# South Dakota DOT

## QC/QA Asphalt Concrete

## Training Manual

**2025**

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# QC/QA ASPHALT CONCRETE TRAINING MANUAL

Prepared By:

South Dakota Department of Transportation
Division of Planning & Engineering
Materials & Surfacing Program

Prepared For:

Bituminous Certification Program

Presented By:

South Dakota Department of Transportation
Division of Planning & Engineering
Materials & Surfacing Program

# FOREWORD

SDDOT, along with the Asphalt Industry, has always tried to maintain their level of expertise in an ever-changing environment. The Asphalt Industry, which includes Asphalt Cement Suppliers, Aggregate Producers, Asphalt Concrete Producers, Federal Highways Administration, and the SDDOT, has realized that a change in the way that we do business will improve the quality of our asphalt pavements.

In January of 1996, a meeting was held to bring the entire Asphalt community together to start a process of sharing information and training. This meeting, although not immediately realized, has led to a large effort in improving the quality of our asphalt pavements.

Since January of 1996, there have been numerous meetings, phone calls, and faxes working out the Quality Improvement Program that we all want. This Quality Improvement has led to the formation of a Specification Task Force for developing a QC/QA specification that not only deals with procedures for Quality Pavement but also has provided the necessary checks and balances we need. Unified goals are essential to implement a Quality Improvement Process.

The advent of QC/QA Specification Implementation requires an intensive training process. This process began with the Executive Hot Mix Asphalt Seminars held across SD in October 1996. This training continued with the first of many Bituminous Technician Training Classes that began in December of 1996 and will continue for many years in the future.

The QC/QA Asphalt Concrete Training Manual is current as of the printing date. It is anticipated that this manual will be a used as a training document and updated in the future as we see the need for changes.

It is the desire of the contributing authors of this manual that it will serve as a valuable reference for those involved with asphalt construction in South Dakota.

# INTRODUCTION

For many years, Transportation engineers have been looking at asphalt pavements for solving the infrastructure pavement needs. These ever-growing needs caused by heavy truckloads and increased traffic volumes mandate that we build asphalt pavement right the first time. The SDDOT does not have the financial independence to fix or repair all our highways in the State Truck System to full design requirements when they need attention. SDDOT presently has a backlog of highway needs and prioritizes those highway segments according to need. To keep this backlog static, or at best reducing the total, the Asphalt Construction Industry is called upon to deliver pavements that meet or exceed their design life.

SDDOT has adopted Quality Control / Quality Assurance methods for monitoring the asphalt mix produced to give the citizens of South Dakota a long-lasting high-performance asphalt pavement. Across the nation, nearly every State is looking into Quality Improvements necessary to provide highways that meet the Traveling Public's Requirements.

With asphalt mix designs many variables exist. These variables include aggregate (crushed/rounded, gradation, particle shape, etc.) and asphalt binder (different sources). Many combinations of these variables exist within the boundaries of South Dakota. The proper asphalt content and air void levels are critical to the long-term performance of the asphalt pavement. In the Asphalt Concrete Mix Design Process, the proper configuration of all the ingredients is necessary for long-term pavement performance.

This Quality Control/Quality Assurance Asphalt Concrete Training Manual is provided to those in the industry as a ready reference. This training manual includes SDDOT's QC/QA Specification, Training Requirements, Asphalt Concrete Mix Design Procedures, along with applicable policies relating to asphalt construction current at the time of printing.

Our intent is to provide personnel involved in the design and construction of asphalt pavements with the information needed to perform their tasks with Quality in mind.

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# QC/QA ASPHALT CONCRETE TRAINING MANUAL

## 1. PURPOSE AND PROCESS:

The purpose of the South Dakota Quality Control / Quality Assurance Asphalt Concrete Training Manual is to explain the inspection, sampling, and testing methods necessary to comply with the Standard Specification for Roads and Bridges Asphalt Concrete - Class Q Hot Mixed Asphalt Concrete Pavements. This manual will serve as a guide for the Contractor, the Aggregate Producer, and SDDOT personnel.

Quality Control is the responsibility of the contractor.
Quality Assurance is the responsibility of the state.

The Contractor will provide a Quality Control System that assures all asphalt concrete materials and constructed pavement, including aggregate process control and handling conforms to the contract requirements.

## 2. SCOPE FOR ASPHALT CONCRETE - CLASS Q:

This training manual is applicable to the production and construction of hot mix pavement on all projects let using the Standard Specification for Roads and Bridges Asphalt Concrete - Class Q. Use the current Standard Specification for Roads and Bridges Asphalt Concrete - Class Q, current Materials Manual and the correct set of plans.

## 3. CERTIFICATION PROGRAM FOR TECHNICIANS ON QC/QA PROJECTS:

The purpose of this program is to develop and maintain a pool of well-trained technicians for the Department and its Contractors, and to test and manage highway construction materials. The intent of this program is to improve the quality and performance of pavements through knowledge and understanding of the products.

On gyratory Class Q projects, the Contractor will have a minimum of one certified Asphalt Concrete Aggregate Testing and Asphalt Concrete Hot Mix testing certified tester conducting the QC testing and one certified Roadway Inspection person on the project. The State will have a minimum of one certified Asphalt Concrete Aggregate Testing and Asphalt Concrete Hot Mix Testing tester conducting the QA testing and one Roadway Inspection certified person on the Project. The certified technicians must be present at the plant and roadway whenever the plant is supplying asphalt concrete to the roadway.

The requirements for certification are shown in the Materials Testing and Inspection Certification program manual in this section which is current as of the printing date.

## 4. SAMPLING AND TESTING MATERIALS:

Aggregate material will be sampled from the cold feed belt in a manner that will assure a representative sample is obtained. The procedures in SD 201 and SD 213 will be followed to obtain and reduce the material sampled to the testing size. Aggregate sample size will be large enough to obtain four (4) splits of the minimum sample size needed (6 if IA tests are required) The QC splits are to be retained until the QC, QA, and IA technicians have obtained their tests results for the individual lot and have found their results to be within the allowable tolerances in the Materials Manual for Class Q, SD 317, and the Project Engineer has told the QC technician he can dispose of the samples. The QA splits are to be retained until the Bituminous Engineer has completed F and t testing on the materials and has notified the Project Engineer or QA technicians that samples can be discarded.

Hot mix asphalt samples will be obtained from the windrow in front of the pickup machine in a manner that will assure a representative sample is obtained. The procedures in SD 312 and SD 313 will be followed to obtain and reduce the material sampled to the testing size. The sample will be large enough to obtain 4 splits and make reheat samples if necessary (6 splits if IA is obtained). The QC splits are to be retained until the QC, QA, and IA technicians have obtained their tests results for the individual lot and have found their results to be within the allowable tolerances in the Materials Manual for Class Q, SD 317, and the Project Engineer has told the QC technician to dispose of the samples. The QC gyratory samples made will be labeled the same as the sample number with an A and a B and be retained until the end of the Project. The QA splits are to be retained until the end of the Project and the Bituminous Engineer has completed the F and t tests on the sets of test results.

If the difference between the QC and QA/IA test results is greater than allowed in the Materials Manual for Class Q or in SD 317, the Engineer will investigate the reason for the difference. This investigation will include review and observation of sampling, splitting, test equipment condition, and testing procedures on a sample. If upon test result review, equipment or procedural problems are found, the problems will be corrected and documented.

Asphalt binder and liquid asphalt are to be sampled according to SD 301. Asphalt binders require a sample of two 1-quart metal cans per 250 ton of material. The sample will be obtained from an in-line sampling valve located between the storage unit and the mix plant. Emulsions require a sample of two 1/2-gallon plastic jugs. Other liquid asphalt requires a sample of two 1-quart metal cans per 100 ton of material. The oil content will be determined daily by using SD 314. Hydrated lime will be sampled according to Materials Manual using SD 502 if not furnished from a certified lime plant.

These procedures will be used by certified technicians on all projects let with the Standard Specification for Roads and Bridges Asphalt Concrete - Class Q. Test data and forms will be submitted on SDDOT forms unless the Engineer approves other forms for use. The forms will be submitted in a timely manner to the Area and Region personnel.

Test procedures in this manual are the current procedures at the time of printing of this Training Manual. The current edition of sampling and testing procedures used by the South Dakota Department of Transportation will be in the SDDOT Materials Manual and at the SDDOT website dot.sd.gov

**5. TEST REPORTS AND CONTROL CHARTS:**

Test results will be reported on SDDOT forms unless approved by the Engineer. QC/QA Numbering will begin with a prefix of QC or QA or IA followed by 01 or 001 and run consecutively throughout the Project. IA or QA tests will be referenced to their corresponding QC or QA tests (QC01/QA01). Non payfactor material will be labeled with an N prefix before the test number (NQC01). Test Strip material will be identified with a TS before the test number (TS01). The core samples will be numbered consecutively with an A and a B following the test number for each sublot. A computer program called Material Sampling and Testing (MS&T) in the Construction Management System will be used on Projects and the numbering system and recording will be according to the requirements of the system. Computations and rounding numbers will be as required by the Materials Manual and the MS&T system.

Roadway diaries are to include hours paved, equipment in use, stations paved, course, depth, width, crown, spread checks, tonnage, weather, temperature of mix delivered to the road and other pertinent data. Plant diaries are to include plant start and shutdown times, mix temperature of material produced, oil spot checks, aggregate bin splits being used, actual calculated oil percentage for the day, tons plant produced, mix and binder content changes, and weather conditions. This list is not complete and may be expanded to cover as much pertinent data as you wish. There are no restrictions on such notes, and they serve as important documentation. The Project Engineer will be responsible for collecting the information from the inspectors and recording it in the project diary.

Control charts will be maintained for gradation of the control sieves in the Job Mix Formula, asphalt binder content, hydrated lime content, maximum specific gravity (rice), bulk specific gravity (Gyratory), air voids, VMA, VFA, dust to binder ratio and in-place density for the Project. The QC technician will maintain the control charts and the QA technician will give their test results to be added to the charts in a different pen color and give the IA samples to be added as they become available in a different color, as well.

The current forms are in the SDDOT Materials Manual. An electronic version is available in the MS&T system.

## 6. COMPARISON OF QUALITY CONTROL AND ACCEPTANCE TESTS OR INDEPENDENT ASSURANCE TESTS ON ENTIRE PROJECT:

The purpose of this procedure is to provide a method of comparing two different sets of multiple test results. This procedure can be used to compare the contractor QC tests to the SDDOT QA tests and the SDDOT IA test results to determine if the material tested came from the same population. The procedure for this is from the AASHTO Implementation Manual for Quality Assurance (February 1996) Appendix F. This is the F-test and t-test statistical procedures which will be conducted by the Bituminous Engineer.

## 7. SDDOT PROFICIENCY SAMPLE PROGRAM:

Contractors or consultants doing mix designs for the South Dakota Department of Transportation must participate in the SDDOT round robin Proficiency Sample Program.

## 8. QC/QA PROJECT INSPECTION REPORT:

This section is a checklist of items for QC/QA Projects. This list is not all inclusive and does not include every necessary item.

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# ASPHALT CONCRETE, GENERAL

## 320.1 DESCRIPTION

These requirements are applicable to all types of hot mixed asphalt pavements irrespective of class, type, asphalt material, or pavement use. Exceptions to the general requirements are in the specified requirements for each class.

The work consists of one or more courses of asphalt concrete mixture constructed on a prepared foundation.

## 320.2 MATERIALS

**A. Composition of Mixtures:** The asphalt concrete shall be composed of a mixture of aggregate, asphalt binder, additives, and approved modifiers. Unless otherwise specified in the plans, no RAP is allowed in the asphalt concrete. Aggregate fractions shall be combined in proportions resulting in a mixture meeting the specified requirements.

