\% of standard} = \frac{(\text{Wet density} - \text{Correction}) \times 100}{\text{Standard Density}}$$

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(4) Percent of Standard Density for the Lot. 22

$$\text{\% of standard} = \frac{\text{Sum of \% of standard for 3 density measurements}}{3}$$

4.2 Report.

A. Report the standard density to the nearest 0.1 lb./ft^3 (DOT-56).

B. Report the percent of standard density for each site to the nearest 1% (DOT-56).

C. Report the percent of standard density for the lot to the nearest 1% (DOT-56) Figure 1.

5. References:

AASHTO T 310
SD 114
SD 403
SD 411
DOT-56

Sample ID 2370767

Density Report - PC Concrete

(Bridge Deck Overlay)

DOT - 56
6-22

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Date 06/02/2019 Tested By Tester, One Checked By Tester, Two
Field No. 01 Structure No. 48-013-210 Test Mode 2" DIRECT TRANSMISSION
Nuclear Gauge No. MQ 777 Daily Standard Count 2811

Unit Weight Determination

Test Number	01	02	03
A. Weight of Concrete and Measure	44.0	44.7	43.8
B. Weight of Measure	8.2	8.8	8.2
C. Weight of Concrete (A - B)	35.8	35.9	35.6
D. Volume of Measure	0.249	0.250	0.249
E. Unit Weight PCF (C / D)	143.8	143.6	143.0
F. Adjusted Unit Weight * (E x 94) ÷ (100 - J)	142.3	142.5	142.8

Test Number	01	02	03
G. Slump	0.50	0.50	0.25
H. Mix. Temp. (°F)	82	83	85
I. Air Temp. (°F)	73	73	75
J. % Air	5.0	5.3	5.9

Standard Density

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K. Compute Standard Density**	142.3	Line F. from Test No.	01
	142.5	Line F. from Test No.	02
	142.8	Line F. from Test No.	03
L. Total	427.6		
M. Standard Density (Average)	142.5		

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**Average of the 3 Adjusted Unit Weights. The Average may be based on 2 tests for the first low slump pour.

In-Place Density Measurements

Lot Location: Begin Station 0+00 End Station 2+04.21 RT of Centerline
Length 204.21 feet Width 18.0 feet Quantity 408.4 yd²

Site No.	Distance from Lot Beginning	Distance from Outer Edge	Wet Density PCF	Correction (If Applicable)	Corrected Wet Density PCF	% of Standard ***
1	0+20	6.5	144.6	3.0	141.6	99
2	0+72	13.8	143.1	3.0	140.1	98
3	1+34	10.5	141.3	3.0	138.3	97

Percent of Standard Density Required min 98 Average Obtained 98

---

* If the adjusted unit weight for the most current test is not within 1.5 Lbs/Cu. Ft. (24 kg/m³) of the previous test, a check test must be run.
***The lot will contain no more than 1 test below the specification and no test 2% or more below the specification.
Remarks:

Figure 1

Method of Test for Determining Compressive Strength of Concrete

---

1. Scope:

This test is for determining compressive strength of 6” diameter x 12” long and 4” diameter x 8” long molded concrete cylinders. The test is limited to concrete having a unit weight in excess of 50 lbs./ft^3.

2. Apparatus:

2.1 A power operated hydraulic type compression test machine shall be used. The testing machine must have sufficient capacity, be capable of providing the rates of loading prescribed in section 3.4 and be capable of applying load consistently without shock or intermittence.

2.2 The test machine shall be fitted with two steel bearing blocks with hardened faces (Rockwell hardness of no less than 55HRC) and with a minimum dimension 3% greater than the test specimen’s diameter.

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2.3 The test machine shall include a spherically seated block (Lubricated with petroleum-type oil such as conventional motor oil) that will bear on the upper surface of the specimen. The sphere shall have a diameter of at least 75% of the diameter of the specimen to be tested. The bearing face shall have a diameter no greater than 10” when testing a 6” diameter cylinder and no greater than 6 ½" when testing a 4” diameter specimen.

2.4 Extrusion controllers shall be fitted with elastomeric pads satisfying AASHTO T 22. Elastomeric pads shall have a diameter 1/16” smaller than the inside diameter of the extrusion controller and have 1/2" ± 1/16” of compressible material.

NOTE: Pads should be visually inspected approximately every 25 tests and be replaced if cracks or splits longer than 3/8” are present. Scuffing or abrasion of the perimeter is permissible provided it does not reduce the thickness of the pad. The pad inspection and record of when they are changed is recorded on the DOT-12.

2.5 The cavity of the extrusion controller must have a diameter of no less than 102% and no greater than 107% of the diameter of the cylinder. The depth of the cavity shall be twice the thickness of the elastomeric pad.

3. Procedure:

3.1 Compression tests on specimens shall be made as soon as practicable after removal from moist storage. A 28-day test shall be performed within ± 20 hours of the 28th day.

3.2 Clean the bearing faces of the bearing blocks, test specimen, and extrusion controllers (Elastomeric caps) so that they are free of any debris.

3.3 Place the test specimen in the lower extrusion controller, place the top extrusion controller on the specimen. Check the spacing between the sides of the specimen and the extrusion controllers to ensure no contact between the cylinder and the controllers. Slide the specimen and extrusion controller configuration into the compression machine and center it with the concentric circles on the upper bearing block.

3.4 Verify the load indicator is set to zero

3.5 Apply the load to the specimen. The load shall be applied at a rate of 28 to 42 psi/second. During the first half of the anticipated loading phase, a higher loading rate shall be permitted. Adjustments to maintain the specified loading rate may be made during the latter half of the loading phase. Make no adjustments in the loading rate as the ultimate load is being approached and the stress rate is decreasing due to cracking in the specimen.

NOTE: For 6” diameter specimens, the loading rate shall be 790 to 1190 lbs./second. For 4” diameter specimens, the loading rate shall be 350 to 530 lbs./second.

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3.6 Apply the load until the specimen fails, or at least 500psi above minimum 28 day strength has been obtained. Record the maximum load (Q) carried by the specimen during the test rounded to the nearest 100 lb.

3.7 If the specimen was loaded to failure, record the type of fracture pattern according to figure 2. If the fracture pattern is not one of the typical patterns shown in figure 2, describe the pattern and sketch if necessary. If the specimen was not loaded to failure, record the break type as “NONE”.

4. Report:

4.1 Calculations.

$CS = Q/(\pi \times R^2)$

Which reduces to:

For 6” diameter specimen $CS = Q/ 28.274$
For 4” diameter specimen $CS = Q/ 12.566$

Where:

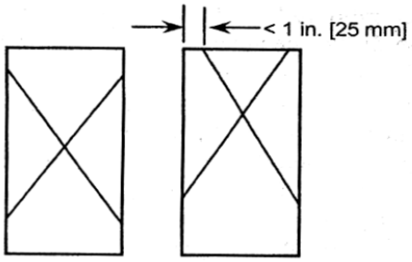
CS = Compressive strength (psi)
Q = Load at failure (lb.-force)
π = 3.1416
R = Radius of specimen (in.)

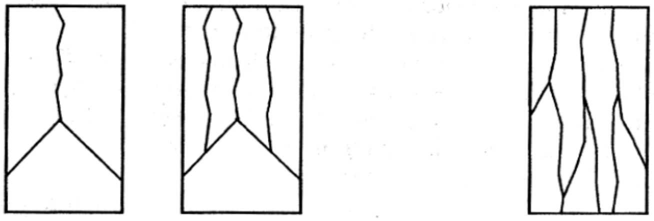
4.2 Report the compressive strength to the nearest 10 psi. on a DOT-23. If compressive strength needs to be corrected to 28 day strength, use correction factor in figure 1. 23

Back

Age-Days		Factor	Age-Days		Factor	Age-Days		Factor
7		0.66	35		1.04	63		1.1375
8		0.70	36		1.045	64		1.14
9		0.73	37		1.05	65		1.1425
10		0.76	38		1.055	66		1.145
11		0.78	39		1.06	67		1.1475
12		0.81	40		1.064	68		1.15
13		0.825	41		1.068	69		1.1525
14		0.845	42		1.072	70		1.155
15		0.86	43		1.076	71		1.1575
16		0.88	44		1.08	72		1.16
17		0.89	45		1.083	73		1.1617
18		0.91	46		1.087	74		1.1634
19		0.92	47		1.09	75		1.165
20		0.93	48		1.093	76		1.1667
21		0.94	49		1.097	77		1.1684
22		0.95	50		1.1	78		1.17
23		0.96	51		1.103	79		1.1717
24		0.97	52		1.107	80		1.1734
25		0.975	53		1.11	81		1.175
26		0.98	54		1.113	82		1.1767
27		0.99	55		1.117	83		1.1784
28		1	56		1.12	84		1.18
29		1.005	57		1.1225	85		1.1817
30		1.01	58		1.125	86		1.1834
31		1.015	59		1.1275	87		1.185
32		1.02	60		1.13	88		1.1867
33		1.027	61		1.1325	89		1.1884
34		1.033	62		1.135	90		1.19

Figure 1



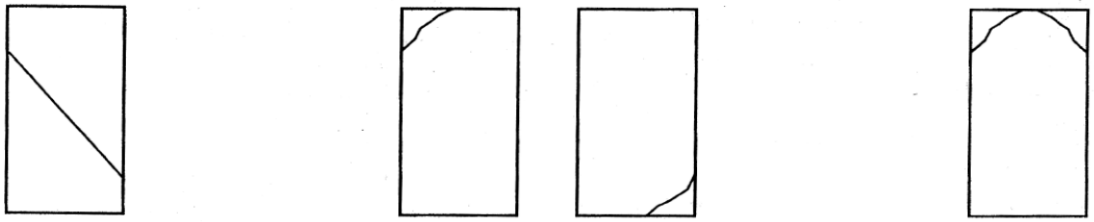


Type 1
Reasonably well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Back



Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type 1

Type 5
Side fractures at top or bottom (occur commonly with unbonded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Figure 2

5. References:

AASHTO T 22
ASTM C39
ASTM C1231
DOT-12
DOT-23

Procedure for Checking In-place Silicone Sealant for Bonding, Width, Thickness, Shape, and Non-Adherence to Backer Rod

---

1. Scope:

This test is for checking the bonding, width, thickness, shape and non-adherence to backer rod of in-place cured silicone sealant.

2. Apparatus:

2.1 Knife.

2.2 Ruler with 1/16” divisions.

2.3 Marking pen.

2.4 Tube of silicone sealant.

3. Procedure:

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3.1 Select the test sites in accordance with SD 311 Record the locations.

3.2 At each test site, cut an approximate 3” lineal strip of sealant on 3 sides to full depth. Leave the 4th side attached to the in-place sealant. When cutting along the sawed joint, make the cut next to the concrete.

3.3 Mark 2 lines with a marking pen 1” apart on the 3” cut piece.

3.4 Check the bonding by pulling the 3” strip straight up until the marked lines are 2” apart. If the sealant is properly bonded, it should not pull away from the sides beyond the original cut. Verify sealant has not bonded to the backer rod.

3.5 Cut the 4th side of the 3” specimen and remove for checking width, thickness and shape.

3.6 Repair the sealant, where the specimen was removed with the same material used on the project.

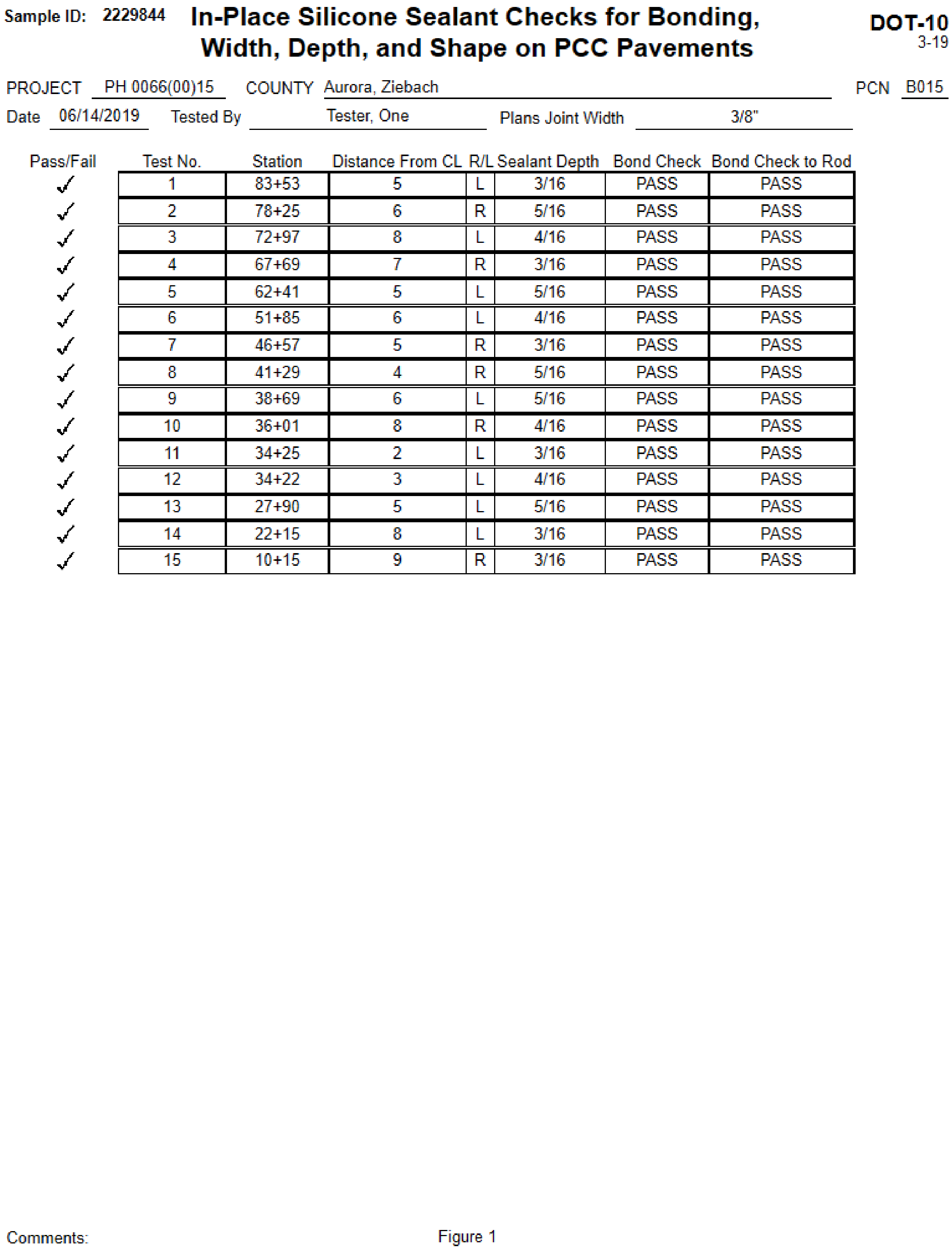
4. Report:

4.1 Report the measurements to the nearest 1/16”.

4.2 Report the results of the bonding check.

5. References:

SD 311
DOT-10



Sample ID: 2229844

In-Place Silicone Sealant Checks for Bonding, Width, Depth, and Shape on PCC Pavements

DOT-10
3-19

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Date 06/14/2019 Tested By Tester, One Plans Joint Width 3/8"

Pass/Fail	Test No.	Station	Distance From CL	R/L	Sealant Depth	Bond Check	Bond Check to Rod
✓	1	83+53	5	L	3/16	PASS	PASS
✓	2	78+25	6	R	5/16	PASS	PASS
✓	3	72+97	8	L	4/16	PASS	PASS
✓	4	67+69	7	R	3/16	PASS	PASS
✓	5	62+41	5	L	5/16	PASS	PASS
✓	6	51+85	6	L	4/16	PASS	PASS
✓	7	46+57	5	R	3/16	PASS	PASS
✓	8	41+29	4	R	5/16	PASS	PASS
✓	9	38+69	6	L	5/16	PASS	PASS
✓	10	36+01	8	R	4/16	PASS	PASS
✓	11	34+25	2	L	3/16	PASS	PASS
✓	12	34+22	3	L	4/16	PASS	PASS
✓	13	27+90	5	L	5/16	PASS	PASS
✓	14	22+15	8	L	3/16	PASS	PASS
✓	15	10+15	9	R	3/16	PASS	PASS

Back

Comments:

Figure 1

Procedure for Checking Sandblast Cleaning of Contraction Joints

---

1. Scope:

This test is for checking the cleanliness of contraction joints prior to sealing with silicone.

2. Apparatus:

2.1 Orange or other colored water based spray paint.

3. Procedure:

3.1 Prior to sealing the contraction joints with silicone, discuss the importance of a clean contraction joint with the Contractor and advise that his cleaning (Sandblasting) operation will be checked.

3.2 Spray a light coat of paint approximately 1 foot in length on both vertical faces of a contraction joint. This test site can be located anywhere in the contraction joint.

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3.3 Have the Contractor perform his normal cleaning operation.

3.4 Visually and physically examine the joint for cleanliness. For 3/8” contraction joints, the top 3/4” to 1” should not have any paint on it. For contraction joints wider than 3/8”, more than 1” from the top down will need to be clean depending on the width of the contraction joint. The silicone adheres to the top portion of the vertical faces of the joint and they need to be clean. Some minute traces of paint remaining in the pores of the concrete will be acceptable. That portion of the joint below the top 3/4” to 1” need not be clean.

3.5 Repeat steps 3.2 through 3.4 until an acceptable cleaning method is established. The Contractor may have to vary the location and/or the angle of the sandblasting nozzle. Each variation of the contraction joint width and/or depth will probably require different nozzle location and/or angle settings.

3.6 Check the cleaning operation on a daily basis or as needed, following the above procedures to assure the joints are clean.

4. Report:

4.1 Report the observations in the project diary.

5. References:

SD 421

SD 423

Method of Test for Slump Loss of Portland Cement Concrete

---

1. Scope:

This test is for determining the slump loss of fresh concrete.

2. Apparatus:

2.1 Mold conforming to AASHTO T 119.

2.2 Tamping rod. A round smooth 5/8” steel rod with the tamping end rounded to a hemispherical tip of 5/8” diameter. The minimum length shall be 18”.

2.3 Trowel, rubber mallet, small scoop, shovel, and a metal straight edge a minimum of 12 long.

2.4 Measuring tape capable of measuring to 1/4.

2.5 Plastic sheeting.

Back

2.6 Air meter conforming to AASHTO T 152. (Type A or B).

3. Procedure:

3.1 The Contractor shall batch at least 1 yd^3 and place it in an earthen pit or suitable container lined with plastic sheeting. Plastic sheeting shall be used to prevent moisture loss through the ground or forms.

NOTE: The concrete shall be isolated from vibration for the duration of the test. 17

3.2 Obtain a sample of fresh concrete by scooping the concrete from multiple locations within the pit or container. The concrete may be placed directly into the slump cone and air meter bucket or placed into a container.

3.3 Test the fresh concrete for initial slump in accordance with SD 404.

3.4 Test the fresh concrete for initial air content in accordance with SD 403.

3.5 Cover the concrete with plastic sheeting.

3.6 At two and four hours after batching, remix the sample locations with a shovel and obtain a sample in accordance with 3.2 above. Test for slump in accordance with SD 404.

4. Report:

Report each slump test, initial air content and time each test was performed on a DOT-23.

5. References:

AASHTO T 119
ASSHTO T 152 17
SD 403
SD 404
DOT-23

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Table of Contents

Miscellaneous Section

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Method of Sampling Paint

---

1. Scope:

This procedure is for sampling aluminum pastes, varnishes, and ready-mixed paints.

2. Apparatus:

2.1 Friction top, minimum one pint paint cans.

3. Procedure:

3.1 Sample size.

A. Ready-mixed paint, approximately 1 pt.

NOTE: Fill the sample container completely full.

3.2 Sampling.

Back

A. Bridge paint.

B. Ready-mix paint: Ready-mixed paints must be thoroughly mixed and “Boxed” as follows:

(1) Pour off some of the thin portion into a clean container.

(2) Stir the settled paste with a paddle, breaking up any lumps.

(3) Gradually add the thin portion back while mixing thoroughly.

(4) “Box” paint by pouring mixed paint back and forth from one container to the other until uniform.

NOTE: As an alternate mixing method, the paint may be stirred several minutes with a commercial type of paint mixer before sampling.

C. Traffic paint:

(1) Collect samples from the spray gun. Turning off the air on air-atomizing systems or turning down the pressure and removing spray tip on airless systems may help to obtain sample. Do not collect the sample from the first 1000 feet of paint sprayed.

(2) Fill one pint metal container. It may help to use a funnel or similar device to aid in getting paint into the sample container.

4. Report:

DOT-1 and DOT-2.

5. References:

DOT-1
DOT-2

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Lime Mill Certification

---

1. Scope:

Mills furnishing Lime to South Dakota Department of Transportation projects will be classified by the Chief Materials and Surfacing Engineer as Certified mills or non-certified mills in accordance with this procedure.

2. Apparatus:

2.1 Dipper, hand scoop, sampling tube, shovel or any satisfactory sampling device.

2.2 Sample container (Cement can)

2.3 Miscellaneous. Brooms, brushes and a funnel.

3. Procedure:

Back

3.1 Certified mill.

A. Basis for qualification.

(1) A certified mill is any mill that furnishes lime on a relatively continuous basis or a volume sufficient to justify the sampling and testing necessary to qualify and maintain a "Certified" status. The mill will:

(a) Have an acceptable quality history based upon the manufacturer's data or Department of Transportation test records, as required by the Chief Materials and Surfacing Engineer.

(b) Maintain mill laboratory facilities which are periodically inspected by an authorized representative of the Office of Materials and Surfacing.

(c) As production warrants, and/or as directed by the Chief Materials and Surfacing Engineer, at the beginning of each month, make available a minimum of one random composite sample of material produced during the previous month along with copies of results of tests made by the plant since the last sample. This sample will be collected from the mill and tested by the Department.

Additional samples may be requested as deemed necessary, to determine the quality of lime being produced.

(d) In addition to making a sample available as specified in (c) above, the certified mill will also furnish the Central Testing Laboratory weekly certified analysis of its product, reporting the following:

(1) Percent calcium and magnesium oxide.

(2) Percent free water or mechanical moisture.

(3) Accumulative percentage, by weight of residue retained on the #6, #20 and #100 sieves.

(e) When tests confirm non-specification material or product, the certified plant will be notified of the deviation and may be removed from the certified list until the deviation and cause have been corrected.

Back

3.2 Non-certified mills.

A. Basis for qualification.

(1) Any mill not currently identified as a certified mill will be a non-certified mill.

(a) The manufacturer and appropriate Department of Transportation personnel will be notified by the Office of Materials and Surfacing when a mill is certified and when there is a change in a mill's certification.

3.3 Lime delivery.

A. From a certified mill.

(1) Two copies of a Certificate of Compliance will accompany each conveyance to the project.

(2) No sampling will be required on the project.

B. From a non-certified mill.

(1) Two copies of a properly executed Certificate of Compliance will be submitted by the manufacturer for each conveyance, prior to or at the time of delivery to the project. Information required by the certificate may be included as part of the

standard bill of lading, loading or weight ticket, or shipping invoice.

The original will be placed in the project file. The copy will be forwarded to the Office of Materials and Surfacing.

(2) A sample consisting of two cement cans will be obtained and submitted to the Central Testing Laboratory for testing for each conveyance of lime received on the project. The sample will be obtained from the loading or unloading spout/hose.

Seal sample containers against contamination from air or moisture immediately after filling. Submit the samples and a Certificate of Compliance as required, to the Central Testing Laboratory.

(3) Shipments of lime received from a non-certified mill without the required certification will not be used until the Engineer in charge of the project has obtained the documents or has received satisfactory test results on the samples.

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3.4 Safety precautions.

A. Although lime (Calcium hydroxide) does not normally cause severe burns, care should be exercised to avoid excessive material contact with lungs, eyes and the exposed areas of the body.

4. Report:

Report the test results.

5. References:

DOT-60

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION DOT-60
CERTIFICATE OF COMPLIANCE 6-18
LIME

FILE # _______________

PROJECT ________________________ COUNTY __________________________ PCN ______________________

CAR OR TRUCK NO.__________________ NET WEIGHT: TON ___________________ SEAL NO.____________

MANUFACTURER ___________________ DESTINATION _______________________ DATE ________________

This sealed shipment of hydrated lime is in compliance with the Department of Transportation Specifications in effect on the project shown. AND, if submitted herewith, the two test specimens obtained by the manufacturer in accordance with SD 502, are truly representative of the transported material described above. They have been as indicated below.

1.____________	For Truck Shipment	Specimens and certificates sent with driver for delivery to the Project Engineer
2.____________	For Rail Shipment	Specimens mailed directly to: South Dakota Department of Transportation, Central Testing Laboratory, Pierre, SD 57501. The Certificate is mailed to: Project Engineer.

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Signed ____
Manufacturer's Authorized Agent

INSTRUCTIONS

The Certificate of Compliance and its duplicate copy must accompany each load of hydrated lime, if the material is to be used on the project prior to receipt of satisfactory test results from the Central Testing Laboratory.

Certified shipments of lime which have been sampled by the manufacturer will have the 2 Certificates (original and one copy) and the 2 test specimens forwarded as follows:

1. SEALED SHIPMENTS BY TRUCK TRANSPORT - The driver will deliver to the Engineer in charge of lime blending operations, the 2 Certificates and the 2 test specimens at the time the load is delivered to the project.
2. SEALED SHIPMENTS BY RAILROAD CAR - The original and 1 copy of the Certificate of Compliance will be affixed to the lower side of 1 of the upper hopper car doors. The inside of the boxcar door, or to the car's placard board. The 2 test specimens (when taken by the manufacturer) should be sent directly to the South Dakota Department of Transportation, Testing Laboratory, Pierre, SD 57501. NOTE: The Project Engineer must be informed by the manufacturer, if the test specimens are sent directly to the Central Testing Laboratory.