The operation of the plant shall not commence until the Department's Bituminous Engineer has established or verified a job mix formula, in writing, meeting the aggregate and mix design specification requirements for the class and type of asphalt concrete specified. The job mix formula established or verified by the Department's Bituminous Engineer shall fix a single percentage of aggregate passing each required sieve size, a single percentage of asphalt binder to be added to the aggregate, a single asphalt binder application temperature at the mixer, a single temperature at which the mixture is to be discharged from the mixer, and a single temperature at which the mixture is to be delivered to the road. The following table sets forth the tolerances for the job mix formula:

| | |
|---|---|
| Gradation, percent passing, sieve sizes | |
| 3/8 inch & larger | ±7 |
| #4 thru #40 | ±5 |
| #200 | ±2.0 |
| Percent asphalt binder content | ±0.3 |
| Percent hydrated lime content | ±0.10 |
| Temperature of mixture when emptied from mixer | ±20°F |
| Temperature of mixture on delivery to the road | -20°F & +30°F |
| Asphalt binder application temperature | ±20°F |
| Percent RAP content (if used) | ±5 |

Job mix formula tolerances for Class Q asphalt concrete shall conform to Section 322.

The mixture shall conform within the range of tolerances established by the job mix formula for that class of asphalt concrete. Should a change in sources of materials be proposed or when unsatisfactory results are obtained, a new job mix formula shall be established.

Blade laid asphalt concrete mixture shall consist of the fine aggregate components of the asphalt concrete class specified on the project. The job mix formula established or verified by the Department's Bituminous Engineer shall set the fines components at approximately the same proportions as the asphalt concrete class specified on the project and shall fix a single percentage of asphalt binder to be added to the aggregate, a single asphalt binder application temperature at the mixer, a single temperature at which the mixture is to be discharged from the mixer, and a single temperature at which the mixture is to be delivered to the road. The blade laid asphalt concrete mixture may contain a small amount of coarse aggregate (+#4 sieve). The Department will not perform quality testing on any of the coarse aggregate (+#4 sieve) in the blade laid asphalt concrete mix.

**B. Aggregates:** Aggregates shall conform to Section 880.

**C. Asphalt Binder:** Asphalt binder shall conform to Section 890.

**D. Shoulder Joint Sealant:** Joint sealant shall conform to Section 870.

**E. Additives:** An additive is any material added to a bituminous mixture or material, such as mineral filler, asphalt additives, and similar products without a specific pay item. Additives shall not be incorporated into the mixture without approval of the Department's Bituminous Engineer.

**F. Hydrated Lime:** Hydrated lime shall conform to Section 760.

## 320.3 CONSTRUCTION REQUIREMENTS

**A. Weather and Seasonal Limitations:** Asphalt concrete shall not be placed when the underlying surface is wet or frozen. Asphalt concrete shall not be placed when weather conditions prevent proper handling, compaction, or finishing. The temperature and seasonal limitations are as follows:

**MINIMUM AIR TEMPERATURES & SEASONAL LIMITATIONS**

| Compacted Thickness | Surface Course | | Subsurface Course & Shoulder Course | |
|---|---|---|---|---|
| | Minimum Temperature*[1] | Seasonal Limits | Minimum Temperature*[1] | Seasonal Limits |
| 1 inch or less | 45°F | May 1 to Oct. 15 (inclusive) | 45°F | none |
| over 1 inch | 40°F | May 1 to Oct. 15 (inclusive) | 40°F | none |

*[1] Minimum air and surface temperature in the shade.

**B. Equipment:**

1. **Requirements for All Plants:** The central plant for mixing the aggregate and asphalt binder may be a batch or drum mix type mixing plant.

Stockpiles of aggregate shall be kept separate and adequate measures to prevent contamination must be used at stockpile sites. Contaminated piles will be rejected. Segregated piles will be rejected until corrected.

When mineral filler, hydrated lime, or other additives are required, a separate feed system shall be provided to store and accurately and uniformly proportion the required quantity into the mixture.

All cold feed bins shall be equipped with dividers to prevent overflow of aggregate to adjacent bins.

The plant shall be equipped with emission control equipment including a dust collector capable of eliminating or conserving the dust necessary to meet gradation limits and environmental standards.

Burner fuel used for production of asphalt concrete shall be propane, butane, natural gas, Grade 1 fuel oil, Grade 2 fuel oil, Grade 4 fuel oil, Grade 4 (light) fuel oil, Grade 5 (light or heavy) fuel oil, or Grade 6 fuel oil. Fuel heavier than Grade 2 shall meet the requirements of ASTM D396. Recycled fuel oils, RFO4, RFO5L, and RFO5H may also be used provided they meet the requirements of ASTM D6448. The burner fuel supplier shall certify each load of burner fuel meets the applicable ASTM specification. Recycled fuel oils and fuel oils heavier then Grade 2 shall be properly preheated and efficiently burned. Production of mix shall be stopped if flameouts or signs of incomplete combustion occur.

A pyrometer or other thermometric instrument shall be installed in the supply line between the asphalt binder storage tank and the asphalt binder discharge point in the plant to accurately measure the temperature of the asphalt binder.

An in-line sampling valve shall be installed in the supply line between the asphalt binder storage tank and the asphalt binder discharge point in the plant.

The plant shall be equipped with accurate weighing or volumetric measurement devices.

Asphalt binder storage tanks shall be kept level. Accurate calibration charts which show the quantity of material contained in a tank at each 1/4 inch increments of depth and a suitable device to measure the depth of the material shall be provided. Storage tanks shall uniformly heat the material, under effective and positive control, to the required temperature. Heating shall be accomplished by steam coils, electricity, or burners, provided the flame does not come in direct contact with the heating tank. The asphalt circulating system shall be of adequate size to ensure proper and continuous circulation during the entire operating period. An accurate thermometer must be installed in the tank so the temperature can be monitored.

When hydrated lime is used, the Contractor's hydrated lime system shall be equipped with scales to accurately determine the amount of hydrated lime used at any time. The Contractor's hydrated lime system shall control fugitive lime dust from being released into the air.

Hydrated lime, when added, shall be added at the pugmill to moistened aggregate containing a minimum moisture content of 1.0% above the saturated surface dry condition of the aggregate, as noted on the approved job mix formula. The mixing of the aggregate, hydrated lime and water shall be accomplished by using an enclosed twin-shaft pugmill with a minimum effective length of 4.5 feet. A water spray system must be installed at the discharge end of the pug mill. This water system must be used when directed by the Engineer to prevent fugitive lime dust from being released into the air.

2. **Batch Type Mixing Plants:** Batch type plants shall have at least two storage bins with sufficient capacity to furnish the quantity of mineral aggregate materials necessary to operate at the calibrated capacity of the plant. Each compartment shall have partitions to prevent diversion of material into other compartments. Vibrators shall be provided to prevent bridging or arching of the bin contents.

Batch plants shall be fully automatic, to the extent the only manual operation required would be for the proportioning of one batch utilizing a single actuation switch or starter.

The automatic unit shall include a timer to automatically control the measuring, mixing, and dumping processes through a central control. The automatic unit shall include a time lock device, capable of controlling the operations of a complete mixing cycle.

When RAP is used, batch plants shall be modified to permit the RAP to feed directly into the weigh hopper of the plant.

When RAP is used, the heated virgin aggregate shall be deposited in the weigh hopper first followed by the RAP. These two materials shall be "dry" mixed for a minimum of 10 seconds before introduction of asphalt binder into the pugmill. Wet mixing time shall be a minimum of 25 seconds. Mixing times may be adjusted by the Engineer, as necessary, to achieve uniform mixing and coating. Discharge of the heated virgin aggregate shall be from one bin only and shall be discharged into the center of the weigh hopper. The amount of aggregate stored in the bin shall not exceed one batch in weight and shall be fed into the bin in a manner that will prevent segregation.

A recording pyrometer shall be mounted in the discharge chute of the dryer. Daily charts of continuous aggregate temperature readings shall be submitted to the Engineer. In lieu of a recording pyrometer, a computer printout showing the aggregate temperature readings at the discharge chute of the dryer may be substituted as approved by the Engineer.

3. **Drum Mix Plants:** The dryer drum shall uniformly heat, coat, and mix the materials without overheating the materials and adversely affecting the mixture.

**a.** Materials and additives, except RAP, shall be fed simultaneously into the dryer.

**b.** The aggregate and RAP feed system shall be easily and accurately calibrated and shall provide positive control of the aggregate feed. The rate of feed shall be continuously monitored by belt scale or other device interlocked with the asphalt metering mechanism.

**c.** RAP, when used, shall be introduced into the drum and combined with the aggregate so the RAP does not come into direct contact with the burner flame. Asphalt binder shall be added to the mixture in the drum after the aggregates and RAP have been combined.

**d.** The asphalt metering device shall positively control the rate asphalt is introduced into the mixture and shall respond instantaneously to variation in the aggregate feed rate.

**e.** Production shall be limited to the rate required to obtain uniform aggregate coating and a uniform mixture meeting job mix temperature requirements. The rate must be within manufacturers rated plant capacity.

**f.** A recording pyrometer shall be mounted in the discharge end of the mixer for determining the temperature of the mix. Daily charts of continuous mix temperature readings shall be submitted to the Engineer. In lieu of a recording pyrometer, a computer printout showing the mix temperature readings at the discharge end of the mixer may be substituted as approved by the Engineer.

**4. Blade Laid Asphalt Concrete Equipment:** The Contractor shall use either a motor grader blade or a paver to perform the blade laid asphalt concrete work. The equipment shall force the mixture into the joints and cracks to adequately level and fill the joints and cracks while not exceeding the required application rate.

If the Contractor uses a motor grader blade, the blade shall be equipped with gates, wings, or other devices approved by the Engineer to prevent the material from windrowing at the edges of the blade.

If the Contractor uses a paver, the paver shall be equipped with a solid screed bar plate measuring a minimum of 12 inches wide by 1.5 inch thick.

Self-propelled pneumatic tired rollers shall cover an overall surface width of at least 60 inches and shall furnish a minimum rolling weight (mass) of 250 pounds per inch of roller width.

**5. Pavers:** Self-propelled pavers shall be equipped with a hopper having a bottom conveyor, a full width vibrating screed with heaters and augers, and shall be capable of spreading and finishing the mix to the specified widths, typical section, and thickness. Hydraulic extendable screeds may be used for variable width pavements. Auger extensions shall be used as recommended by the paver manufacturer and shall extend to within 12 to 18 inches of the edge of the paver screed. The paver shall provide an accurate, smooth, and uniform textured spread and shall provide preliminary compaction.

An attachment shall be provided on the paver that will place a beveled edge on the mat as specified.

Pavers shall be equipped so that the height and transverse slope of the screed is automatically controlled using a fixed or traveling stringline on either or both sides of the paver. The traveling stringline shall utilize either mechanical skis or non-contacting grade averaging sensors. The traveling stringline shall have a minimum effective length of 25 feet. The system shall be capable of manually controlling the transverse slope and screed height.

6. **Rollers:** Rollers for compacting the asphalt concrete shall be of the self-propelled type, capable of producing a smooth surface finish. The number and weight of rollers furnished shall be sufficient to compact the mix to the required density. The rollers shall be capable of being reversed smoothly, without shoving or tearing the asphalt concrete.

   Rollers shall be equipped to prevent "pickup" on the tires or drums. Moistening the drums or tires with water, a water detergent solution, or enclosing the roller to prevent heat loss from the tires may be required. The use of fuel oil or other petroleum solvents to prevent "pickup" will not be permitted. Measures shall be taken to prevent oil, grease, or fuels from being dropped on the mat by rollers or any other type of equipment.

**C. Preparation of the Mineral Aggregate:**

1. **Stockpiling Aggregate:** Stockpiles of mineral aggregate for asphalt concrete shall be built in layers, completing each layer over the full area of the pile before the next layer is started. The height of each layer shall be controlled to minimize segregation. The maximum drop of the materials from the conveyor shall not exceed 10 feet. Coning shall not exceed 10 feet. The stockpile shall be leveled with rubber tired equipment between layers to maintain a level platform for the next layer. Dumping, casting, or pushing over the sides of the previous layers will not be permitted. Segregated piles will be rejected until corrected. The equipment operating on the pile shall be free of dirt, grease, oil, and other contaminants. The size of the equipment shall be limited to that which can be operated on the stockpile without degradation of the material. The leveling requirement will be waived for the fines stockpile when split on a 1/4 inch or smaller screen unless there is indication of segregation. Aggregate stockpiles shall be kept separate and adequate measures to prevent contamination must be used at stockpile sites.

2. **Stockpile Tests:** The Contractor shall run process control tests on the mineral aggregate when producing material. A gradation, PI, fractured faces, and lightweight particles test shall be run for every 1500 tons produced per pile. The Contractor shall also test the quality (abrasion and soundness) of the mineral aggregate. The quality shall be tested once per source. All sampling and testing shall be accomplished in

accordance with the Department’s Materials Manual. The Engineer may reduce the frequency of the stockpile tests on ledge rock sources depending on the quality and uniformity of the materials. Test results shall be recorded on forms furnished by the Department, and shall be immediately submitted to the Engineer.

3. **Mix Design Submittal:** The asphalt concrete mix designs shall be performed by the Department's Bituminous Mix Design Lab. Prior to submitting samples to the Department’s Bituminous Mix Design Lab, 50% of the plan quantity or 15,000 tons whichever is less, of the mineral aggregate shall be produced.

When RAP is required, the Contractor shall sample the RAP from the roadway by an approved method. The sampling method shall ensure a representative sample of material is obtained from approximately the same depth as the plans shown milling depth. The RAP sample shall be obtained from a minimum of three locations throughout the project length. The Contractor shall daylight all edges of the sampling area leaving no vertical faces or shall fill the sample area with an approved product leaving no vertical faces. The equipment used shall generate a representative sample of RAP similar to what will be produced from the cold milling operation. The Contractor shall notify the Area office a minimum of 5 calendar days prior to sampling the RAP from the roadway. A representative from the Area office shall witness all sampling of RAP to be submitted for mix design. This material shall be used to perform the mix design. A portion of this sample shall be submitted to the Department’s Bituminous Mix Design Lab.

The Contractor shall notify the Area office a minimum of 5 calendar days prior to sampling and submitting the mix design aggregates. A representative from the Area office shall witness all sampling of aggregates to be submitted for mix design.

A representative from the Area office shall complete the Form DOT-1 for the composite aggregate sample and RAP sample required for submittal to the Department’s Bituminous Mix Design Lab in Pierre, SD. The Area office representative shall take possession of the aggregate and RAP samples for mix design and aggregate quality testing. Samples shall be obtained a minimum of 21 calendar days prior to hot mix production. The Department will deliver the samples to the Department’s Bituminous Mix Design Lab.

The Department may allow the Contractor to transport and deliver the RAP and aggregate 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.

Mix designs will only be performed on samples when accompanied by the following information:

**a.** A completed data sheet (DOT 1), including the legal description of all mineral aggregate sources.

**b.** The mineral aggregate and RAP samples submitted shall be representative of the materials produced for the project.

**c.** The average stockpile test results of each mineral aggregate stockpile produced along with the recommended bin splits of each material produced.

**d.** A 1 gallon sample of asphalt binder intended for use shall be obtained from the designated supplier for the project.

**e.** A temperature viscosity curve (chart) or required mixing temperature for the asphalt binder intended for use and the specific gravity of the asphalt binder. The asphalt binder supplier shall provide the recommended lab mixing and compacting temperatures and the recommended field mixing and compaction temperatures for modified asphalt binders.

Two mix designs per type will be made by the Department without charge. Should the Contractor desire an additional mix design, or if additional mix designs are required due to the materials not meeting specifications, the costs involved shall be at the Contractor's expense.

**4. Proportioning of Aggregates:** If blending of aggregates is required, separate bins and stockpiles shall be provided. Materials shall be kept separated until they are delivered in their proper proportions onto the feeder leading to the dryer. Spreading or dumping filler, sand, or crushed rock over the top of gravel pits, stockpiles, or in hoppers at the crushing plants will not be permitted. Charging bins directly from pits, crusher, or screening plants will not be permitted.

The mineral aggregate exclusive of other additives shall be separated into at least two fractions dividing on the #4 sieve or other size agreed upon, and placed into separate compartments ready for proportioning and mixing.

**D. Preparation of the Mixture:** The mineral aggregate shall be satisfactorily mixed with the proper quantity of asphalt binder at the central mixing plant.

The mixing plant shall be operated using automatic controls. Manual operation will be permitted for the remainder of the day when automatic controls fail, provided specified results are obtained. The Contractor shall restore automatic operation prior to the next day's production.

The asphalt binder shall be added to the mix in the proportionate quantity and at the temperature established by the job mix formula.

In batch plants, the mineral aggregate shall be mixed dry for a minimum of 5 seconds.

After introducing the required aggregate and asphalt binder into the mixer, the materials shall be continuously mixed until the aggregate is completely and uniformly coated and a thorough distribution of the asphalt throughout the aggregate is obtained. Mixtures containing incompletely coated particles at the time of discharge from the plant or thereafter will be rejected. The Contractor shall make appropriate adjustments in the production of mixtures to ensure the mixture is completely coated at the time of discharge from the plant.

When hot mix storage bins are used, storage of the mix shall be limited to a maximum of 15 hours. The point of temperature measurement will be the discharge end of the mixer.

**E. Transportation and Delivery of the Mixture:** The mixture shall be transported from the plant to the point of use in pneumatic tired vehicles. The vehicle boxes shall be tight, clean, and smooth. Boxes shall be cleaned only with lime water, soap, a detergent solution, or an approved commercial product specifically intended for this use. Oil, diesel fuel, or other petroleum solvents shall not be used. No material shall be used which could adversely affect the asphalt concrete. Excess solution in the box shall be disposed of before the vehicle is loaded.

Loads shall be tarped in inclement weather conditions and when ordered by the Engineer.

**F. Blade Laid Asphalt Concrete:** Prior to placing the blade laid asphalt concrete mix, the Contractor shall thoroughly sweep the surface to remove all loose existing joint material and loose asphalt concrete from cracks, joints, and spall areas. In curb and gutter sections or in rural sections where a finished and maintained lawn extends to the edge of the shoulder, the Contractor shall use a pickup broom with an integral self-contained storage. The pickup broom must be a minimum of 6 feet wide. While sweeping in curb and gutter sections, the pickup broom must have working gutter brooms. A rotary power broom may be used in all other locations.

The blade laid asphalt concrete mix shall be compacted by at least two complete coverages with self-propelled pneumatic tired rollers.

**G. Tacking, Spreading, and Compacting:** The surface, including all vertical contact faces, on which the asphalt concrete is to be placed, shall be tacked in accordance with Section 330. The tack coat shall be allowed a cure period, as determined by the Engineer, prior to asphalt concrete placement.

Surfaces which have been primed with cutback asphalt shall be allowed to cure for a minimum of 72 hours prior to being overlaid with asphalt concrete.

Asphalt concrete shall be placed by self-propelled pavers. Handwork is permissible in inaccessible or odd shaped areas. In lieu of a self-propelled paver, asphalt concrete may be placed by a shouldering machine on shoulders less than 6 feet in width.

Spot leveling and repair of the existing surface with asphalt concrete shall be required prior to the paver laid courses at locations designated. Potholes and areas of localized disintegration shall be cleaned of loose material, squared, tacked, leveled with asphalt concrete, and satisfactorily compacted. Spot leveling may be blade laid in lifts not exceeding 3 inches of uncompacted depth. Compaction shall be by the specified roller coverage method. The Contractor may use a steel face roller provided the roller does not damage the mineral aggregate during compaction.

Paver laid mix shall be spread using automatic transverse and longitudinal grade controls. If the automatic controls fail or malfunction, the Engineer may permit manual operation for the remainder of the day, provided the finished product meets the specifications. Frequent breakdowns shall constitute cause for suspension of the work until repair or replacement is made.

Following placement of the first pass using the traveling stringline for control, adjacent passes and succeeding lifts shall be placed using the traveling stringline riding on the previously laid material. A shoe attachment may be used to match the longitudinal joint(s) on the final paver pass(es) of the top lift unless otherwise directed by the Engineer.

A shoe attachment on the paver shall be used to automatically match the elevation of asphalt concrete shoulders with concrete pavements.

Automatic slope controls will be required on paving equipment for placing asphalt concrete on shoulders, 8 feet or more in finished width.

Asphalt concrete shall be placed directly on the roadbed in a uniform windrow and then fed into the paver by a paver feeder. The use of a paver feeder is not required on shoulders, turning lanes less than 500 feet roadway paving less than 500 feet and transitions into bridge decks less than 500 feet. The paver feeder shall pick up substantially all of the mix and feed it into the paver without segregation. The size of the windrow shall be regulated so the paver is fed a continuous and adequate supply of mix. The screed shall not be raised solely to accommodate excess material in the windrow or paver hopper. A Material Transfer Vehicle (MTV) which takes material directly from the trucks, stores and mixes it, and then dumps into the paver hopper may be used if approved by the Engineer.

The "temperature of mixture on delivery to the road" shall be defined as the temperature of the mix just prior to placement or just prior to spreading by blade.

On the final surfacing lift, laydown operations shall commence at the farthest point and progress continuously toward the plant.

On rural projects, a partial width pass may be extended beyond the adjacent pass by as much as one day's run. The paver shall be moved back the following working day to place the adjoining pass. Where a difference in elevation exists between two lanes carrying traffic in the same direction on rural multilane asphalt concrete construction, one of the affected lanes shall remain closed to traffic.

The plant production and availability of hauling vehicles shall be sufficient to provide a uniform and consistent quantity of asphalt concrete to the paver so laydown operations are continuous. Stops and starts shall be restricted to a minimum and excessive stopping of the paver will result in suspension of paving activities until corrective measures are taken. Stopping normal laydown operations to surface an approach, thereby creating an unnecessary joint, will not be permitted.

Laydown operations shall proceed from the center to the shoulders of the roadbed surface. When turning lanes are present, the Contractor may alter the laydown operation. In curb and gutter sections, laydown may proceed from the gutter line to the centerline. The Contractor shall submit the proposed laydown operation to the Engineer for approval prior to beginning laydown operations.

The longitudinal joints of succeeding lifts shall be offset approximately 6 inches. The center longitudinal joint of the top lift shall be located on centerline except where a center turning lane is present. Longitudinal joints shall be located within 12 inches of the lane line.

At the end of the day's paving, the Contractor shall place a temporary ramp from the top of the lift of asphalt concrete to the existing surface. The temporary ramp shall extend a minimum of 3 feet per 1 inch of asphalt concrete placed. Transverse joints of the final lift shall be formed by sawing back the previous run to expose the full depth of the course. The finished transverse joint of all lifts shall have a uniform texture and comply with the straightedge requirement. Waste material resulting from forming joints and temporary ramps shall be removed and disposed of.

Segregation or excessive pulling of the mix shall warrant suspension of operations.

Immediately after the mix has been placed and surface irregularities adjusted, the mix shall be thoroughly and uniformly compacted by rolling.

Multiple lift laydown operations will not be allowed on the same location on the same day unless approved by the Engineer. The use of ice or other materials to accelerate the cooling of the lift will not be allowed.

Vibratory rollers shall have an automatic shutoff to deactivate the vibrators when the roller speed is less than 0.5 mph Rollers shall be operated according to the manufacturer's recommendations for speed, impacts per foot, and amplitude of vibration for the thickness of mix being compacted. Rolling shall be longitudinal, commencing at the outer edges of the mat and progressing toward the center in straight, parallel strips, overlapping at least 6 inches. On superelevated curves, rolling shall progress from the lower to the upper edge of the mat. The Contractor shall vary the points of reversal to prevent a transverse crease. The rollers shall not stand idle on any part of the mat that has not been completed and cooled sufficiently to resist deformation.

Class Q asphalt concrete placed on the shoulder shall be compacted using the same roller pattern used on the adjacent mainline asphalt concrete or as directed by the Engineer.

The beveled edge shall be satisfactorily compacted and shall retain the specified dimensions after compaction.

Longitudinal joints shall be compacted in accordance with the following:

For confined edges, on the first pass adjacent to the confined edge, the compaction equipment shall be entirely on the hot mat 6 to 12 inches from the longitudinal joint.

For unconfined edges, on the first pass adjacent to the unconfined edge, the compaction equipment shall extend 4 to 6 inches beyond the edge of the mat.

The surface of each lift shall be free of waves and other irregularities. The final lift surface shall be checked with a 10-foot straightedge. The variation of the surface from the straightedge between any two contact points shall not exceed 0.02 feet. The crown, on all lifts, as indicated by checking with a 10-foot straightedge, shall be within 0.04-feet of specified crown in any 10 foot length.