CERTIFICATE DISTRIBUTION BY PROJECT ENGINEER:
Original - To project file
Duplicate - To Central Testing Laboratory with test specimens (except in 2, above)

Procedure for Testing Direct Tension Indicators (DTI) Assemblies

---

1. Scope:

This test is to ensure that the bolt will be at or above the specified minimum bolt tension after installation when the direct tension indicator has been compressed to the specified maximum gap and that the bolt will not have excessive plastic deformation when the direct tension indicator is compressed to the specified minimum gap.

2. Apparatus:

2.1 Calibrated bolt tension measuring device: (Skidmore-Wilhelm or other approved device).

2.2 0.005 inch tapered thickness gage: This is the same thickness gage that is to be used to inspect the bolts after installation and is to be supplied by the Contractor per the standard specifications.

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2.3 Direct tension indicator assembly: (Bolts, nuts, washers, and direct tension indicators)

A. Three direct tension indicator assemblies for each diameter, length, rotational capacity lot and direct tension indicator lot are required. Three additional direct tension indicator assemblies with three long bolts are required for testing short bolts as defined below:

NOTE: A long bolt is defined as a bolt with adequate length to be properly installed in a calibrated tension measuring device. A short bolt is defined as a bolt that is too short to be tested in the device.

Short Bolts for DTI Testing

Lengths shorter than listed below require additional longer bolts for DTI testing.

Size	1/2"	5/8"	3/4"	7/8"	1"	11/8"	1 1/4"
Length	2"	2 1/4"	2.5"	2.75"	3"	3.25"	3.5"

B. The direct tension indicators, bolts, nuts and washers shall conform to the project specifications and shall be new and unused. They shall be randomly selected from the material to be used in the work unless long bolts are required.

2.4 Wrenches: Tensioning of the bolts shall be accomplished with a hand wrench such that tension readings can be recorded exactly. The use of a torque multiplier or a handle extension may be necessary and is acceptable. The use of an impact wrench for this testing is not allowed. A second wrench is required to prevent rotation of the bolt head while the nut is tightened.

3. Procedure:

3.1 Long bolts.

A. Direct tension indicators *(*See figure 1*)* are made in different sizes, types and have different numbers of spaces. They are also available in plain or coated (Galvanized or epoxy coated) finishes. Verify that the direct tension indicator is of the size, type and finish specified and that the number of spaces is in accordance with table 1. Record this information on the DOT-96.

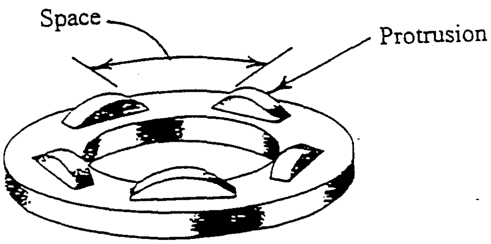

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Figure 1
(Direct Tension Indicator)

Table 1

Number of spaces									
DTI dia. (in.)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Type 325	4	4	5	5	6	6	7	7	8
Type 490	N/A	N/A	6	6	7	7	8	8	N/A

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B. Direct tension indicator assemblies: The bolt, nut, washer and direct tension indicator shall be assembled into the calibrated bolt tension measuring device in the same configuration as is to be used in the work (See figure 2). Face plates, inserts and spacers with standard hole sizes shall be used. (Standard hole diameters are nominally 1/16” larger than the nominal bolt diameter.)

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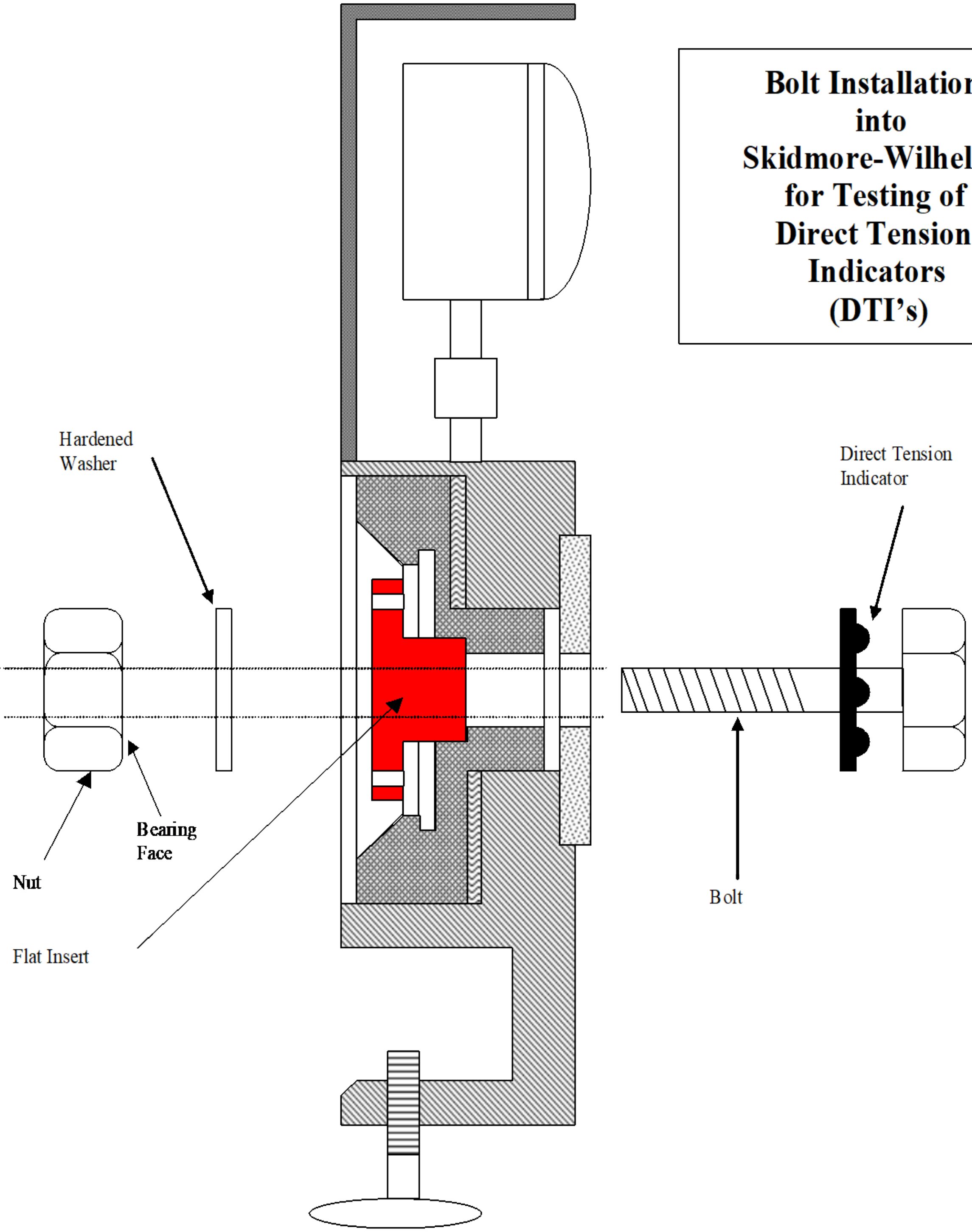

**Direct Tension Indicator
Under
"UNTURNED" Element**

Figure 2

The bolt used for direct tension indicator testing shall be of sufficient length and installed in such a manner that 3 to 5 threads are located behind the bearing face of the nut as shown in figure 2. Shim plates and/or washers (One washer under the nut must always be used) may be required to achieve this arrangement.

C. Tighten the nut until the bolt tension reading on the dial of the calibrated bolt tension measuring device reaches the minimum required bolt tension, as shown in table 2. Use another wrench on the bolt head to prevent rotation while tightening the nut.

Table 2

Minimum required bolt tension in kips (1 kip = 1000 lbs.)									
Bolt dia. (in.)	1/2	5/8	¾	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
ASTM F3125 Grade A325	13	20	29	41	54	59	75	89	108
ASTM F3125 Grade A490	N/A	N/A	37	51	67	84	107	127	N/A

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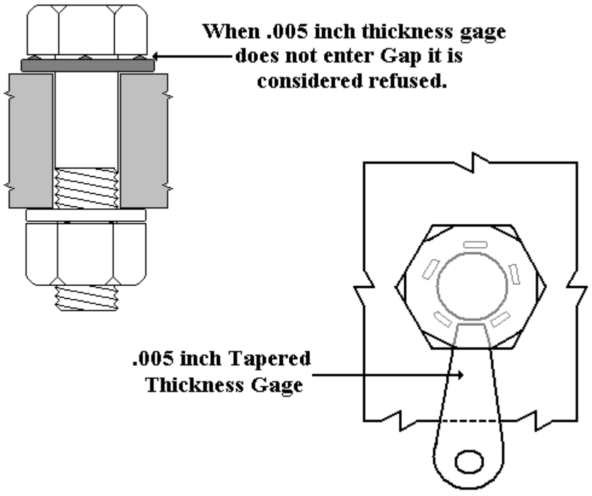
D. Determine and record on the DOT-96, the number of spaces between the protrusions on the direct tension indicator for which the .005 inch thickness gage is refused (Does not fit into the space as shown in figure 3). If the number of spaces for which the .005 inch thickness gage is refused is greater than the maximum number specified in table 3, the direct tension indicator fails the verification test.



(Measuring gap with thickness gage)

Figure 3

Table 3

Verification criteria					
	No. of spaces on DTI				
	4	5	6	7	8
Max. No. of spaces refused: • All plain DTI's • Coated* DTI's under "Unturned" element	1	2	2	3	3
Max. No. of spaces refused: • Coated* DTI's under "Turned" element	3	4	5	6	7

* Coated direct tension indicators (DTI's) are defined as galvanized or epoxy coated.

NOTE: Unless otherwise specified on the plans, the South Dakota Standard Specifications for Roads and Bridges require galvanized DTI's. Epoxy coated DTI's are sometimes specified for use on weathering steel structures. Plain DTI's are almost never allowed.

Back

E. The bolt shall be further tightened until the .005 inch thickness gage is refused at all spaces, but a visible gap exists in at least one of the spaces.

NOTE: The test is not valid if the bolt is tightened to a condition in which there is no visible gap. If this occurs, the test will need to be performed again using a new assembly.

Record the bolt tension reading on the dial of the calibrated bolt tension measuring device on the DOT-96. This tension must be less than or equal to the bolt tensile strength given in table 4.

Table 4

Bolt tensile strength in kips (1 kip = 1000 lbs.)									
Bolt dia. (in.)	1/2	5/8	¾	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
ASTM F3125 Grade A325	17	27	40	55	73	80	102	121	148
ASTM F3125 Grade A490	N/A	N/A	50	69	91	114	145	173	N/A

If the recorded tension is more than the bolt tensile strength shown, the direct tension indicator assembly fails the verification test.

F. Remove the bolt assembly from the bolt tension measuring device. Turn the nut onto the full length of the threads of the bolt, excluding the thread runout, by hand. If this can be done, the direct tension indicator has passed the test. If it is not possible to hand turn the nut onto the full length of the threads of the bolt, excluding thread runout, the direct tension indicator fails the verification test unless the following criteria is met.

If the bolt tension reading recorded in Section 3.1.E is less than 95% of the average load measured in Section 3.1 G, the rotational capacity test (SD 507) for the bolt assembly lot, the direct tension indicator assembly passes this portion of the test.

The results should be recorded on the DOT-96.

If any one of the three direct tension indicators fails the verification test, the lot of DTI's is considered to be in non-compliance with the specifications and should not be allowed to be used in the work.

Bolts, nuts, washers, and direct tension indicators used for testing shall not be incorporated into the work.

3.2 Short bolts.

Back

A. Using the additional direct tension indicators and the long bolts as per section 2.3.A, perform the testing using the procedures in sections 3.1.A through 3.1.D.

B. Remove the direct tension indicator assembly from the calibrated bolt tension measuring device.

C. Using a new direct tension indicator assembly with the short bolt and a new direct tension indicator, install the bolt, nut, washer and direct tension indicator into a steel section or in a joint in the project material. The bolt hole used must be a standard sized hole defined as nominally 1/16" larger than the nominal bolt diameter. The assembly shall be installed into the steel section in the same configuration as it is to be used in the work.

D. The bolt shall be tightened until the .005 inch feeler gage is refused in all spaces, but a visible gap exists in at least one of the spaces.

NOTE: The test is not valid if the bolt is tightened to a condition in which there is no visible gap. If this occurs, the test will need to be performed again using a new assembly.

E. Remove the direct tension indicator assembly from the bolt tension measuring device. Turn the nut onto the full length of the threads of the bolt, excluding the thread runout, by hand. If this can be done, the direct tension indicator assembly has passed the test. If it is not possible to hand turn the nut onto the full length of the threads of the bolt, excluding thread runout, the direct tension indicator assembly fails the verification test. The results should be recorded on the DOT-96.