Irregularities shall be corrected before the temperature of the asphalt mix drops below 175°F. The longitudinal profile can only be improved by using a grinder with diamond blades mounted on a horizontal shaft and when approved by the Engineer. Areas that have been ground shall not be left smooth or polished, but shall have a uniform texture similar in roughness to the surrounding unground asphalt concrete. Grinding shall be day lighted to the outside edge of the pavement. Ground surfaces shall be flushed sealed. Under no circumstances shall operations continue when it becomes evident final rolling is not producing a smooth, uniform, compacted surface free from roller marks and other irregularities.

The mix shall be compacted on the road by one of the following methods. Unless otherwise specified, the Specified Density Method shall be used.

1. **Specified Density Method:** The mix shall be compacted to the density specified for the class of asphalt concrete designated. The percent of density shall be based on the maximum specific gravity of the test specimens prepared in the field in accordance with SD 312. The compacted density of asphalt concrete shall be determined according to SD 311.

   Compaction rolling shall be completed before the temperature of the mix drops below 175°F. Vibratory rollers may be used in the static mode for finish rolling.

   Compaction of mix placed on entrances to farms, residences, or businesses and intersecting road approaches shall be compacted by the specified roller coverage method.

2. **Specified Roller Coverage Method:** The mix shall be compacted by at least four complete coverages with pneumatic tired rollers and at least one complete coverage with steel faced rollers, or as approved by the Engineer. Self-propelled pneumatic tired rollers shall cover an overall surface width of at least 60 inches and furnish a minimum rolling weight (mass) of 250 pounds per inch of roller width. Self-propelled tandem smooth steel rollers (two steel drums operating in the same track) shall furnish a minimum rolling weight (mass) of 325 pounds per inch of roller width.

Breakdown rolling may be accomplished by steel-faced rollers, only when approved by the Engineer.

Rolling shall proceed on the mat as soon as lay down is completed. Completion of rolling on any segment shall not lag behind the laydown more than 1000 feet. During periods of cool weather this maximum distance between laydown and final rolling shall be reduced as ordered by the Engineer.

Compaction to a specified density will not be required. However, additional roller coverage may be required in order to obtain a smooth surface finish.

**H. Maintenance:** The Contractor shall maintain the work during construction and until the Acceptance of Field Work is issued by the Area Office. Maintenance shall include protection and repair of the prepared base course, tack coat, wearing surface mat, shoulders, and seal course. Rich or bleeding areas, breaks, raveled spots, or other nonconforming areas in the wearing surface or base shall be corrected.

**I. Traffic Control:** Hauling or allowing traffic on the roadway will not be permitted until the surface has been compacted and cooled sufficiently to resist marking or distortion.

Where traffic is to be maintained by means of part width construction, the Contractor shall control all traffic by identified pilot cars and flaggers. The Contractor shall schedule work so traffic will not be greatly inconvenienced with long one-way lanes.

**J. Compaction Sample:** When ordered by the Engineer and at locations designated by the Engineer, the Contractor shall saw and remove a compaction sample in accordance with SD 311. After removal, the Contractor shall repair the sample location to the satisfaction of the Engineer. The Engineer shall take immediate possession of all samples for further testing.

**K. Shoulder Joints:** When specified, a continuous groove shall be constructed by forming, sawing, or routing the joint between the Portland cement concrete pavement and the asphalt concrete shoulder.

Sawing may be done with either diamond or water-cooled abrasive blades.

If a router is used the router must be mechanical, power driven, and capable of cutting a groove to the required dimensions. Equipment designed to plow the groove to dimension will not be permitted. The walls of the finished groove shall be vertical and the groove bottom shall be flat.

The groove shall be thoroughly cleaned immediately after forming, sawing, or routing. Dry sawed joints shall be cleaned with high-pressure air. Wet sawed joints shall be cleaned with high-pressure water followed by high-pressure air. The air compressor shall produce a minimum of 125 CFM output and shall be equipped with a maximum 3/4 inch nozzle. The groove (including the sides) shall be free of dirt, dust, water, oil, grease, and loose material immediately prior to sealing. The Portland cement concrete surface shall be free of asphalt and any curing compound that would prevent bonding.

The groove shall be completely dry and filled level with joint sealer by a sealing device, which will not entrap air in the sealed joint.

Joint sealer application will not be permitted when the air temperature near the joint is less than 40°F or is 40°F and falling.

## 320.4 METHOD OF MEASUREMENT

A. **Asphalt Binder:** Asphalt binder will be measured to the nearest 0.1 ton. Quantities of asphalt binder in excess of the asphalt content listed on the job mix formula plus the 0.3% tolerance will not be accepted for payment.

B. **Asphalt Concrete:** Asphalt concrete will be measured to the nearest 0.1 ton for the class specified. The mixture of mineral aggregate, asphalt binder, and hydrated lime, when required, will be weighed after mixing. No deduction will be made for the weight of the asphalt binder or hydrated lime, when required, included in the mixture.

   Deduction will not be made for material removed from temporary approaches authorized by the Engineer.

C. **Compaction Sample:** Compaction samples will be measured by actual count of compaction samples ordered and accepted by the Engineer.

D. **Sawing and Sealing Shoulder Joints:** Field measurement for this work will not be required. Plan quantity will be the basis of payment. If changes are ordered by the Engineer, the length will be measured to the nearest foot and the quantity adjusted.

E. **Hydrated Lime:** Hydrated lime, when provided as an additive to the asphalt concrete mixture to meet the moisture sensitivity requirements, will be measured to the nearest 0.1 ton. Quantities of hydrated lime in excess of the lime content listed on the job mix formula plus the 0.10% tolerance will not be accepted for payment.

F. **Stockpile Tests:** Stockpile tests will not be measured for payment.

## 320.5 BASIS OF PAYMENT

A. **Asphalt Binder:** The accepted quantities of asphalt binder will be paid for at the contract unit price per ton. The amount bid for this item shall be at least the cost of the asphalt binder furnished and delivered to the project site.

B. **Asphalt Concrete:** The accepted quantities of asphalt concrete will be paid for at the contract unit price per ton complete in place.

C. **Compaction Sample:** Compaction samples will be paid for at the contract unit price per each. Payment will be full compensation for all labor, equipment, materials, and all other items incidental to sampling and repair of the sample locations to the satisfaction of the Engineer.

**D. Sawing and Sealing Shoulder Joints:** Sawing and sealing shoulder joints will be paid for at the contract unit price per foot.

**E. Hydrated Lime:** Hydrated lime will be paid for at the contract unit price per ton complete in place. Payment for hydrated lime will only be made when hydrated lime is actually used. The amount bid for this item shall be at least the cost of the hydrated lime furnished and delivered to the project site.

**F. Stockpile Tests:** There will be no direct payment for the stockpile testing and related requirements. All costs related to the testing for labor, test equipment, laboratory, tools and all incidentals required to satisfactorily perform the required work shall be incidental to the asphalt concrete pavement items.

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## 321.1 DESCRIPTION

This work consists of constructing one or more courses of asphalt concrete on a prepared surface.

## 321.2 MATERIALS

The materials and their use shall conform to Section 320.2.

## 321.3 CONSTRUCTION REQUIREMENTS

The construction requirements shall be as prescribed in Section 320.3 with the following modifications:

A. **Mix Design Specifications:** Unless otherwise specified in the plans, the mix design criteria shall conform to the following requirements for the class and type of asphalt concrete specified.

**MIX DESIGN SPECIFICATIONS**

| MIX DESIGN PARAMETERS | Class D | Class E | Class G |
|---|---|---|---|
| % Air Voids | 4.0 Min. | 4.0 Min. | 4.0 Min. |
| % VMA*1 3/4 inch nominal maximum size | 13.5 Min. | 13.5 Min. | 13.5 Min. |
| 1/2 inch nominal maximum size | 14.5 Min. | 14.5 Min. | 14.5 Min. |
| Gyratory Gyrations | 40 | 50 | 60 |
| Dust/Binder Ratio (based on effective binder) | 0.6-1.4 | 0.6-1.4 | 0.6-1.4 |
| Moisture Sensitivity*2 | NA | NA | 70 Min. |

*1 Evaluated for compliance during the mix design. If the percent passing the 1/2 inch sieve is greater than or equal to 90% the mix shall be considered 1/2 inch nominal maximum size. If the percent passing the 1/2 inch sieve is less than 90% the mix shall be considered 3/4 inch nominal maximum size. Mixes containing 80% or more limestone ledge rock shall meet the VMA requirements of 13.0% Min. for a 3/4 inch nominal maximum size and 14.0% Min. for 1/2 inch nominal maximum size.

*2 Moisture sensitivity will be tested according to SD 309. Hydrated lime shall be used to meet the moisture sensitivity requirement of the mix. Hydrated lime will not be required if the moisture sensitivity requirements are met without the addition of hydrated lime. Hydrated lime will be included in the dust (-#200)/binder ratio.

B. **Thickness:** The compacted thickness of each lift shall not exceed 3 inches.

C. **Density:** The minimum density requirement shall be 92% of the maximum specific gravity of the test specimens prepared in the field in accordance with SD 312. The compacted density of asphalt concrete shall be determined according to SD 311.

## 321.4 METHOD OF MEASUREMENT

Measurement as prescribed in Section 320.4.

## 321.5 BASIS OF PAYMENT

Payment as prescribed in Section 320.5.

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## 322.1 DESCRIPTION

The work consists of constructing one or more courses of gyratory controlled QC/QA hot mixed asphalt concrete pavement on a prepared foundation.

## 322.2 MATERIALS

Mineral aggregate shall conform to the requirements of Section 322.3. All other materials and their use shall conform to Section 320.2.

## 322.3 CONSTRUCTION REQUIREMENTS

The construction requirements shall be as prescribed in Section 320.3 with the following additional requirements:

### A. Laboratories:

1. **Quality Control Laboratory:** The Contractor shall furnish and maintain a Quality Control (QC) laboratory at the plant site. The laboratory shall be furnished with the necessary space, equipment, and supplies to properly perform all specified testing. The laboratory shall be equipped with a gyratory compactor meeting the requirements of AASHTO T 312. The laboratory equipment shall meet the requirements of the test methods contained in the Department's Materials Manual and Materials Testing & Inspection Certification Program Manual. A copy of the equipment calibration records shall be kept in the QC laboratory.

   The Contractor's QC laboratory shall be equipped with a mechanical convection oven meeting the requirements of Section 600.

   The Contractor shall furnish a cut off saw equipped with a diamond tipped blade. The saw is to separate the core samples to the actual lift thickness. The cores shall be sawed by the Contractor to the correct lift line prior to testing the cores for density.

2. **Quality Assurance Laboratory:** The Contractor shall also provide a separate Quality Assurance (QA) laboratory for QA testing performed by the Engineer. The QA laboratory shall meet the requirements of Section 600.

### B. Quality Control:

1. **Contractor Furnished Quality Control Program:** QC for the asphalt concrete pavement is the responsibility of the Contractor. The Contractor shall provide and maintain a QC program. The program shall assure that all asphalt concrete materials and constructed pavement submitted for acceptance conforms to the contract requirements. The Contractor shall be responsible for all asphalt concrete materials and constructed pavement, including aggregate process control and handling.

The Contractor shall provide at least one technician certified in Asphalt Concrete Aggregate Testing and Asphalt Concrete Hot Mix Testing for conducting the QC testing and at least one technician certified in Asphalt Concrete Roadway Inspection for roadway inspection. All of the Contractors QC testing and inspection technicians shall meet the Department's certification requirements or be under the direct supervision of a certified technician for the type of work they are actually performing. The certified testing and inspection technicians must be present at the plant and roadway whenever the plant is supplying asphalt concrete to the roadway.

At or prior to the preconstruction meeting the Contractor shall submit a QC plan to the Engineer for approval. The plan shall contain the following minimum requirements:

**a.** The names and phone numbers of the individual(s) responsible for the Contractor's QC program.

**b.** A listing of the certified technician(s) responsible for the QC inspection, material sampling, and testing.

**c.** A copy of the completed performance checklist and training and evaluation records for all temporary or seasonal personnel who will be performing QC inspection or sampling and testing.

**d.** An organizational chart indicating lines of authority.

**e.** The Contractor shall notify the Engineer if a control test strip will be used. The Contractor may produce approximately 500 tons of material to establish a roller pattern and verify the field produced mix properties match those of the lab mix design. After test strip placement, further mixing and laydown operations will be suspended until the laboratory test results of the asphalt mixture and core densities are available. The material used in the test strip will not be included in the mix pay factor analysis. The material used in the test strip shall be tested for all the properties listed in the Department's Materials Manual. The Engineer shall approve the location of the test strip.

If a control test strip is not constructed, the QC plan shall specify how the Contractor will establish a roller pattern to achieve the specified density and volumetric requirements.

The Engineer will provide the following to the Contractor at the preconstruction meeting:

- Names of the certified individuals in charge of Quality Assurance (QA) testing and roadway inspection.

- An organizational chart including the names and phone numbers of those in the direct line of authority.

2. **Mineral Aggregate Testing Prior to Production:** The aggregate producer shall provide test results to the Contractor and Engineer for each stockpile of virgin mineral aggregate that will be incorporated into the asphalt concrete mixture a minimum of 3 weeks prior to asphalt concrete production. The aggregate producer shall use an individual certified in Asphalt Concrete Aggregate Testing. The required tests shall include gradation, crushed particles, fine aggregate angularity, flat and elongated particles, sand equivalent, and lightweight particles at the following minimum frequencies:

    One test per 1500 tons for each virgin mineral aggregate ingredient produced.

    A minimum of three tests for each virgin mineral aggregate stockpile.

   The Contractor may vary the frequency of the crushed particles, fine aggregate angularity, flat and elongated particles, sand equivalent, and lightweight particles tests on ledge rock sources depending on the quality and uniformity of the materials.

3. **Contractor Furnished Mix Designs:** Asphalt concrete mix designs shall be performed by the Contractor and verified by the Department's Bituminous Mix Design Lab. A certified Asphalt Concrete Mix Design and Production Control technician shall perform the asphalt concrete mix design. All Contractors submitting mix designs to the Department are required to participate in the Proficiency Sample Program.

   Prior to submitting samples to the Department's Bituminous Mix Design Lab, 50% of the plans quantity or 15,000 tons, whichever is less, of the virgin mineral aggregate shall be produced.

   When RAP is required, the Contractor shall sample the RAP from the roadway by an approved method. The sampling method shall ensure a representative sample of material is obtained from approximately the same depth as the plans shown milling depth. The RAP sample shall be obtained from a minimum of three locations throughout the project length. The Contractor shall daylight all edges of the sampling area leaving no vertical faces or shall fill the sample area with an approved product leaving no vertical faces. The equipment used shall generate a representative sample of RAP similar to what will be produced from the cold milling operation. The Contractor shall notify the Area office a minimum of 5 calendar days prior to sampling the RAP from the roadway. A representative from the Area office shall witness all sampling of RAP to be submitted for mix design. This material shall be used to perform the mix design. A portion of this sample shall be submitted to the Department's Bituminous Mix Design Lab.

   The Contractor shall notify the Area office a minimum of 5 calendar days prior to sampling and submitting the mix design aggregates. A representative from the Area office shall witness all sampling of aggregates to be submitted for mix design.

   A representative from the Area office shall complete the Form DOT-1 for the composite aggregate sample and RAP sample required for submittal to the Department's Bituminous Mix Design Lab. The Area office representative shall take possession of the aggregate and RAP samples for mix design and aggregate quality testing. Samples shall be obtained a minimum of 21 calendar days prior to hot mix production. The Area office will deliver the samples to the Department's Bituminous Mix Design Lab in Pierre, SD.

The Area office may allow the Contractor to transport and deliver the RAP and aggregate 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.

Mix designs will only be performed on samples when accompanied by the following information:

**a.** A completed data sheet (form DOT-1), including the legal description of virgin mineral aggregate source(s).

**b.** Representative virgin mineral aggregate samples and RAP samples shall be proportionate to the bin splits proposed for use during construction.

**c.** A summary sheet showing all test results from the gradations completed and the average gradation of each mineral aggregate stockpile produced along with the proposed bin splits to be used in the production of asphalt concrete pavement.

**d.** A 2 gallon sample of asphalt binder intended for use shall be obtained from the designated supplier for the project.

**e.** A mix design report and moisture sensitivity test results, if required, that includes the lab data and test results required in SD 318, SD 319, and Section 322.3 B.4. The Contractor's mix design shall meet all of the mix design specifications.

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. The mix design report will include the single percentage of aggregate passing each required sieve size, a single percentage of asphalt binder to be added to the mixture, a single percentage of hydrated lime to be added to the mixture, a single asphalt binder application temperature, a single temperature at which the mix is to be discharged from the mixer, and a single temperature at which the mix is to be delivered on the road.

4. **Gyratory Controlled QC/QA Mix Design Requirements and Specifications:** Unless otherwise specified in the plans, the mix design criteria shall conform to the following requirements.

## a. Consensus Virgin Mineral Aggregate Requirements:

### 1) **Crushed Particles** (SD 211)

The crushed particles shall be tested on the composite virgin mineral aggregate sample.

| Table A<br>Crushed Particles | |
|---|---|
| | Minimum two or more crushed faces (%) |
| Class Q1 | 50 |
| Class Q2 | 65 |
| Class Q3 | 75 |
| Class Q4 | 90 |
| Class Q5 | 100 |

### 2) **Fine Aggregate Angularity** (SD 217)

| Table B - Fine Aggregate Angularity | |
|---|---|
| | Minimum Uncompacted Void Content (%) |
| Class Q1 | 40.0 |
| Class Q2 | 41.5 |
| Class Q3 | 43.0 |
| Class Q4 | 44.0 |
| Class Q5 | 45.0 |

### 3) **Flat and Elongated Particles** (SD 212)

The maximum amount of flat and elongated particles for the coarse aggregate shall not exceed the limits shown in Table C. Flat and elongated particles are defined where the ratio of maximum to minimum dimension is greater than 5:1. The aggregate tested shall be the composite virgin aggregate material that is retained on a #4 sieve

| Table C – Flat and Elongated Particles | |
|---|---|
| | Maximum Flat and Elongated Particles (%)*1 |
| Class Q1 | No Limit |
| Class Q2 | 10 |
| Class Q3 | 10 |
| Class Q4 | 10 |
| Class Q5 | 10 |

*1 evaluated for specification at mix design only

4) **Sand Equivalent** (SD 221)

| Table D - Sand Equivalent | |
|---|---|
| | Sand Equivalent Minimum (%) |
| Class Q1 | 40 |
| Class Q2 | 42 |
| Class Q3 | 45 |
| Class Q4 | 50 |
| Class Q5 | 60 |

**b. Source Virgin Mineral Aggregate Requirements:**

**1) Source Virgin Mineral Aggregate Requirements**

| Table E - Source Mineral Aggregate Requirements | | | | | |
|---|---|---|---|---|---|
| | Light Weight Particles (SD 208 & SD 214) | | Sodium Sulfate Soundness (SD 220; 5 cycles) | | Los Angeles Abrasion Loss (SD 204) |
| | +#4 | -#4 | +#4 | -#4 | |
| Class Q1 | 4.5% maximum | 4.5% maximum | 15% maximum | 15% maximum | 45% maximum |
| Class Q2 | 3.0% maximum | 3.0% maximum | 15% maximum | 15% maximum | 45% maximum |
| Class Q3 | 3.0% maximum | 3.0% maximum | 15% maximum | 15% maximum | 40% maximum |
| Class Q4 | 1.0% maximum | 1.0% maximum | 12% maximum | 12% maximum | 35% maximum |
| Class Q5 | 0.5% maximum | 0.5% maximum | 12% maximum | 12% maximum | 35% maximum |

2) **Gyratory Controlled QC/QA Gradation** (Sieve Analysis; SD 202) Virgin mineral aggregate gradations, at mix design, must be within the control points for the designated aggregate size of the table below.

| Table F - Gyratory Controlled QC/QA Gradation*[1] | | |
|---|---|---|
| | Control Points (percent passing) | |
| Sieve Size | Min. | Max. |
| 3/4 inch | 100 | |
| 1/2 inch | 90 | 100 |
| 3/8 inch | | 85 |
| #8 | 30 | 55 |
| #200 | 2.0 | 7.0 |

*[1] the gradation sample shall not include hydrated lime.

**c. Mixture Requirements:**

**1) Gyratory Compactive Effort**

The mixture shall be compacted in accordance with SD 318. The number of gyrations and densification criteria are in listed in Tables G and H.

**Table G - Gyratory Compactive Effort**

| | $N_{initial}$ | $N_{design}$ | $N_{maximum}$ |
|---|---|---|---|
| Class Q1 | 6 | 40 | 65 |
| Class Q2 | 6 | 50 | 75 |
| Class Q3 | 6 | 60 | 85 |
| Class Q4 | 7 | 70 | 95 |
| Class Q5 | 7 | 80 | 110 |

**2) Mixture Densification Criteria**

**Table H – Target Mixture Densification Criteria**

| | Percent of Mixture Maximum Specific Gravity ($G_{mm}$) | |
|---|---|---|
| | $N_{design}$ | $N_{maximum}$*1 |
| Class Q1 | 96.0 | ≤98.0 |
| Class Q2 | 96.0 | ≤98.0 |
| Class Q3 | 96.0 | ≤98.0 |
| Class Q4 | 96.0 | ≤98.0 |
| Class Q5 | 96.0 | ≤98.0 |

*1 $N_{maximum}$ evaluated for specification at mix design only

**3) Voids in Mineral Aggregate Criteria (VMA)**

VMA is calculated from the mixture bulk specific gravity at $N_{design}$ gyrations.

**Table I - Voids in Mineral Aggregate Criteria**

| Nominal Maximum Aggregate Size | Minimum VMA, %*1 |
|---|---|
| Class Q1 | 14.5 |
| Class Q2 | 14.5 |
| Class Q3 | 14.5 |
| Class Q4 | 14.5 |
| Class Q5 | 14.5 |

*1 the minimum VMA% required for hot mix during production shall be 13.5%

**4) Voids Filled with Asphalt (VFA)**

VFA is calculated from the mixture bulk specific gravity at $N_{design}$ gyrations.

**Table J - Voids Filled with Asphalt Criteria**

| | VFA*1, % |
|---|---|
| Class Q1 | 70-80 |
| Class Q2 | 65-80 |
| Class Q3 | 65-78 |
| Class Q4 | 65-78 |
| Class Q5 | 65-75 |

*1 evaluated for specification at mix design only

**5) Dust to Binder Ratio**
The dust to binder ratio shall be 0.6 to 1.4 The dust to binder ratio is calculated as the percent by mass of the total material passing the #200 sieve (including hydrated lime) divided by the effective asphalt binder content (expressed as percent by mass of mix). If the aggregate gradation percent passing the #8 sieve is less than 39% at mix design, the dust to binder ratio shall be increased to 0.8 to 1.6.

**6) Moisture Sensitivity** (SD 309)
The minimum retained tensile strength ratio for the mixture is 80%. The moisture sensitivity requirement will be waived if 1.00% hydrated lime is added to the mix. Hydrated lime will not be required, or can be added at a rate lower than 1.00% if the moisture sensitivity requirement is met. If lime is used, a minimum of 0.50% hydrated lime shall be added to the mix. Liquid anti-stripping additives will not be allowed in lieu of hydrated lime. An item will be included in the contract for hydrated lime. Payment for hydrated lime will only be made when hydrated lime is actually used. Moisture sensitivity will only be evaluated during the mix design process.

**7) Asphalt Pavement Analyzer:** (AASHTO T 340)
Samples shall be compacted at the $N_{design}$ gyratory level at the Contractor selected binder content and tested at the PG binder high temperature. Field samples will be tested at the binder and air void content of the selected field gyratory samples or as made at the $N_{design}$ gyratory level from a sample of field produced mix.

| **Table K - Asphalt Pavement Analyzer Criteria** | |
|---|---|
| | APA, Maximum Rutting (mm) |
| Class Q1 | 8 |
| Class Q2 | 7 |
| Class Q3 | 6 |
| Class Q4 | 5 |
| Class Q5 | 5 |

**8) Moisture Content of Mix**
The maximum moisture in the field produced mix shall be 0.3%. The mix shall be sampled from the windrow in front of the laydown machine and placed in an airtight tared container. The mix shall be dried to a constant mass as described in SD 305.