If any one of the three direct tension indicator assemblies fails the verification test, the DTI lot is considered to be in non-compliance with the specifications and should not be allowed to be used in the work.

Bolts, nuts, washers, and direct tension Indicators used in the testing shall not be incorporated into the work.

4. Report:

A. Report results of the testing as required by this procedure on the DOT-96.

5. References:

ASTM F3125
ASTM F959
SD 507
DOT-96

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DOT-96
09-14

DIRECT TENSION INDICATORS (DTI)

Project No. P 0019(20)00 County Clay PCN 238H

Test No. 01 Tested By Brian Hipple Date 09/07/2014

All Section References to SD 503
Reference Sec. 3.1A

Size of Bolt: 3/4" **Length of Bolt:** 3 1/2" **Heat/Lot #:** M2001 **Mfg.:** Bennett **Finish:** Galvanized
Size of DTI (Nominal Diameter): 3/4" **Type** (Circle One): [✓ A325] A490
Finish (Circle One): **Plain** **Galvanized** [✓ **Epoxy Coated**]
Heat / Lot No. 125865A **Manufacturer** Wrought
No. of Spaces on DTI: 5 **No. of Spaces Per Table 1:** 5
NOTE: If the number of spaces on the DTI's are not the same as shown in Table 1, the DTI's are not acceptable for use.
Reference Sec. 3.1.C
Minimum Required Bolt Tension from Table 2: 29,000 **Lbs.**
Tension in Table 2 is in kips. To convert to pounds (Lbs.) multiply value from Table 2 by 1000.
Reference Sec. 3.1.D

DTI	No. of spaces .005" Thickness Gage Refused at Min. Tension (A)	Max. Allowable Spaces Refused (B)	Is (A) ≤ (B) (Circle One)
#1	0	2 Spaces From Table 3	[✓ YES] (Pass) NO (Fail)
#2	0		[✓ YES] (Pass) NO (Fail)
#3	0		[✓ YES] (Pass) NO (Fail)

Reference Sec. 3.1.E (Long Bolts)
Reference Sec. 3.1.D (Short Bolts)

DTI	Bolt Tension Reading (When all spaces refused & at least one visible gap) (A)	Min. Bolt Tensile Strength (B)	Is (A) ≤ (B) (Circle One)
#1	39,000 (lbs)	40,000 (lbs) From Table 4	[✓ YES (Pass)] NO (Fail)
#2	39,500 (lbs)		[✓ YES (Pass)] NO (Fail)
#3	39,000 (lbs)		[✓ YES (Pass)] NO (Fail)

DTI	Was it possible to tighten the bolt to a point where the .005" thickness gage is refused at all spaces, but such that a visible gap exists in at least one space without causing damage to the bolt? (Circle One)	
#1	[✓ YES (Pass)] NO	* If the nut cannot be hand-turned onto the bolt excluding thread runout for any of the three bolts, the criteria in 3.1.F must be met.
#2	YES (Pass) [✓ NO]	
#3	[✓ YES (Pass)] NO	

Reference Sec. 3.1.F

Average Measured Bolt Tension from 3.1.G of the Rotational Capacity Test SD 507 (A)	95% of Avg. Meas. Bolt Tension (A x 0.95) (B)	DTI Assembly	Bolt Tension Reading from 3.1.E (C)	Is (C) ≤ (B) (Circle One)
42,567	40,438	#1	N/A	YES (Pass) NO Fail
		#2	39,500	[✓ YES (Pass)] NO Fail
		#3	N/A	YES (Pass) NO Fail

Note if there are any signs of stripping or if the nuts could not be run on the threads by hand for any of the three bolts:

RESULTS: If the DTI Assemblies failed any of the above Pass/Fail criteria, the DTI Assemblies should not be accepted. (Circle One)

[✓ **ACCEPTED**] **REJECTED**

(OVER)

Example 1

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ROTATIONAL CAPACITY TEST

Project No.________________________ County ____________________ PCN ______________________

Test No. ______________ Tested By ______________________ Date ______________________

All Section References to SD 507

Bolt Length: ______________________ Heat/Lot No.____________________

Bolt Diameter:______________________ Manufacturer____________________

Reference Section 3.1 (Long Bolts)

Bolt	Reference Sec. 3.1.D Required Initial Tension on Bolt from Table 1 (Kips)	Reference Sec. 3.1.D Measured Initial Tension on Bolt (Kips)	Reference Sec. 3.1.F Measured Bolt Tension (P) at Required Tension (Lbs) (See Table 1 - SD 507)	Reference Sec. 3.1.F Measured Torque at Required Tension (Ft-Lbs) (See Table 2 - SD 507)	Reference Sec. 3.1.G Measured Bolt Tension (P) at Required Rotation (Lbs) (See Table 3 - SD 507)
#1					
#2					
#3					

Tension in Table 1 is in Kips, to convert to pounds (Lbs.) multiply value in Table 1 by 1000.

Reference Section 3.1.H

BOLT	Did the bolt show any signs of stripping or fracture upon visual inspection? (Circle One)		
#1	YES (Fail) (See Table 5)	NO	If the bolt or nut show any signs of stripping or fracture, the assembly fails the rotational capacity test. Note any evidence of stripping/fracture. (If YES - See SD 507, Table 5) ____ ____
#2	YES (Fail) (See Table 5)	NO	
#3	YES (Fail) (See Table 5)	NO	

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BOLT	Was the measured bolt tension equal to or greater than the tension required in Table 4? (Circle One)		
#1	YES	NO (Fail) (See Table 6)	If the bolt tension is less than the tension in Table 4, the bolt assembly fails the rotational capacity test. (If NO - See SD 507, Table 6)
#2	YES	NO (Fail) (See Table 6)	
#3	YES	NO (Fail) (See Table 6)	

BOLT	Calculated Maximum Torque (Tmax)	Is the Torque less than or equal to the calculated maximum torque (Tmax)? (Circle One)		
#1		YES	NO (Fail)	If the measured torque is greater than the calculated maximum torque, the assembly fails the rotational capacity test.
#2		YES	NO (Fail)	
#3		YES	NO (Fail)	

RESULTS: If the bolt assemblies failed any of the above tests, the assembly fails the rotational capacity test. (Circle One)

ACCEPTED **REJECTED**

Reference Section 3.2 (Short Bolts)

Reference Sec. 3.2.F

BOLT	Measured Torque at Required Rotation (Ft.-Lbs.)
#1	
#2	
#3	

Reference Section 3.2.G

BOLT			
#1	YES (Fail)	NO	If the bolt or nut shows any signs of stripping or fracture, the assembly fails the rotational capacity test. Note any evidence of stripping/fracture.
#2	YES (Fail)	NO	
#3	YES (Fail)	NO	____

BOLT	Calculated Maximum Torque (Tmax)	Is the Torque less than or equal to the calculated maximum torque (Tmax)? (Circle One)		
#1		YES	NO (Fail)	If the measured torque is greater than the calculated maximum torque, the assembly fails the rotational capacity test.
#2		YES	NO (Fail)	
#3		YES	NO (Fail)	

RESULTS: If the bolt assemblies failed any of the above tests, the assembly fails the rotational capacity test. (Circle One)

ACCEPTED **REJECTED**

Method of Measuring the Thickness of Coatings on Metal Surfaces

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1. Scope:

This procedure covers the use of digital thickness instruments (Gauges) in the nondestructive measurement of the thickness of paint or galvanized coatings on metal surfaces.

2. Apparatus:

2.1 Digital thickness sensor.

3. Procedure:

3.1 Factors affecting accuracy of results.

A. Thickness of the coating: The precision of the instruments may change with coating thickness depending on the design of the instrument. Generally, the precision may be assumed to be a fixed percentage of the coating thickness.

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B. Distance between point of measurement and edge of specimen: The effect may be significant as far as 1/2” from the edge.

3.2 Calibration of instrument.

A. Each instrument shall be calibrated in accordance with the manufacturer’s instructions before use, by employing suitable thickness standards.

B. Coated standard: The coated standard is used to calibrate the instrument. The zero reading shall be checked on the bare (Uncoated) base metal of the specimen before measurement. A suitable correction must be applied if the reading is not zero. The thickness of the coating on the standard should be approximately the same as the thickness of the coating on the specimen to be measured.

3.3 Testing.

A. Each instrument shall be operated in accordance with the manufacturer’s instructions.

B. Preparation of surface: Foreign material such as dirt, grease or corrosion products shall be removed by suitable cleaning, with an organic cleaner, without abrading the surface.

C. Surface defects: Area on specimens having visible defects such as flux, acid spots, dross, oxides and excess drops should be avoided in making measurements.

D. Number of readings: Local variation in coating thickness and normal variations in instrument readings require that a minimum of 5 readings be taken and that the average of the readings be used. Individual readings which are obviously out of line with the other readings from the same area should be rejected.

E. Galvanization shall be uniform and any visible thin areas shall be rejected.

4. Report:

4.1 The report shall include the following:

A. Producer of the culvert.

B. Manufacturer of the steel.

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C. Heat number.

D. Gauge.

E. Weight of spelter coating per ft^2 of surface.

5. References:

ASTM D7091

Procedure for Wrench Calibration and Snug Tightening

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1. Scope:

This procedure provides the method for calibration of a manual torque wrench or an adjustable impact wrench and the snug tightening procedure to be used in the work.

2. Apparatus:

2.1 A calibrated bolt tension measuring device.

2.2 Spacers and/or washers with proper hole size to adjust bolt length in the tension measuring device.

2.3 A rigid mounting for the bolt tension calibrator.

2.4 Wrenches, either adjustable impact or manual torque.

2.5 An appropriate supply of properly sized, uncoated, lot identified direct tension indicating washers (DTI's) which meet the requirements of ASTM F959. See paragraph 3.3.

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2.6 Suitable tapered tip flat feeler gauges Range 0.005" to 0.030" in 0.001 inch increments. See paragraph 3.3.

2.7 A rigidly mounted steel plate with round hole 1/16" over nominal size of bolts to be installed in structure. Can utilize holes in structural steel members to be erected.

2.8 An adequate supply of heavy hex head high strength bolts which meet the requirements of ASTM F3125, nuts and washers to calibrate DTI's. See paragraph 3.3 A.

3. Procedure:

3.1 Frequency of calibration.

A. Each installation wrench shall be calibrated at least once each working day for each bolt diameter, length and grade using fastener assemblies that are being installed in the work.

Wrenches shall be re-calibrated when significant difference is noted in the surface condition or level of lubrication of the bolt threads, nuts or washers. Torque wrenches used for acceptance testing shall be calibrated prior to each test, but not more often than once per day for each bolt diameter length and grade of fastener being tested.

3.2 Calibration procedure, long bolts.

A. Long bolts shall be of sufficient length so that when installed in the tension measuring device, with a hardened washer under the turned element, at least 3 full threads are exposed between the nut face and the underside of the bolt head when the end of the bolt is at least flush with the outside face of the nut.

(1) Select 3 bolt, nut and washer assemblies from each diameter, length and grade for which each individual installation wrench is to be calibrated, or for which acceptance testing is to be conducted.

(2) Install each bolt, nut and washer assembly into the tension measuring device and install sufficient spacers and/or washers so that at least 3, but not more than 5, full threads are exposed between the nut face and the underside of the bolt head. The element (Nut or bolt head) turned during calibration must be the same as to be turned in the work. A hardened washer must be in place under the turned element.

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(3) Tighten each assembly using the snug tightening procedure which will be used to snug tight the fasteners in the work. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Assure the proposed snug tightening procedure does not produce more than 50% of the required fastener tension, as specified by table 1. If so, revise the snug tightening procedure.

Table 1 – Required fastener tension (Kips)

Bolt dia. (Inch)	½	⅝	¾	⅞	1	1 ⅛	1 ¼	1 ⅜	1 ½
Grade A325	12	19	28	39	51	56	71	85	103
Grade A490	15	24	35	49	64	80	102	121	148

(4) When the calibrated installation wrench is to be an adjustable impact wrench, each of the 3 assemblies shall be tightened further and the wrench adjusted or set to cut-out at not less than the minimum tension as shown in table 2. Wrench setting for final installation tightening shall be in the average of the 3 tests.

Table 2

Bolt dia. (Inch)	½	⅝	¾	⅞	1	1 ⅛	1 ¼	1 ⅜	1 ½
Grade A325	13	20	29	41	54	59	75	89	108
Grade A490	16	25	37	51	67	84	107	127	155

(5) When the wrench is to be a manual torque wrench, each of the 3 assemblies shall be tightened further and the torque noted which was required to induce the bolt tension as specified in table 2. Torque shall be measured with the turned element in motion. The torque used for calibration shall be the average of the 3 tests.

3.3 Calibration procedure, short bolts.

Short bolts are defined as those lengths which are too short to meet the criteria for long bolts, as described in paragraph 3.2 A.