**5. Quality Control Testing:**

**a. Calibration Testing:**

**1) Cold Feed:** Prior to production of asphalt concrete, the QC and QA certified technicians shall 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 shall meet the requirements of the mix design report and shall conform to the tolerances shown in the Department's Materials Manual. The split companion calibration testing shall continue until the results meet the requirements of the mix design report and are within the listed tolerances. The split companion calibration testing shall be performed on each mix type produced prior to production of that mix type.

2) **Mixture Testing:** The QC and the QA technicians shall perform correlation testing on a reheated prebuilt split companion sample (from the mix design process) supplied by the Contractor. The correlation testing will be for the theoretical maximum specific gravity (Rice Method) and gyratory bulk specific gravities.

Two gyratory compaction samples shall be made using a compactive effort of $N_{design}$. The bulk specific gravity shall than be measured on specimens compacted to $N_{design}$ gyrations. Air voids shall be calculated using the theoretical maximum specific gravity and bulk specific gravity at $N_{design}$ gyrations. The percent of theoretical maximum specific gravity densification shall be determined at $N_{design}$. The results shall be within the tolerances shown in the Department's Materials Manual.

3) **Bulk Specific Gravity Reheat Correlation:** The QC and the QA technicians shall perform a reheat correlation test for the bulk specific gravity. The reheat correlation test shall be performed on a split sample of a sublot from within the first lot of production for the mix design. An additional reheat correlation test shall be performed on a split sample of a sublot from within the first lot of production for any new mix designs.

Cool a split portion of the sample down to room temperature. After the split sample has cooled, reheat and compact according to SD 318. Calculate the difference in the bulk specific gravities of the non-reheated and reheated tests. The average difference using the QC and QA technician's test results will be the correction factor for a reheated bulk specific gravity. This test may be repeated at the discretion of the Contractor or the Engineer.

b. **Asphalt Concrete Quality Control (Production) Testing:** After the calibration cold feed and mixture testing is completed and the results are within the specified tolerances, the Contractor will be allowed to begin production of asphalt concrete.

The Engineer shall randomly determine all sample locations. Sampling and splitting not performed by the Engineer shall be witnessed by the Engineer. To ensure that a representative random sample is obtained, the QC sample locations shall only be given to the Contractor immediately prior to sampling. The hot mix sample shall be obtained before the cold feed gradation sample. If hydrated lime is used in the mix, the hydrated lime shall be momentarily shut off while obtaining the cold feed gradation sample. If hydrated lime is to be included in the mix, care shall be taken to ensure that the hot mix sample is obtained with hydrated lime included in the sample. There will be a 200 ton buffer between the random sample locations. The intent of the buffer is to prevent back-to-back sampling and to more evenly distribute the sampling and testing workload.

A lot shall consist of five sublots. Sublots shall not represent more than 1000 tons of asphalt concrete unless the current sublot is terminated.

The Contractor shall obtain QC samples at the specified locations for four of the five sublots. The Engineer will sample and split a minimum of one of the five sublots, and witness all QC sampling. The Contractor shall test all five sublot samples (a split of the one sublot sampled by the Engineer and four sublot samples taken by the Contractor). The material shall be sampled, split, and tested by the methods and procedures described in the Department's Materials Manual.

The aggregate and hot mix samples shall be large enough to obtain 4 splits of the minimum sample size needed for testing. If the sample is to be used for IA testing, the samples shall be large enough to obtain 6 splits of the minimum size needed for testing. Immediately after splitting, the QA technician shall take possession of half of the sample for all of the QC samples. The QA technician shall ensure the Department's portion of the backup samples for all QC and QA tests are properly labeled, stored, and retained until the Department's Bituminous Engineer has completed the F-test and t-test statistical evaluation. The QC technician shall retain their backup split until the QC, QA, and IA technicians have obtained their test results for the individual lot and have found the results to be within the allowable tolerances in the Department's Materials Manual, SD 317, and the Engineer has approved the disposal of the backup samples.

The Engineer will determine and mark the core locations after the mix is placed and compacted. The cores will be taken the next working day after the asphalt pavement is placed. The Contractor shall perform the coring under observation by the Engineer. The Engineer will take immediate possession of the core samples for density testing. The Contractor shall fill all core holes before the end of the next working day with hot asphalt concrete and compact the mix to a density close to that of the surrounding pavement.

Core samples for density will be tested by the Engineer.

The QC technician shall complete all of the required tests on the samples selected for QA or IA testing.

**c. Specification Control Limits:** The control limits of materials being produced will be evaluated under two different categories, pay factor attributes and non-pay factor attributes.

1) **Pay Factor Attributes:** Air voids and in place density (compaction) are the two pay factor attributes. These attributes will be statistically analyzed for contract unit price adjustment.

The percent air voids shall meet the requirement in Table L and the in place density of the asphalt concrete when expressed as a percent of the lot average maximum specific gravity (Rice Method) shall meet the requirements in Table L.

| **TABLE L - PAY FACTOR ATTRIBUTES** | | | |
|---|---|---|---|
| a. | % Air Voids | 4.0% ± 1.0% | |
| b. | In Place Density (% Compaction) | Class Q1 | 92.0% to 96.0% |
| | | Class Q2 | 92.0% to 96.0% |
| | | Class Q3 | 92.0% to 96.0% |
| | | Class Q4 | 92.0% to 96.0% |
| | | Class Q5 | 92.0% to 96.0% |

When field test results for air voids or in place density deviate from the job mix formula values, the Contractor may adjust the gradation, asphalt binder content, or both within the allowable tolerances shown for items a, b, c, and d shown in Table N. Bin splits may be adjusted up to ± 5% from the job mix formula bin splits. Adjustments shall be made as a result of an interactive process between the Contractor and the Engineer. The Contractor's recommendations shall prevail, provided all specifications and established mix design criteria are being met.

If new materials are to be incorporated into the asphalt concrete or bin split percentages are adjusted by more than 5% from the job mix formula, a new mix design will be required by the Contractor (unless otherwise approved by the Bituminous Engineer) with verification by the Department's Bituminous Mix Design Lab. The Contractor shall be responsible to verify that all mix design criteria are being met prior to written job mix formula approval.

When a new mix design and job mix formula is required, the current sublot shall be terminated and incorporated into the previous sublot for pay factor analysis. A new lot will be started when production is changed to the new job mix formula. At the end of production, the current sublot shall be terminated and incorporated into the previous sublot unless the hot mix sample and both core sample locations have been obtained and tested for the current sublot.

2) **Non-Pay Factor Attributes:** There are several requirements not used in the determination of the pay factor that are very important to the performance of the asphalt concrete. The below listed attributes are tested at the frequency listed in the Department's Materials Manual. The attributes shall be maintained within the requirements in Section 322.3 B.4 or as otherwise specified.

| Table M – Non-Pay Factor Attributes |
|---|
| Virgin Mineral Aggregate Gradation |
| Asphalt Binder Content |
| Hydrated Lime Content |
| Moisture Content of Mix |
| Sand Equivalent |
| Lightweight Particles |
| Crushed Particles |
| Fine Aggregate Angularity |
| Voids in Mineral Aggregate (VMA) |
| Dust to Binder Ratio |
| RAP Content (if used) |

The asphalt binder and hydrated lime content are not statistically evaluated as pay factor attributes, but may be price adjusted (DOT-18) for failure to conform to specification requirements.

The VMA and dust to binder ratio are calculated using the asphalt binder percentage determined from the daily cutoff from that day's production. The bulk specific gravity of the mineral aggregate will be determined by the Department's Materials & Surfacing Central Laboratory during the mix design verification.

When RAP is required, the VMA will be calculated using the bulk specific gravity of the mixture, the percent stone of the mixture, and the bulk specific gravity of the aggregate as determined by the Department's Materials & Surfacing Central Laboratory during the mix design verification, all including RAP. When RAP is required, the Dust to Binder Ratio will be calculated using the percent -#200 material from the virgin aggregate, the percent hydrated lime, and the effective binder content of the total mixture including RAP.

The bulk specific gravity of the mineral aggregate may be tested during production at the discretion of the Contractor or the Engineer. A split portion of material shall be given to the other entity for verification.

If the VMA or dust to binder ratio value does not meet the requirements in Section 322.3 B.4, the Contractor shall make corrective actions before production continues and document the corrective actions taken. If three out of any five consecutive tests for VMA or dust to binder ratio exceed the criteria in Section 322.3 B.4, the Contractor shall immediately cease operations. A new mix design will be required by the Contractor (unless otherwise approved by the Department's Bituminous Engineer) with verification by the Department's Bituminous Mix Design Lab prior to resuming production. The Contractor shall be responsible to verify that all mix design criteria are being met.

| TABLE N – JOB MIX FORMULA TOLERANCES | | |
|---|---|---|
| Attribute | | Tolerance from Target Value |
| a. | Sieve 5/8" thru 3/8” | ± 7 |
| b. | Sieve #4 thru #50 | ± 5 |
| c. | Sieve #100 thru #200 | ± 2.0 |
| d. | Percent Asphalt Binder | ± 0.3 |
| e. | Sand Equivalent*[1] | Minimum or more |
| f. | Percent Lightweight Particles*[1] | Maximum or less |
| g. | Fine Aggregate Angularity*[1] | Minimum or more |
| h. | Crushed Particles*[1] | Minimum or more |
| j. | Percent Hydrated Lime | ± 0.10 |
| k. | Asphalt Application Temperature | ± 20°F |
| l. | Temp. of Mixture when emptied from the mixer | ± 20°F |
| m. | Temp. of Mixture on delivery to the road | -20°F & + 30 °F |
| n. | Percent RAP Content (if used) | ± 5 |

*[1] These properties are not listed on the job mix formula but will be tested for compliance with the mix design specifications listed in Tables A-E.

If two out of any five consecutive tests for the gradation requirements (Items a, b, or c) fail to meet the tolerances contained in Table N, the Contractor shall immediately cease operations. The Contractor shall investigate the cause of the variation in production. Production will not be allowed to resume until a passing cold feed sample is obtained and the Engineer has approved the corrective action.

If the asphalt binder content, hydrated lime content, or RAP content falls outside the tolerance in Table N; the Contractor shall make corrective actions before production continues and document the corrective actions taken. If two out of any five consecutive tests for the asphalt binder content, hydrated lime content, or RAP content fail to meet the tolerances contained in Table N; the corrective action shall include recalibration of the binder meter, the lime weigh and feed system, or the RAP feed system, respectively.

The maximum moisture content in the field-produced mix shall be 0.3%. If the moisture content in the mix exceeds the maximum allowed the Contractor shall make corrective actions before production continues and document the corrective actions taken. Burner adjustments, increase mix temperature, slower plant production rates, use of drier aggregates, and adjustment to the amount of time material is in drum for mixing and heating are possible corrective actions. Additional moisture content in the field-produced mix tests shall be conducted to verify that the corrective action has worked to produce specification mix.

If the sand equivalent, percent lightweight particles, fine aggregate angularity, or crushed particles (Items e, f, g, or h) for a single test fall outside the tolerances shown in Table N, the Contractor shall immediately cease operations. The Contractor shall investigate the cause of the variation in production. The Contractor will not be allowed to continue operations until a passing cold feed sample is obtained and the Engineer has approved the corrective action.

3) **Test Identification:** Number the production control sublot tests consecutively in accordance with the Department's Materials Manual starting with number "QC01" or "QC001" based on the total number of samples needed. The two density cores in a sublot shall have the same number along with an "A" or "B" designation and shall match the sublot number. The two gyratory specimens shall be numbered with the sublot number and an "A" and a "B" for the two specimens. Use "N" before the sublot number for non-pay factor material. Use "Info" before the number for information samples. Use "TS" before the sublot number for test strip samples. Use "R" after the number for remedial samples. Use "Cal" before the number for calibration samples.

4) **Control Charts:** The Contractor shall provide QC charts that include the control limits and each individual test result for the following parameters:

   **a)** Gradation of the control sieves in the Job Mix Formula
   **b)** Asphalt Binder Content
   **c)** Hydrated Lime Content
   **d)** Maximum Specific Gravity (Rice)
   **e)** Bulk Specific Gravity (Gyratory)
   **f)** Air voids
   **g)** In place density
   **h)** VMA
   **i)** Dust to Binder Ratio

   QC test results shall be recorded on the control charts immediately after completion of the test. The control charts shall also include the QA and Independent Assurance test results. The control charts shall be prominently displayed and accessible to the Engineer. The control charts shall be given to the Engineer upon completion of the project.

5) **Documentation:** The Contractor is responsible for documenting all observations, inspection records, mixture adjustments, test results, and corrective actions on a daily basis. The Contractor shall also record and maintain a plant record of plant starts and stops, mix temperatures leaving the plant, bin split of aggregates, and the temperature of the asphalt binder going into the mix.

   Field observations and inspections shall be noted as they occur in a permanent duplicating field book or diary, provided by the Engineer. The roadway diaries shall include hours paved, equipment in use, stations paved, course depth, width, crown, spread checks, tonnage, weather, and temperature of mixture delivered to the road. Plant diaries shall include plant start and shutdown times, mix temperature of material produced, binder spot checks, aggregate bin splits being used, actual calculated asphalt binder percentage for the day, tons of mix produced, mixture or aggregate adjustments, weather conditions, and any other pertinent information.

The Engineer will collect copies of documentation records and recorded mix temperature charts daily. All records shall be made available at all times upon request by the Engineer. The test results and original work sheets, including all gyratory specimen compaction sheets, for the production control testing listed in Table M shall be given to the Engineer upon completion of the test.

**C. Quality Assurance:** The Engineer will randomly sample and test a minimum of one sublot for each lot. The Engineer may test any or all of the splits of the QC sublot samples as part of the QA program. The Engineer will provide at least one individual certified in Asphalt Concrete Aggregate Testing and Asphalt Concrete Hot Mix Testing for conducting the QA testing and at least one individual certified in Asphalt Concrete Roadway Inspection for roadway inspection.

The QA technician will complete all of the required tests on the samples that are selected for QA testing.

The services of contractor's personnel to assist in obtaining the QA samples should be limited only to instances when hazardous conditions or liability issues exists that dictate their involvement and the following requirements are met:

1. The QA sample location or time is only given to the contractor immediately prior to sampling.
2. The contractor's personnel are used only to provide labor to assist in physically obtaining the QA sample.
3. The Engineer is present to witness the taking of the QA sample.
4. The Engineer witnessing the sampling and the contractor labor performing the sampling are certified in accordance with the Department's Certification program.
5. The Engineer immediately takes possession of the QA sample.

QA test results will be made available to the Contractor within 24 hours, or the next working day.

The split sample test results (QA) of the sample taken by the Engineer will be compared to the Contractor test results (QC) for conformance with the Department's Materials Manual. Populations of the QC sample test results will be compared to the QA sample test results utilizing the procedures shown in SD 317. If the test results are within the allowable tolerances, found to be similar, and found to represent the same population, as determined by F-test and t-test statistical evaluation procedures conducted by the Bituminous Engineer, the Contract unit price adjustments will be based on the Contractor QC test results.

Sampling and splitting not required to be performed by the Engineer will be witnessed by the Engineer.

The Engineer will test the core samples for density.

The Engineer will perform or witness the measurement of the depth of the asphalt binder in the storage tanks as described in SD 314. The Engineer will determine the temperature of the asphalt binder in the tank and will perform the daily calculation of the asphalt binder content.

The Engineer will perform the daily calculation of the hydrated lime content.

The Engineer will test the moisture content of the hot mix. The mix for the moisture test shall be sampled from the windrow in front of the laydown machine and placed in an airtight, tared container. The mix shall be dried to a constant mass as described in SD 305.

**D. Independent Assurance Procedures:** The Department will perform Independent Assurance (IA) testing on project produced materials. Random samples of mineral aggregate and hot mix asphalt concrete used for QC testing will be selected by the Region Materials Engineer for IA testing.

The Region Materials Engineer will perform IA testing for the attributes listed in the Department's Materials Manual. The tolerances from the Department's Materials Manual will be used to independently evaluate the QC and QA testing procedures and equipment. The Region Materials Engineer shall witness the sampling and splitting of the designated IA sample (an actual sublot sample). The Region Materials Engineer may select either Engineer or Contractor sampled sublot for the IA testing.

The Region Materials Engineer will also perform IA testing for the bulk specific gravity on in place density cores. A separate IA core shall be obtained by the Contractor while obtaining the in place density core used to determine the pay factor. The IA core shall be taken at the same offset and within one foot of the core used in determining the pay factor.

**E. Dispute Resolution System:** Process verification procedures using F-test and t-test statistical evaluation procedures to determine if both QC and QA test results represent the same sample population may result in the need for testing backup sublot samples and substituting the new test result for pay factor calculations. If the QC and QA test results do represent the same population, as determined by F-test and t-test statistical evaluation procedures, the Contractor's test results may be used for quality acceptance.

## 322.4 METHOD OF MEASUREMENT AND ACCEPTANCE

The method of measurement shall be as prescribed in Section 320.4 except the method of measurement for QA and QC field laboratories and the method of measurement and acceptance for asphalt concrete will be made according to the following:

A. **Asphalt Concrete:** The asphalt concrete shall be statistically accepted by lots. A lot shall consist of five sublots. Sublots shall not represent more than 1000 tons unless the current sublot is terminated. The first lot shall start at the beginning of production or following the Control Test Strip.

A lot will be terminated when a new mix design is completed and a new job mix formula is issued. If less than five sublots have been completed when a lot is terminated, the sublots will be included in the previous lot, and the pay factor computed for the revised lot. If there is no previous lot, the lot will not be terminated until five sublots are obtained.

1. **Determination of Contract Unit Price Adjustment:** Asphalt concrete that is not compacted according to the Specified Density Method will not be included in the pay factor calculations but may be price adjusted (DOT-18) for failure to conform to specification requirements. The material specified to be sampled and tested on a QC/QA basis will be evaluated for payment under this subsection. All QC test results for a lot will be analyzed collectively and statistically by the Quality Level Analysis-Standard Deviation Method using the procedures herein defined. The lots will be analyzed to determine the total estimated percent of the lot that is within the specification limits.

   Quality Level Analysis (specification conformance analysis) is a statistical procedure for estimating the percent of material that is within the specification limits (PWL). The PWL is determined by using the lot mean, ( $\overline{X}$ ) and the lot standard deviation(s). Two measures of quality are required to establish the contract unit price adjustment. The first measure is the Acceptable Quality Level (AQL) which is the PWL at which the lot will receive 100% pay or a composite pay factor of 1.00. The second measure of quality is the Rejectable Quality Level (RQL) at which the Engineer has determined the material may not perform as desired and may be rejected.

   The AQL has been selected at 90 PWL and the RQL at 60 PWL. The RQL using the pay factor equation will result in 85% pay or a pay factor of 0.85.

   An individual pay factor for any attribute resulting in less than 85% pay may result in the lot being rejected.

   When the Acceptable Quality Level of any individual pay factor attribute has a QL of 90 or less the composite pay factor shall not exceed 1.00.

   A lot may be accepted provided the composite pay factor is at least 0.85 and there are no isolated defects identified by the Engineer.

   A lot containing material with less than a 0.85 composite pay factor may be rejected. All of the rejected material shall be removed from the work. The Engineer will determine if the material may remain in place at a reduced price. A lot containing material with less than a 0.85 composite pay factor may not be overlaid prior to the Engineer determining the acceptability of the lot.

   The Engineer may reject any quantity of material that appears to be defective based on visual inspection or test results. The visual rejection may include segregation, low temperature material, very high or low asphalt content, etc. Such rejected material shall not be used in the work or included with the lot acceptance tests. Rejected material will not be measured for payment.

The Contractor may elect to remove any defective material and replace it with new material to avoid a pay factor less than 1.00. Any such new material will be sampled, tested, and evaluated for acceptance according to this specification.

2. **Quality Level Analysis:** The standard deviation method procedures are as follows:

   **a.** Only test results on material incorporated in the work will be included in the quality level analysis.

   **b.** Calculate the arithmetic mean ($\overline{X}$) of the test values:

$$\overline{X} = \frac{\Sigma x}{n}$$

   Where:
   $\Sigma$ = summation of
   x = individual test value to $x_n$
   n = total number of test values

   **c.** Calculate the sample standard deviation(s):

$$S = \sqrt{\frac{n\Sigma(x^2) - (\Sigma x)^2}{n(n-1)}}$$

   Where:
   $\Sigma(x^2)$ = summation of the squares of individual test values.
   $(\Sigma x)^2$ = summation of the individual test values squared.

   **d.** Calculate the upper quality index ($Q_U$):

$$Q_U = \frac{USL - \overline{X}}{s}$$

   Where: USL = upper specification limit or target value (TV) plus allowable deviation.
   Target Value = the single specification value which would result in an ideal product.

   **e.** Calculate the lower quality index ($Q_L$):

$$Q_L = \frac{\overline{X} - LSL}{s}$$

Where: LSL = lower specification limit or target value minus allowable deviation.

**f.** Determine $P_U$ (percent within the upper specification limit which corresponds to a given $Q_U$) from Table P.

Note: If a USL is not specified, $P_U$ will be 100.

**g.** Determine $P_L$ (percent within the lower specification limit which corresponds to a given $Q_L$) from Table P.

Note: If an LSL is not specified, $P_L$ will be 100.

**h.** Determine the Quality Level (the total percent within specification limits).

Quality Level (QL) = $(P_U + P_L) - 100$

**i.** To determine the pay factor for each individual attribute (PF) = 55 + 0.5(QL).

**j.** Determine the Composite Pay Factor (CPF) for each lot. The third decimal place of the CPF shall be rounded to the nearest hundredth by the computer program.

$$CPF = \frac{[f_1(PF_1) + f_2(PF_2)]}{(100)\ \Sigma f}$$

f = 1 to 2

Where: $f_{1\text{ or }2}$ = price adjustment factor listed in Table O for each measured attribute.

$PF_{1\text{ or }2}$ = Pay Factor for each measured attribute.

$\Sigma f$ = Sum of the "f" (price adjustment) factors.

The asphalt concrete pavement contract unit price will be adjusted according to Section 322.4. Payment for the asphalt concrete will be made at a price determined by multiplying the contract unit price by the composite pay factor. The following table will be used to calculate the composite pay factor:

| Table O - Pay Attributes & Price Adjustment Factors | |
|---|---|
| **Measured Attribute** | **Factor "f"** |
| Design Air Voids | 50 |
| In Place Density (% Compaction) | 50 |

All mineral aggregate testing prior to production and QC/QA testing shall be incidental to the contract unit price per ton for asphalt concrete.

Asphalt concrete will be measured to the nearest 0.1 ton. The mixture of mineral aggregate and asphalt will be weighed after mixing. No deduction will be made for the weight of the asphalt included in the mixture.

Deduction will not be made for material removed from temporary approaches. Deductions will be made for all rejected and wasted asphalt concrete pavement.

B. **QA and QC Field Laboratories:** There will be no measurement or payment for the QC laboratory furnished and used by the Contractor to perform the QC testing. The Contractor furnished QA laboratory will be measured in accordance with Section 600.4.

## 322.5 BASIS OF PAYMENT

The basis of payment shall be as prescribed in Section 320.5 except the basis of payment for asphalt binder, asphalt concrete, and QA and QC field laboratories will be made according to the following:

**A.** **Asphalt Binder:** The accepted quantities of asphalt binder will be paid for at the contract unit price per ton. The amount bid for this item shall be at least the cost of the asphalt binder furnished and delivered to the project site.

Payment for the asphalt binder is not subject to the statistical pay factor adjustment.

**B.** **Asphalt Concrete:** The accepted quantities of asphalt concrete, will be paid for at the contract unit price as adjusted by the pay factor calculations in Section 322.4 of this specification per ton complete and accepted in place.

Asphalt concrete that is not compacted according to the Specified Density Method will not be included in the pay factor calculations. Asphalt concrete that is not included in the pay factor calculations shall be paid for at the contract unit price per ton.