Wrenches to be used to install short bolts may be calibrated using DTI's. However, DTI's must first be calibrated.

A. DTI Calibration.

(1) Select 3 DTI's of each diameter from the same lot, as identified on the shipping container.

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(2) Using appropriate length bolt, nut and flat washer of the same diameter as DTI, install DTI under bolt head against the face plate of the tension calibrator. Protrusions on DTI must bear on the head of the bolt.

(3) Install the appropriate adapter in the back of the tension calibrator, to allow flat washer and nut to be installed. Use shims or flat washers to position 3 to 5 full threads between the face of the nut and underside of the bolt head.

(4) Tighten the nut while holding the bolt head with a suitable wrench, to induce the bolt tension, as shown in table 3.

Table 3

Bolt dia. (inch)	½	⅝	¾	⅞	1	1 ⅛	1 ¼	1 ⅜	1 ½
Grade A325	13	20	29	41	54	59	75	89	108
Grade A490	16	25	37	51	67	84	107	127	155

(5) Using the feeler gauges, measure and record the opening between the DTI face and the underside of the bolt head at each location between the protrusions. The number of protrusions will vary from 4 to 8, depending upon the nominal size of the DTI. Average the measurements for each DTI.

(6) Average the results from the 3 DTI's. The resulting number becomes the DTI calibration to be used to calibrate wrenches for installation of short bolts of the same diameter as the DTI.

B. Short bolt calibration.

(1) Select 3 bolt, nut and washer assemblies from each diameter, length and grade for which each individual installation wrench is to be calibrated or for which acceptance testing is to be conducted. Also, select a DTI from the calibrated lot for each bolt assembly.

(2) Install each bolt, nut, and washer assembly into the proper steel plate (See 2.7) with the DTI under the bolt head. Use sufficient spacers and/or washers, so that at least 3, but not more than 5 threads are exposed between the nut face and the underside of the bolt head.

(3) With a wrench holding the bolt head, tighten each assembly by turning the nut to obtain a snug tight condition.

Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. See paragraph 3.2 A.(3).

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(4) When the calibrated installation wrench is to be an adjustable impact wrench, each of the 3 assemblies shall be tightened further, until the average clearance under the DTI is equal to the value obtained during DTI calibration. See paragraph 3.3 A.(6). The wrench shall be adjusted or set to cut-out at not less than the DTI calibration clearance.

(5) When the wrench is to be a manual torque wrench, each of the 3 assemblies shall be tightened further, with the torque wrench, until the average clearance under the DTI is equal to the value obtained during DTI calibration. See paragraph 3.3 A.(6). The torque required to produce this DTI clearance shall be recorded. Torque shall be measured with the nut in motion. The minimum torque used for the final installation tightening shall be the average of the 3 tests.

(6) DTI’s used to calibrate wrenches must be utilized in the same position on the fastener assembly as when they were calibrated on the bolt tension calibrator. Case discussed in paragraph 3.3 A. is the DTI under the bolt head, turn the nut to tighten. This DTI calibration procedure could also be used to calibrate wrenches where the DTI was under the nut and the bolt head was turned. Wrenches cannot be calibrated nor can DTI’s be calibrated when the DTI is placed under the turned element.

3.4 Snug tightening procedure.

A. Bolts shall be installed in all holes of the connection with a hardened washer under the turned element and brought up to a snug tight condition.

B. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. The snug tightening procedure used in the work shall be the same snug tightening procedure used when conducting the wrench calibration in paragraph 3.2 A.(3) and 3.3 B.(3).

C. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges. Start the pattern of each member being spliced at the center of the pattern and work toward all edges of the connection.

D. Following this initial snug tightening, all bolts in the joint shall again be systematically tightened, as necessary, using a similar pattern until all bolts are simultaneously snug tight and the connection is fully compacted.

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4. Report:

Report the testing of the bolts in the project diary.

5. References:

ASTM F3125
ASTM F959

Procedure for Core Sampling Treated Timber Products

---

1. Scope:

This test is for sampling treated timber products for treatment analysis.

2. Apparatus:

2.1 Increment borer with hollow bit and extractor. (AWPA Standard M2.)

2.2 Foil, plastic wrap or other non-absorbent material.

2.3 Splints, tubes or other devices for shipment of samples.

3. Procedure:

3.1 Inspect the increment borer to insure that it is free of rust, pitch or preservatives.

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3.2 Randomly select the post to be sampled in accordance with the “Minimum Sample and Test Requirements” (MSTR).

3.3 For round material (Piling, poles and posts), the borer shall be directed toward the center.

3.4 For sawn material, the borer shall be directed as shown in figure 1.

3.5 If the borer passes through an internal knot, check or shake, or if the core is crushed, broken or smeared with treating solution, it shall be discarded. A second boring shall be taken to obtain a specimen suitable for measurement.

3.6 Carefully remove and handle each core so its shape and size shall remain undisturbed. Wrap each core in foil, plastic film (Saran Wrap) or other non-absorbent material, and securely place in splints, tubes or corrugations (As found by removing the outer paper layer in corrugated cardboard) for shipping to the Central Laboratory for testing.

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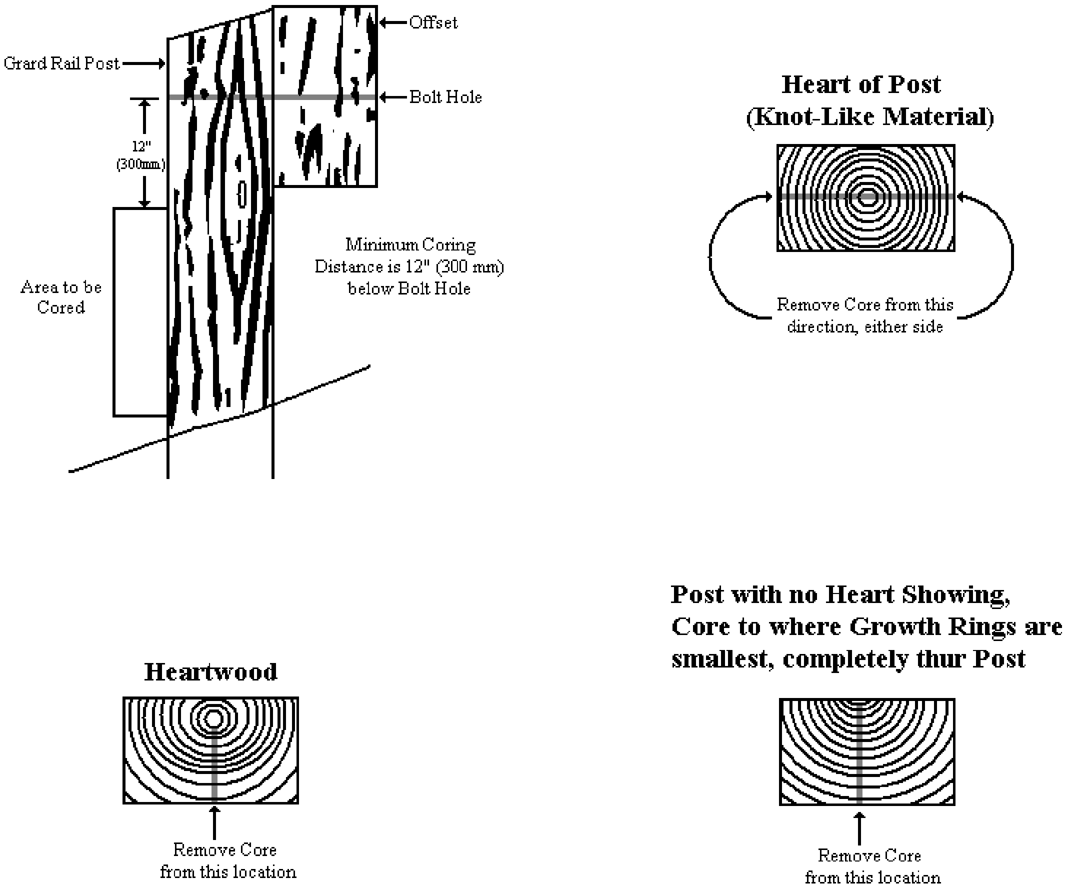

NOTE: Bore all cores at right angles to the sawn face.

Figure 1

4. Report:

Complete a DOT-1 form for each sample.

5. References:

AWPA Standard M2
DOT-1

Procedures for Rotational Capacity Testing for High Strength Bolts

---

1. Scope:

The rotational capacity test is designed to evaluate the presence and efficiency of a lubricant on the nut, and the compatibility of the bolt assemblies as represented by the components selected for testing such that, when installed, the desired bolt tension is achieved without excessive plastic deformation.

This procedure may be applied to all bolts requiring rotational capacity testing regardless of length. A separate procedure is provided for long and short bolts. A long bolt is defined as any bolt with adequate length to be properly installed in a calibrated bolt tension measuring device. A short bolt is defined as any bolt that is too short to be tested in the device.

2. Apparatus:

2.1 Rotational capacity of long bolts.

A. Calibrated bolt tension measuring device: (Skidmore-Whilhelm or other approved device).

B. Calibrated torque wrench.

C. Hand wrench.

D. Protractor.

E. Bolts, nuts, and washers.

a. Three assemblies for each diameter and length of bolt are required. If bolts of the same diameter and length are supplied from more than one lot, three assemblies are required for each lot.

b. The bolts, nuts, and washers shall conform to the project specifications and shall be new and unused. They shall be randomly selected from the material to be used in the work.

2.2 Rotational capacity of short bolts.

A. Steel section with standard size hole (Standard hole diameters are nominally 1/16” larger than the nominal bolt diameter.) In lieu of providing a steel section for this testing, the bolts may be tested in a steel joint in the project material.

B. Calibrated torque wrench.

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C. Hand wrench.

D. Protractor.

E. Bolts, nuts, and washers.

  a. Three assemblies for each diameter and length of bolt are required. If bolts of the same diameter and length are supplied from more than one lot, three assemblies are required for each lot.

  b. The bolts, nuts, and washers shall conform to the project specifications and shall be new and unused. They shall be randomly selected from the material to be used in the work.

3. Procedure:

3.1 Determining rotational capacity of long bolts.

A. Mark off a vertical line on the face plate of the calibrated bolt tension measuring device. Using a protractor, mark off additional lines at 120 degrees, and 240 degrees as shown in figure 1.

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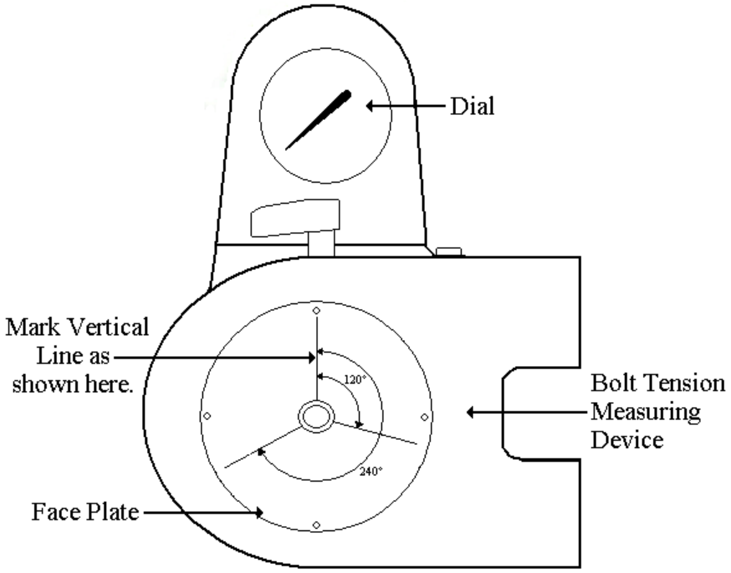

Figure 1

B. Measure the length (L) and diameter (D) of the bolt and record the information on the DOT-96. See figure 2.

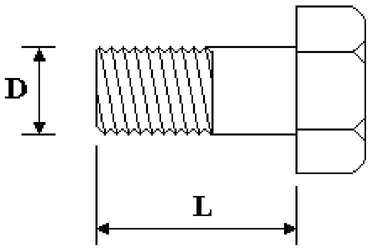

Figure 2

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C. The bolt, nut, and washer shall be assembled into the calibrated bolt tension measuring device as shown in figure 3. Face plates, bolt rotation prevention inserts (If available), and spacers with standard holes shall be used. (Standard hole diameters are nominally 1/16" larger than the nominal bolt diameter.) The bolt shall be of sufficient length and installed utilizing sufficient shim plates and/or washers (One washer under the nut must always be used) such that 3 to 5 threads are located behind the bearing face of the nut as shown in figure 3.

D. Tighten the bolt using a hand wrench to achieve a snug tension within the range specified in table 1 for the diameter of the bolt being tested. Record the measured initial bolt tension on the DOT-96.

Table 1

Bolt dia. (Inch)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Snug tension (Kips)	1 to 3	2 to 4	3 to 5	4 to 6	5 to 7	6 to 8	7 to 9	9 to 11	10 to 12

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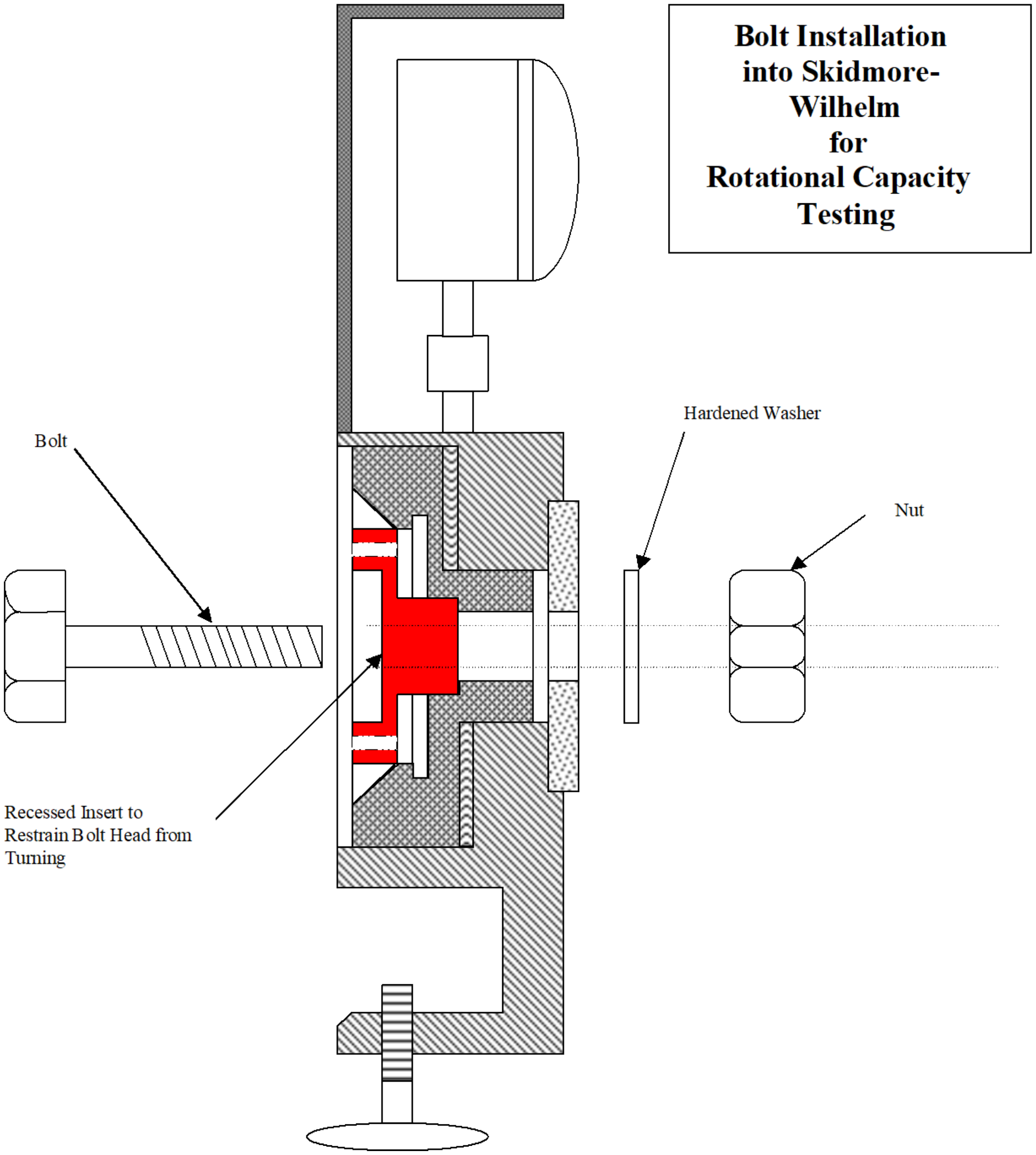

Figure 3

E. Match mark the nut to the vertical line marked on the face plate in 3.1.A as shown below in figure 4. (It may facilitate testing if the wrench socket is also match marked to the vertical line on the face plate.)

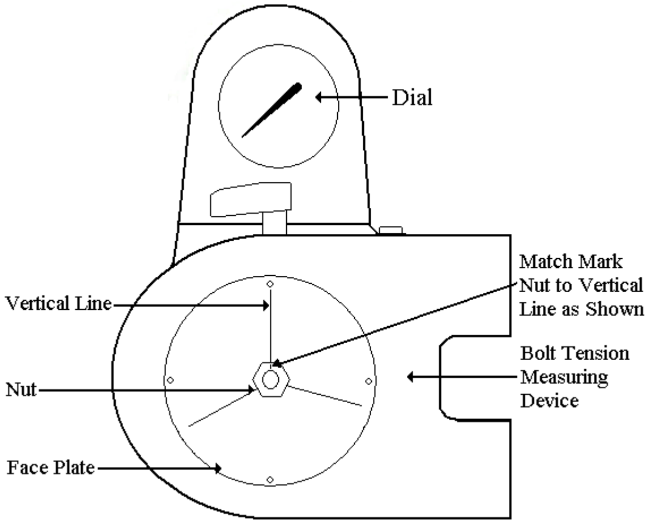

Figure 4

F. Using a calibrated torque wrench, tighten the "Nut" to the tension as specified in table 2. Obtain the bolt tension (P) from the dial of the device and the torque (T) from the wrench and record these values on the DOT-96.

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NOTE: The torque must be measured with the nut in motion.

The head of the bolt shall not be allowed to rotate during this tightening. The bolt tension measuring device may have an insert that will prevent the head of the bolt from rotating, but if not, a hand wrench may be required.

Table 2

Bolt size (Inches)	Required installation tension (Pounds)
1/2	12,000
5/8	19,000
3/4	28,000
7/8	39,000
1	51,000
1-1/8	56,000
1-1/4	71,000
1-3/8	85,000
1-1/2	103,000

G. Further tighten the "Nut" to the rotation as specified in table 3. The rotation of the nut should be measured from the vertical line marked in 3.1.A and the initial match mark made in 3.1.E.

NOTE: The head of the bolt shall not be allowed to rotate during this tightening. The bolt tension measuring device may have an insert that will prevent the head of the bolt from rotating, but if not, a hand wrench may be required.

Table 3

Bolt length	Required rotation
Less than or equal to 4 times the bolt diameter.	2/3 rotation (240˚)
Greater than 4 times the bolt diameter and less than or equal to 8 times the bolt diameter.	1 rotation (360˚)
Greater than 8 times the bolt diameter	1 1/3 rotations (480˚)

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Obtain the bolt tension (Pmax) from the dial of the device at the specified rotation and record these values on the DOT-96.

Loosen the nut and remove the bolt assembly from the bolt tension measuring device. Visually inspect the bolt assembly for evidence of stripping or fracture and record the information on the DOT-96.

H. Acceptance criteria: The bolt and nut assembly is considered to be in conformance if all of the following requirements are met:

1. If the visual inspection as per 3.1.G shows no signs of stripping or fracture the bolt assembly meets the requirements. If signs of stripping or fracture are visible, the bolt assembly fails the rotational capacity test. Some minor amount of stretch is expected to occur between the face of the nut and the bolt head and does not constitute failure of the test.

2. If the bolt tension (Pmax) measured in 3.1.G is equal to or greater than the tension required in table 4 below the bolt assembly meets the requirements.

   If the measured bolt tension is less than the tension required in table 4 the bolt assembly fails the rotational capacity test.

Table 4

Bolt dia. (Inch)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Tension (Kips)	14	22	32	45	59	64	82	98	118

3. The torque (T) measured in 3.1.F is less than or equal to the maximum torque (Tmax), which is calculated as follows:

$T_{max} = 0.25\ P\ (D/12)$

Where:

T_{max} = Maximum torque in ft.-lbs.

P = Bolt tension (Measured in 3.1.F) in pounds.

D = Bolt diameter in inches.

If the Torque (T) measured in 3.1.F is greater than the maximum torque (Tmax) the bolt assembly fails the rotational capacity test.

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Failure of the rotational capacity test does not necessarily mean that the bolts, nuts, and washers represented cannot be used in the work. It is possible that the nuts may be dry or were improperly lubricated. The nuts may be sent back to the supplier to be re-lubricated and the rotational capacity test re-run. If the assembly still fails the rotational capacity test, then the bolt assemblies should not be allowed for use.

3.2 Determining rotational capacity of short bolts

A. Mark off a vertical line from the center of the bolt hole on the steel section or in a steel joint in the project material. Using a protractor, mark off additional lines at 120 degrees, and 240 degrees as shown in figure 5.

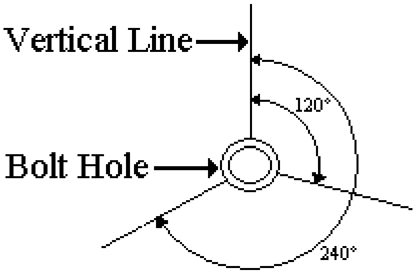

Figure 5

B. Measure the length (L) and diameter (D) of the bolt and record the information on the DOT-96. See figure 6.

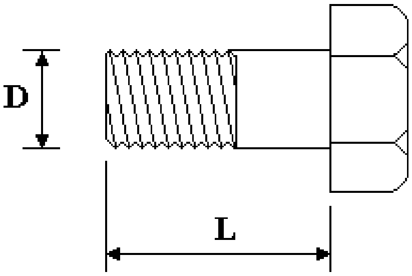

Figure 6

C. The bolt, nut, and washer shall be assembled into the steel section (Or steel joint from project material) as shown in figure 7. The nut should be placed on the side of the steel section on which the reference lines per 3.2.A were drawn. The bolt shall be of sufficient length and installed utilizing sufficient shim plates and/or washers (One washer under the nut must always be used) such that 3 to 5 threads are located behind the bearing face of the nut as shown in figure 7.

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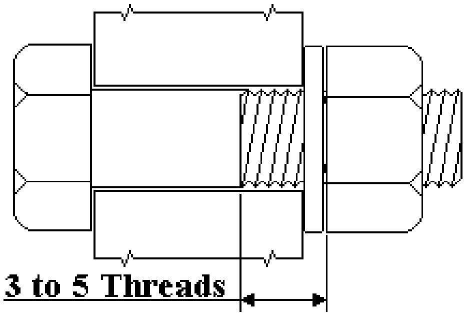


Figure 7

D. Snug the bolt using a hand wrench. (The snug condition should be the normal effort applied to a 12-inch long wrench.)

E. Match mark the nut to the vertical line marked on the steel section in 3.2 A as shown below in figure 8. (It may facilitate testing if the wrench socket is also match marked to the vertical line on the face plate.)

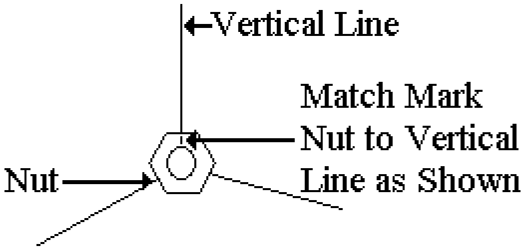


Figure 8

F. Using a calibrated torque wrench, tighten the "Nut" to the rotation as specified in table 5. The rotation of the nut should be measured from the vertical line marked in 3.2.A and the initial match mark made in 3.2.E.

NOTE: The head of the bolt shall not be allowed to rotate during this tightening.

Table 5

Bolt length	Required rotation
Less than or equal to 4 times the bolt diameter	2/3 rotation (240˚)
Greater than 4 times the bolt diameter and less than or equal to 8 times the bolt diameter.	1 rotation (360˚)
Greater than 8 times the bolt diameter	1 1/3 rotations (480˚)

Back

Obtain the torque (T) from the wrench at the required rotation and record this value on the DOT-96.

NOTE: The torque must be measured with the nut in motion.

Loosen the nut and remove the bolt assembly from the steel section. Visually inspect the bolt assembly for evidence of stripping or fracture and record the information on the DOT-96.

G. Acceptance Criteria: The bolt and nut assembly is considered to be in conformance if all of the following requirements are met:

1. If the visual inspection as per 3.2.F shows no signs of stripping or fracture, the bolt assembly meets the requirements. If signs of stripping or fracture are visible, the bolt assembly fails the rotational capacity test. Some minor amount of stretch is

expected to occur between the face of the nut and the bolt head and does not constitute failure of the test.

2. The torque (T) measured in 3.2.F is less than or equal to the maximum torque (Tmax), which is calculated as follows:

$$T_{max} = 0.25 (P \times 1000) (D/12)$$

Where:

T_{max} = Maximum torque in ft-lbs.

P = Bolt tension obtained from table 6 in kips.

D = Bolt diameter in inches.

If the torque (T) measured in 3.2.F is greater than the maximum torque (Tmax) the bolt assembly fails the rotational capacity test.

Table 6

Back

Bolt dia. (Inch)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Tension (Kips)	14	22	32	45	59	64	82	98	118

Failure of the rotational capacity test does not necessarily mean that the bolts, nuts, and washers represented cannot be used in the work. It is possible that the nuts may be dry or were improperly lubricated. The nuts may be sent back to the supplier to be re-lubricated and the rotational capacity test re-run. If the assembly still fails the rotational capacity test, then the bolt assemblies should not be allowed for use.

NOTE: Bolts, nuts and washers used for testing shall not be incorporated into the work.

4. Report:

A. Report results of the testing as required by this procedure on the DOT-96.

5. References:

ASTM F3125
ASTM A563
DOT-96

DOT-96
9-14

DIRECT TENSION INDICATORS (DTI)

Project No. ____________ County ____________ PCN ____________

Test No. ____________ Tested By ____________ Date ____________

All Section References to SD 503
Reference Sec. 3.1A

Size of Bolt: ________ **Length of Bolt:** ________ **Heat/Lot #:** ______ **Mfg.:** ______ **Finish:** ______

Size of DTI (Nominal Diameter): ____________ **Type** (Circle One): A325 A490

Finish (Circle One): **Plain** **Galvanized** **Epoxy Coated**

Heat / Lot No. ____________ **Manufacturer** ____________

No. of Spaces on DTI: ____________ **No. of Spaces Per Table 1:** ____________

NOTE: If the number of spaces on the DTI's are not the same as shown in Table 1, the DTI's are not acceptable for use.

Reference Sec. 3.1.C

Minimum Required Bolt Tension from Table 2: ____________ **Lbs.**

Tension in Table 2 is in kips. To convert to pounds (Lbs.) multiply value from Table 2 by 1000.

Reference Sec. 3.1.D

DTI	**No. of spaces .005" Thickness Gage Refused at Min. Tension (A)**	**Max. Allowable Spaces Refused (B)**	**Is (A) ≤ (B)** (Circle One)
#1			**YES** (Pass) **NO** (Fail)
#2		________ **Spaces**	**YES** (Pass) **NO** (Fail)
#3		From Table 3	**YES** (Pass) **NO** (Fail)

Reference Sec. 3.1.E (Long Bolts)
Reference Sec. 3.1.D (Short Bolts)

DTI	**Bolt Tension Reading** (When all spaces refused & at least one visible gap) **(A)**	**Min. Bolt Tensile Strength (B)**	**Is (A) ≤ (B)** (Circle One)
#1	**(lbs)**		**YES** (Pass) **NO** (Fail)
#2	**(lbs)**	________ **(lbs)**	**YES** (Pass) **NO** (Fail)
#3	**(lbs)**	From Table 4	**YES** (Pass) **NO** (Fail)

DTI	**Was it possible to tighten the bolt to a point where the .005" thickness gage is refused at all spaces, but such that a visible gap exists in at least one space without causing damage to the bolt?** (Circle One)	
#1	**YES** (Pass) **NO**	* If the nut cannot be hand-turned onto the bolt excluding thread runout for any of the three bolts, the criteria in 3.1.F must be met.
#2	**YES** (Pass) **NO**	
#3	**YES** (Pass) **NO**	

Reference Sec. 3.1.F

Average Measured Bolt Tension from 3.1.G of the Rotational Capacity Test SD 507 **(A)**	**95% of Avg. Meas. Bolt Tension (A x 0.95) (B)**	**DTI Assembly**	**Bolt Tension Reading from 3.1.E (C)**	**Is (C) ≤ (B)** (Circle One)
		#1		**YES** (Pass) **NO** Fail
		#2		**YES** (Pass) **NO** Fail
		#3		**YES** (Pass) **NO** Fail

Note if there are any signs of stripping or if the nuts could not be run on the threads by hand for any of the three bolts: ____________

RESULTS: If the DTI Assemblies failed any of the above Pass/Fail criteria, the DTI Assemblies should not be accepted. (Circle One)

ACCEPTED **REJECTED**

(OVER)

Example 1

Back

ROTATIONAL CAPACITY TEST

Project No. P 0019(20)00 County Clay PCN 238H

Test No. 02 Tested By Brian Hipple Date 09/07/2014

All Section References to SD 507

Bolt Length: 3 1/2" Heat/Lot No. M162598

Bolt Diameter: 3/4" Manufacturer Gerdau

Reference Section 3.1 (Long Bolts)

Bolt	**Reference Sec. 3.1.D** Required Initial Tension on Bolt from Table 1 (Kips)	**Reference Sec. 3.1.D** Measured Initial Tension on Bolt (Kips)	**Reference Sec. 3.1.F** Measured Bolt Tension (P) at Required Tension (Lbs) (See Table 1 - SD 507)	**Reference Sec. 3.1.F** Measured Torque at Required Tension (Ft-Lbs) (See Table 2 - SD 507)	**Reference Sec. 3.1.G** Measured Bolt Tension (P) at Required Rotation (Lbs) (See Table 3 - SD 507)
#1	3 - 5	4.5	28,000	320	43,000
#2	3 - 5	4.5	28,000	344	42,500
#3	3 - 5	4.5	28,000	271	42,200

Tension in Table 1 is in Kips, to convert to pounds (Lbs.) multiply value in Table 1 by 1000.

Reference Section 3.1.H

BOLT	Did the bolt show any signs of stripping or fracture upon visual inspection? (Circle One)		
#1	YES (Fail) (See Table 5)	[✓ NO]	If the bolt or nut show any signs of stripping or fracture, the assembly fails the rotational capacity test. Note any evidence of stripping/fracture. (If YES - See SD 507, Table 5) ____________________ ____________________
#2	YES (Fail) (See Table 5)	[✓ NO]	
#3	YES (Fail) (See Table 5)	[✓ NO]	

BOLT	Was the measured bolt tension equal to or greater than the tension required in Table 4? (Circle One)		
#1	[✓ YES]	NO (Fail) (See Table 6)	If the bolt tension is less than the tension in Table 4, the bolt assembly fails the rotational capacity test. (If NO - See SD 507, Table 6)
#2	[✓ YES]	NO (Fail) (See Table 6)	
#3	[✓ YES]	NO (Fail) (See Table 6)	

BOLT	Calculated Maximum Torque (Tmax)	Is the Torque less than or equal to the calculated maximum torque (Tmax)? (Circle One)		
#1	437.5	[✓ YES]	NO (Fail)	If the measured torque is greater than the calculated maximum torque, the assembly fails the rotational capacity test.
#2	445	[✓ YES]	NO (Fail)	
#3	437.5	[✓ YES]	NO (Fail)	

RESULTS: If the bolt assemblies failed any of the above tests, the assembly fails the rotational capacity test. (Circle One)

[✓ **ACCEPTED**] **REJECTED**

Reference Section 3.2 (Short Bolts)

Reference Sec. 3.2.F

BOLT	Measured Torque at Required Rotation (Ft.-Lbs.)
#1	464
#2	458
#3	452

Reference Section 3.2.G

BOLT			
#1	YES (Fail)	[✓ NO]	If the bolt or nut shows any signs of stripping or fracture, the assembly fails
#2	YES (Fail)	[✓ NO]	the rotational capacity test. Note any evidence of stripping/fracture.
#3	YES (Fail)	[✓ NO]	Minor stretch on Bolt 1 & 2 - OK

BOLT	Calculated Maximum Torque (Tmax)	Is the Torque less than or equal to the calculated maximum torque (Tmax)? (Circle One)		
#1	500	[✓ YES]	NO (Fail)	If the measured torque is greater than the calculated maximum torque, the assembly fails the rotational capacity test.
#2	500	[✓ YES]	NO (Fail)	
#3	500	[✓ YES]	NO (Fail)	

RESULTS: If the bolt assemblies failed any of the above tests, the assembly fails the rotational capacity test. (Circle One)

[✓ **ACCEPTED**] **REJECTED**

Back

Method of Sampling Glass Beads

---

1. Scope:

This test covers the procedures for sampling glass beads.

2. Apparatus:

2.1 Sample container (Cement can).

3. Procedure:

3.1 Bead gun.

Flush a 5 gallon bucket full of beads prior to starting application of the marking. Then obtain a cement can full of beads from the bead gun. Then obtain a second, and a third cement can of beads from the bead gun that has been dropping the beads when the truck stops to start painting additional lines. Typically, a sample to be taken prior to starting, a sample taken after painting one edge line/centerline skip and a sample taken after painting the second edge line.

Back

4. Report:

Sample identification on the DOT-1.

5. References:

DOT-1

Procedure for Testing Linseed Oil Base Emulsion Curing Compound

---

1. Scope:

This test is for determining the oil and water phase composition of the linseed oil base emulsion compound for curing concrete.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.2 Drying oven capable of maintaining a temperature of 230° ± 9°F.

2.3 Muffle furnace capable of maintaining temperature at 1400° ± 50°F.

2.4 Crucible with a capacity of 20 grams.

2.5 Desiccator.

Back

3. Procedure:

3.1 Weigh crucible (A).

3.2 Place a minimum of 10.0 grams sample in the crucible.

3.3 Weigh the material to the nearest 0.1 gram (B) and dry it to a constant weight as per SD 108.

3.4 Cool sample to room temperature in desiccator and weigh (C).

3.5 Place sample in the muffle furnace and heat to the above specified temperature. Then turn furnace off.

3.6 Leave sample in the muffle furnace until the sample reaches approximately 300°F.

3.7 Cool sample to room temperature in desiccator and weigh (D).

4. Report:

4.1 Calculate the oil and water phase:

Water E = (B - C)/(B - A) x 100

Oil F = (C - D)/(B - A) x 100

% water phase = E/(E + F) x 100

% oil phase = F/(E + F) x 100

4.2 Report % water phase and % oil phase results.

5. References:

SD 108

Back

Procedure for Determining Roundness of Glass Beads

---

1. Scope:

This test is for determining the percent of round glass beads.

2. Apparatus:

2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.01 gram.

2.2 Sample splitter.

2.3 Sieve #50.

2.4 Adjustable smooth inclined glass or aluminum plate 12 in. x 18 in.

2.5 Wooden pencil or brush.

2.6 Collecting pans.

Back

3. Procedure:

3.1 Reduce sample to 25 to 50 grams by means of a splitter.

3.2 Weigh to the nearest 0.01 grams.

3.3 Split the reduced sample into two fractions using a #50 sieve.

3.4 Set the inclined plate at approximately 3° for the +50 fraction and 10° for the -50 fraction.

3.5 Slowly apply part of the beads to the top of the plate. Tap the plate with a wood pencil or brush to cause the round beads to roll down the incline into a collecting pan. Continue with small applications until the entire sample is processed.

3.6 Repeat the process with the beads that rolled off the plate at least three times for the +50 fraction and at least four times for the -50 fraction.

3.7 Weigh the separated fractions of round beads.

4. Report:

4.1 Calculate the percent of rounds and report to the nearest whole percent.

5. References:

None

Blank

Back

Method of Sampling Seed

---

1. Scope:

This procedure is for sampling cover crop and permanent seed mixtures by the hand-sampling method.

2. Apparatus:

2.1 Collecting pan or bucket (Optional).

2.2 Seed sample envelopes (Available from Region Materials).

3. Procedure:

Back

3.1 Seed shall be sampled by thrusting the hand into the seed bag or drill box and removing representative portions. To take a hand sample, insert the flat hand with fingers together. Once fully inserted to the desired depth, close the hand and withdraw the sample. The sample shall be obtained from various locations and differing depths within the bags or drill box to obtain a representative sample.

3.2 Completely fill the seed envelope.

3.3 A seed bag tag for that lot of seed shall be included inside the seed sample envelope.

3.4 Fill in the required information on the seed sample envelope, including placing a checkmark on the “SD Noxious” line as shown in figure 1.

3.5 Submit the seed sample envelope to SDSU Seed Testing Laboratory for testing.

4. Report:

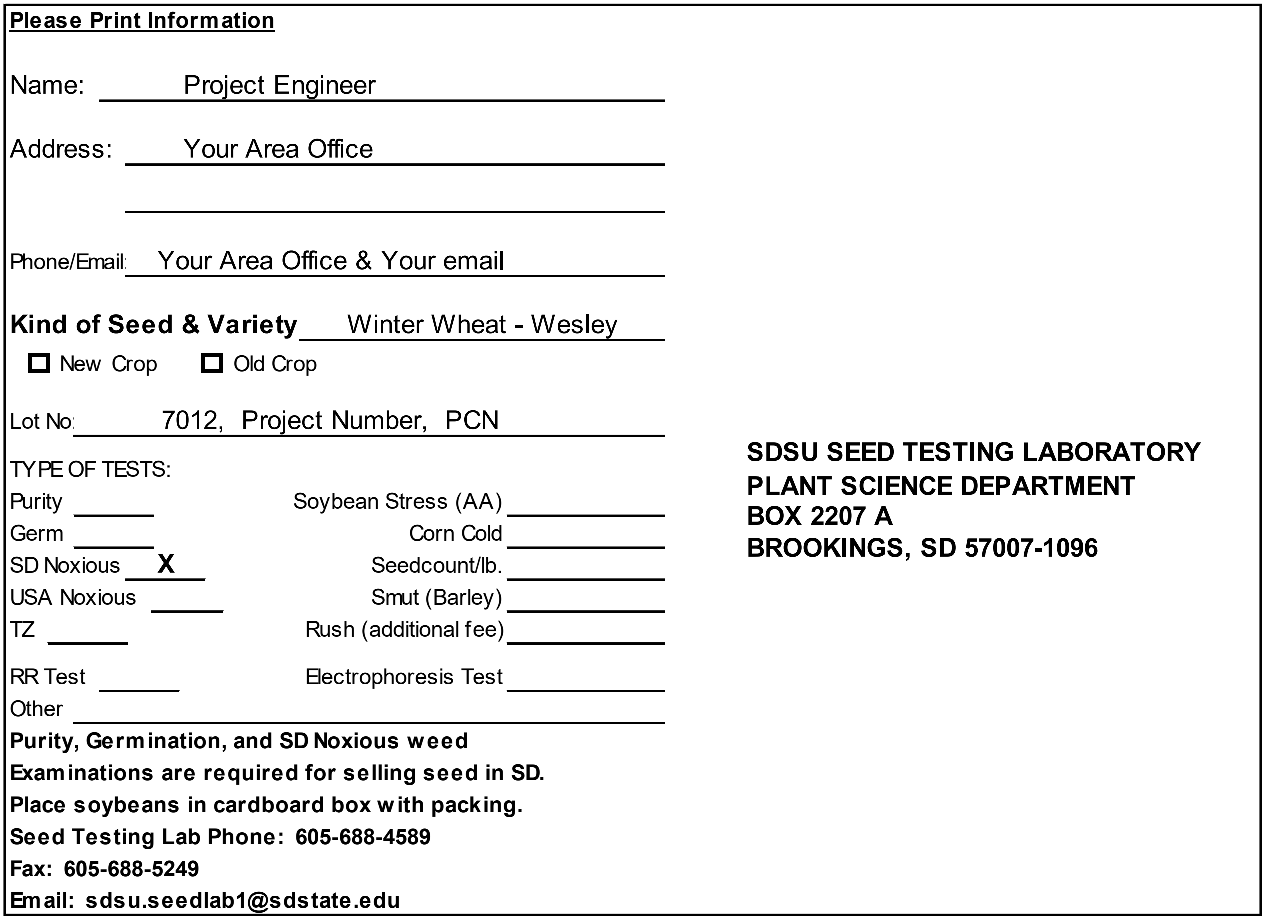
4.1 SDSU Seed Laboratory will complete the seed report and send it to the Area Office.

4.2 A DOT-1 shall be filled out and sent into the Certification Office along with the seed report.

5. References:

None.

SD 512
Page 2



Please Print Information

Name: Project Engineer

Address: Your Area Office

Phone/Email: Your Area Office & Your email

Kind of Seed & Variety Winter Wheat - Wesley

☐ New Crop ☐ Old Crop

Lot No: 7012, Project Number, PCN

TYPE OF TESTS:

Purity		Soybean Stress (AA)	
Germ		Corn Cold	
SD Noxious	X	Seedcount/lb.	
USA Noxious		Smut (Barley)	
TZ		Rush (additional fee)	
RR Test		Electrophoresis Test	

Other

Purity, Germination, and SD Noxious weed Examinations are required for selling seed in SD.

Place soybeans in cardboard box with packing.

Seed Testing Lab Phone: 605-688-4589

Fax: 605-688-5249

Email: sdsu.seedlab1@sdstate.edu

SDSU SEED TESTING LABORATORY
PLANT SCIENCE DEPARTMENT
BOX 2207 A
BROOKINGS, SD 57007-1096

Back

Figure 1

Procedure for Testing of Deformed Steel Bars for Concrete Reinforcement

---

1. Scope:

This test method covers the procedure for mechanical testing of deformed steel bars used in concrete reinforcement. The mechanical test herein is used to determine properties required in the product specifications.

2. Apparatus:

2.1 Tension testing machine (Conforming to AASHTO T244).

2.2 Extensometer (Conforming to AASHTO T244).

2.3 Elongation gauge or calipers.

3. Procedure:

3.1 Initial sample data.

Back

A. Collect all samples received and examine:

1. Sample size must come as a pair (2) either epoxy or black.
2. Sample size pair must be matching designation bar numbers and grade.
3. Each sample size has a separate DOT-1, sample ID number, and representing not more than 3 sizes to be tested.
4. Minimum length of 24 inches.

Do not test higher than a #8 bar.

B. Record the length (1/16”), weight (0.0001 lb.), designation bar number (Size), grade, and weight per foot using the following equation:

Weight per foot = (Weight/length) = (0.001) lb./ft.

C. Each bar must be gauge marked 8 inches. The gauge marks will be on longitudinal ribs, if present, or in clear spaces of the deformation pattern. The marks will not be put on transverse deformations. Black bars will be marked with a file and epoxy bars marked with a permanent marker.

Light marks are desirable on black bars because deep marks may affect the results.

3.2 Testing.

A. The jaws of the tension machine must line up with the 8 inch gauge marks and be tightened.

B. An extensometer is attached to the bar between the 8 inch gauge marks. To minimize slipping of the extensometer, do not clamp on a deformation or a longitudinal rib.

C. Run the machine at a correct continuous and uniform ideal force rate depending on the bar designation number as seen in table 1.

Table 1 - Ideal force rate

Size	Min. force rate (Lbf./Min)	Max. force rate (Lbf./Min)	Ideal force rate (Lbf./Min)
#3	1,080	11,040	6,000
#4	1,980	19,620	10,800
#5	3,060	30,660	16,800
#6	4,440	44,160	24,600
#7	6,000	60,120	33,000
#8	7,860	78,540	43,200

Back

D. Remove the extensometer once yield has begun or when the tensile testing machine displays a message to remove.

E. Once the extensometer has been removed, keep the tensile testing machine at the correct continuous and uniform ideal force rate until fracture occurs.

F. Test only one bar from the sample size. If rejection of results occurs, the second bar shall be tested.

3.3 Determination of tensile properties.

A. The extensometer will produce an autographic stress-strain diagram showing the yield strength (PSI) and ultimate strength (PSI).

1. Yield strength is determined by the extensometer attached to the specimen. When the load producing the specified extension .005 in./in. is reached, record the stress corresponding to that load as the yield strength.

2. However, if the above method cannot be determined due to errors during the testing, the yield strength is determined by the .2% offset method using the autographic stress-strain curve drawn. The yield strength is determined from a line at .2% offset on the strain axis that is drawn parallel to the stress-strain curve. The yield strength is the point where the parallel line intersects the stress-strain curve as seen in figure 1.

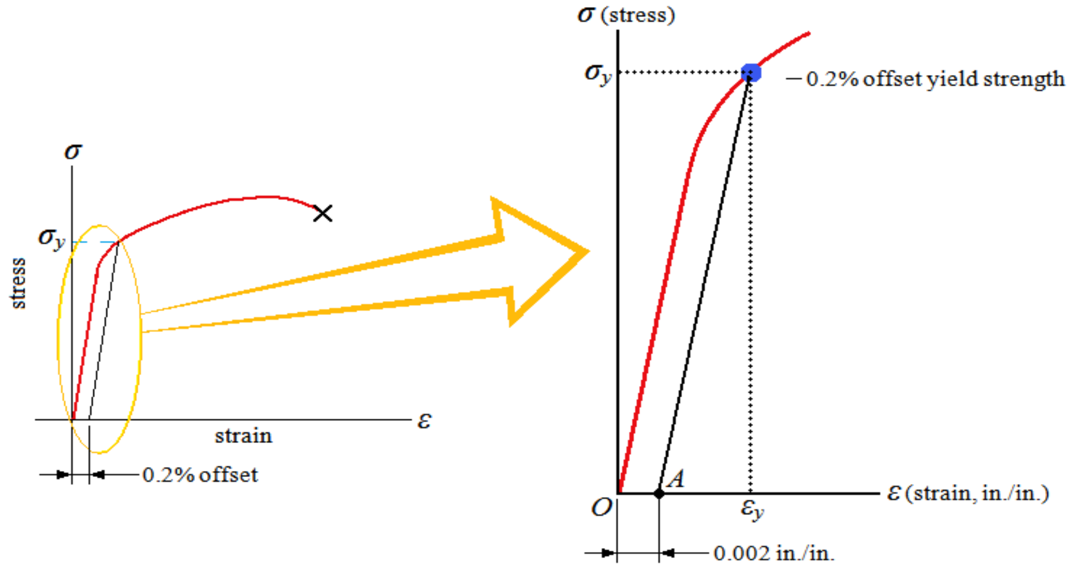


Figure 1

(Stress-strain diagram for determination of yield strength by the .2% offset method)

Back

3. Ultimate strength is calculated by dividing the maximum load the specimen sustains by the nominal bar cross-sectional area (Table 2).

Table 2 - Nominal bar cross-sectional area

Size	Cross-Sectional Area (in²)
#3	0.11
#4	0.2
#5	0.31
#6	0.44
#7	0.6
#8	0.79

B. Percent elongation is determined by fitting the ends of the fractured bar together carefully and measure the final gauge marks with the elongation gauge to the nearest whole number.

1. If using calipers, percent elongation is determined by the following equation:

Percent elongation =

((Final gage length – Initial gage length) / Initial gage length) x 100.

If fracture takes place outside of the gauge length, fit the ends together and measure from the point of fracture to the furthest gauge mark.

4. Report:

A. MS&T

1. DOT-7

Report the following:

I. Grade.

II. Size.

III. Percent elongation to nearest whole number.

IV. Yield strength to nearest hundred (psi).

V. Ultimate strength to nearest hundred (psi).

VI. Weight per foot to nearest thousandths (0.001 lb./ft.).

Back

Report the first bar's results if all specification limits are met. Test the second bar (a) if the first bar does meet specification limits or (b) if otherwise desired by the tester. If the second bar meets all specification limits, report the second bar's results. If a failure occurs on any of the second bar's results, then report all results as the average of the two individual results from each bar. 24

5. References:

AASHTO T 244
AASHTO M 31
ASTM A370
DOT-1
DOT-7

Procedure for Testing of Uncoated Seven-Wire Cable Pretensioning Reinforcement

---

1. Scope:

This test method covers the procedure for mechanical testing of uncoated seven-wire cable for pretensioned reinforcement. The mechanical test herein is used to determine the tensile strength required in the product specifications.

2. Apparatus:

2.1 Tension testing machine (Conforming to AASHTO T 244).

2.2 Elongation gauge.

2.3 Caliper.

3. Procedure:

3.1 Initial sample data.

Back

A. Collect all samples and examine them for:

1. Sample size must be a pair (2).
2. Sample size must be approximately the same length, mass, and diameter.
3. Each sample size has a separate DOT-1 & sample ID number.
4. Minimum length of 24 inches.

B. Record the length (1/16”), weight (0.0001 lb.), grade, and diameter (0.0001 in.) of the entire seven-wire cable.

C. Calculate the weight per foot of the entire seven-wire cable.

Weight per foot = (Weight/length) = (0.1) lb./1000ft

D. Separate the seven-wire cable into its individual seven strands.

E. Pick and record the diameter (0.0001”) of any two outer strands and the center strand.

F. Each strand must be gauge marked 8 inches. Gauge marks will be made with a permanent marker.

3.2 Testing

A. The two outer strands and the center strand must be tested individually.

B. The jaws of the tension machine must line up with the 8 inch gauge marks and be tightened.

C. Run the machine at a correct continuous and uniform ideal force rate as seen in table 1, until fracture occurs.

Table 1: Ideal Force Rate

Min. force rate (Lbf./Min)	Max. force rate (Lbf./Min)	Ideal force rate (Lbf./Min)
314	3140	1730

D. Test only one seven-wire cable from the sample size. If rejection of the results occurs, the second cable will be tested.

3.3 Determination of tensile properties.

Back

A. The tension testing machine will determine maximum load at which the wire strands fracture. Record this number as the breaking strength for each strand.

B. The tensile strength of the seven-wire cable is determined from taking the individual breaking strengths of the strands and using the following equation:

Tensile strength (psi) = Center + (((Outer #1 + Outer #2)/2)x6)

4. Report:

A. MS&T

1. DOT-7

Report the following:

I. Weight per foot of entire seven-wire cable to the nearest tenth (0.1 lb./1000ft).

II. Diameter of entire seven-wire cable to nearest thousandth (0.0001”).

III. Diameter of two outer strands and center strand to nearest thousandth (0.0001”).

IV. Tensile strength to nearest ten (psi).

V. Grade.

Report the first seven-wire cable's results if all specification limits are met. Test the second cable (a) if the first cable does meet specification limits or (b) if otherwise desired by the tester. If the second cable meets all specification limits, report the second cable's results. If a failure occurs on any of the second cable's results, then report all results as the average of the two individual results from each cable. 24

5. References:

AASHTO T 244
AASHTO M 203
ASTM A416
DOT-7

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