The contract unit price of asphalt concrete shall include all cost for labor, equipment, materials, testing, and all incidentals required to furnish and place the asphalt concrete mix according to these specifications.

**C. Laboratories:**

1. **QC Laboratory:** The laboratory used by the Contractor for QC testing shall be incidental to the asphalt concrete pavement item(s).

2. **QA Laboratory:** Payment for the QA laboratory will be according to Section 600.5 of the Standard Specifications.

## TABLE P - QUALITY LEVELS
## QUALITY LEVEL ANALYSIS BY STANDARD DEVIATION METHOD

| $P_u$ or $P_l$ Percent Within Limits for Positive Values Of $Q_u$ or $Q_l$ | UPPER QUALITY INDEX $Q_U$ OR LOWER QUALITY INDEX $Q_L$ | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | n=3 | n=4 | n=5 | n=6 | n=7 | n=8 | n=9 | n=10 to n=11 | n=12 to n=14 | n=15 to n=18 | n=19 to n=25 | n=26 to n=37 | n=38 to n=69 | n=70 to n=200 | n=201 to n=∞ |
| 100 | 1.16 | 1.50 | 1.79 | 2.03 | 2.23 | 2.39 | 2.53 | 2.65 | 2.83 | 3.03 | 3.20 | 3.38 | 3.54 | 3.70 | 3.83 |
| 99 | | 1.47 | 1.67 | 1.80 | 1.89 | 1.95 | 2.00 | 2.04 | 2.09 | 2.14 | 2.18 | 2.22 | 2.26 | 2.29 | 2.31 |
| 98 | 1.15 | 1.44 | 1.60 | 1.70 | 1.76 | 1.81 | 1.84 | 1.86 | 1.91 | 1.93 | 1.96 | 1.99 | 2.01 | 2.03 | 2.05 |
| 97 | | 1.41 | 1.54 | 1.62 | 1.67 | 1.70 | 1.72 | 1.74 | 1.77 | 1.79 | 1.81 | 1.83 | 1.85 | 1.86 | 1.87 |
| 96 | 1.14 | 1.38 | 1.49 | 1.55 | 1.59 | 1.61 | 1.63 | 1.65 | 1.67 | 1.68 | 1.70 | 1.71 | 1.73 | 1.74 | 1.75 |
| 95 | | 1.35 | 1.44 | 1.49 | 1.52 | 1.54 | 1.55 | 1.56 | 1.58 | 1.59 | 1.61 | 1.62 | 1.63 | 1.63 | 1.64 |
| 94 | 1.13 | 1.32 | 1.39 | 1.43 | 1.46 | 1.47 | 1.48 | 1.49 | 1.50 | 1.51 | 1.52 | 1.53 | 1.54 | 1.55 | 1.55 |
| 93 | | 1.29 | 1.35 | 1.38 | 1.40 | 1.41 | 1.42 | 1.43 | 1.44 | 1.44 | 1.45 | 1.46 | 1.46 | 1.47 | 1.47 |
| 92 | 1.12 | 1.26 | 1.31 | 1.33 | 1.35 | 1.36 | 1.36 | 1.37 | 1.37 | 1.38 | 1.39 | 1.39 | 1.40 | 1.40 | 1.40 |
| 91 | 1.11 | 1.23 | 1.27 | 1.29 | 1.30 | 1.30 | 1.31 | 1.31 | 1.32 | 1.32 | 1.33 | 1.33 | 1.33 | 1.34 | 1.34 |
| 90 | 1.10 | 1.20 | 1.23 | 1.24 | 1.25 | 1.25 | 1.26 | 1.26 | 1.26 | 1.27 | 1.27 | 1.27 | 1.28 | 1.28 | 1.28 |
| 89 | 1.09 | 1.17 | 1.19 | 1.20 | 1.20 | 1.21 | 1.21 | 1.21 | 1.21 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.23 |
| 88 | 1.07 | 1.14 | 1.15 | 1.16 | 1.16 | 1.16 | 1.16 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 |
| 87 | 1.06 | 1.11 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.13 | 1.13 |
| 86 | 1.04 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 |
| 85 | 1.03 | 1.05 | 1.05 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 |
| 84 | 1.01 | 1.02 | 1.01 | 1.01 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 |
| 83 | 1.00 | 0.99 | 0.98 | 0.97 | 0.97 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 |
| 82 | 0.97 | 0.96 | 0.95 | 0.94 | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| 81 | 0.96 | 0.93 | 0.91 | 0.90 | 0.90 | 0.89 | 0.89 | 0.89 | 0.89 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 |
| 80 | 0.93 | 0.90 | 0.88 | 0.87 | 0.86 | 0.86 | 0.86 | 0.85 | 0.85 | 0.85 | 0.85 | 0.84 | 0.84 | 0.84 | 0.84 |
| 79 | 0.91 | 0.87 | 0.85 | 0.84 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| 78 | 0.89 | 0.84 | 0.82 | 0.80 | 0.80 | 0.79 | 0.79 | 0.79 | 0.78 | 0.78 | 0.78 | 0.78 | 0.77 | 0.77 | 0.77 |
| 77 | 0.87 | 0.81 | 0.78 | 0.77 | 0.76 | 0.76 | 0.76 | 0.75 | 0.75 | 0.75 | 0.75 | 0.74 | 0.74 | 0.74 | 0.74 |
| 76 | 0.84 | 0.78 | 0.75 | 0.74 | 0.73 | 0.73 | 0.72 | 0.72 | 0.72 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 |
| 75 | 0.82 | 0.75 | 0.72 | 0.71 | 0.70 | 0.70 | 0.69 | 0.69 | 0.69 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.67 |
| 74 | 0.79 | 0.72 | 0.69 | 0.68 | 0.67 | 0.66 | 0.66 | 0.66 | 0.66 | 0.65 | 0.65 | 0.65 | 0.65 | 0.64 | 0.64 |
| 73 | 0.76 | 0.69 | 0.66 | 0.65 | 0.64 | 0.63 | 0.63 | 0.63 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.61 | 0.61 |
| 72 | 0.74 | 0.66 | 0.63 | 0.62 | 0.61 | 0.60 | 0.60 | 0.60 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.58 | 0.58 |
| 71 | 0.71 | 0.63 | 0.60 | 0.59 | 0.58 | 0.57 | 0.57 | 0.57 | 0.57 | 0.56 | 0.56 | 0.56 | 0.56 | 0.55 | 0.55 |
| 70 | 0.68 | 0.60 | 0.57 | 0.56 | 0.55 | 0.55 | 0.54 | 0.54 | 0.54 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.52 |
| 69 | 0.65 | 0.57 | 0.54 | 0.53 | 0.52 | 0.52 | 0.51 | 0.51 | 0.51 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| 68 | 0.62 | 0.54 | 0.51 | 0.50 | 0.49 | 0.49 | 0.48 | 0.48 | 0.48 | 0.48 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 |
| 67 | 0.59 | 0.51 | 0.47 | 0.47 | 0.46 | 0.46 | 0.46 | 0.45 | 0.45 | 0.45 | 0.45 | 0.44 | 0.44 | 0.44 | 0.44 |
| 66 | 0.56 | 0.48 | 0.45 | 0.44 | 0.44 | 0.43 | 0.43 | 0.43 | 0.42 | 0.42 | 0.42 | 0.42 | 0.41 | 0.41 | 0.41 |
| 65 | 0.52 | 0.45 | 0.43 | 0.41 | 0.41 | 0.40 | 0.40 | 0.40 | 0.40 | 0.39 | 0.39 | 0.39 | 0.39 | 0.39 | 0.39 |
| 64 | 0.49 | 0.42 | 0.40 | 0.39 | 0.38 | 0.38 | 0.37 | 0.37 | 0.37 | 0.37 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| 63 | 0.46 | 0.39 | 0.37 | 0.36 | 0.35 | 0.35 | 0.35 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.33 | 0.33 | 0.33 |
| 62 | 0.43 | 0.36 | 0.34 | 0.33 | 0.32 | 0.32 | 0.32 | 0.32 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
| 61 | 0.39 | 0.33 | 0.31 | 0.30 | 0.30 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 |
| 60 | 0.36 | 0.30 | 0.28 | 0.27 | 0.27 | 0.27 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.25 | 0.25 |
| 59 | 0.32 | 0.27 | 0.25 | 0.25 | 0.24 | 0.24 | 0.24 | 0.24 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 |
| 58 | 0.29 | 0.24 | 0.23 | 0.22 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| 57 | 0.25 | 0.21 | 0.20 | 0.19 | 0.19 | 0.19 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| 56 | 0.22 | 0.18 | 0.17 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| 55 | 0.18 | 0.15 | 0.14 | 0.14 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| 54 | 0.14 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| 53 | 0.11 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| 52 | 0.07 | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| 51 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 |
| 50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

NOTE: For negative values of $Q_U$ or $Q_L$, $P_U$ or $P_L$ is equal to 100 minus the table $P_U$ or $P_L$. If the value of $Q_U$ or $Q_L$ does not correspond exactly to a figure in the table, use the next higher value.

# STATE OF SOUTH DAKOTA
# DEPARTMENT OF TRANSPORTATION

## SUPPLEMENTAL SPECIFICATIONS TO
## 2015 STANDARD SPECIFICATIONS FOR ROADS AND BRIDGES

## SEPTEMBER 7, 2022*

***NOTE:** This is only an excerpt from the Supplemental Specifications.*
***(Check the DOT website for the most current version of Supplemental Specifications)***

All items included in this Supplemental Specification will govern over the Supplemental Specifications for Errata.

### MAKE THE FOLLOWING CHANGES TO THE INDICATED SECTIONS:

**Section 320.2 E – Page 126 – Delete the 1st sentence and replace with the following:**

An additive is any material added to a bituminous mixture or material including, but not limited to; mineral filler, warm mix asphalt additives, and similar products without a specific pay item.

**Section 320.3 E – Page 133 – Delete the 2nd paragraph and replace with the following:**

The Contractor will cover the loads with a tarp during inclement weather conditions and when ordered by the Engineer. Tarps will be of sufficient condition to protect the load from infiltration by rain, snow, dust, and other foreign matter and to slow the loss of heat. The Engineer, in the Engineer's sole discretion, will determine the acceptability of the condition of the tarp.

**Section 320.3 G – Page 133 – Delete the last sentence of the 1st paragraph and replace with the following:**

The tack coat will be allowed to break (turn from brown to black) and will be allowed a cure period, as determined by the Engineer, prior to asphalt concrete placement.

**Section 320.3 G – Page 133 – Delete the 7th full paragraph on page 134 and replace with the following:**

On the final surfacing lift, laydown operations may progress continuously toward or away from the plant. If the Engineer, in the Engineer's sole discretion, determines damage to the top mat is occurring, the Engineer may require laydown operations to commence from the farthest point and progress continuously toward the plant.

**Section 320.3 G – Page 133 – Delete the 3rd sentence of the 4th paragraph on page 136 and replace with the following:**

The variation of the surface from the straightedge between any two contact points will not exceed 1/4 inch.

**Section 320.3 G – Page 133 – Delete the 5th sentence of the 5th paragraph on page 136 and replace with the following:**

Ground surfaces will be flush sealed.

**Section 320.3 G.1 – Page 136 – Delete the 2nd sentence of the 1st paragraph and replace with the following:**

The lot average percent of density will be based on the maximum specific gravity of the test specimens prepared in the field in accordance with SD 312. The lot will contain no more than 2 tests below the specification, no more than 1 test 2% below the specification, and no test 3% or more below the specification.

**Section 320.5 A – Page 138 – Delete the last sentence.**

**Section 320.5 E – Page 139 – Delete the last sentence.**

**Section 321.3 C – Page 141 – Delete the 1st sentence of the 1st paragraph and replace with the following:**

The lot average minimum density requirement will be 92% of the maximum specific gravity of the test specimens prepared in the field in accordance with SD 312. The lot will contain no more than 2 tests below the specification, no more than 1 test 2% below the specification, and no test 3% or more below the specification.

**Section 322.3 B.5.c.1.) – Page 153 – Delete Table L and replace with the following:**

| **TABLE L - PAY FACTOR ATTRIBUTES** | | | |
|---|---|---|---|
| a. | % Air Voids | 4.0% ± 1.0% | |
| b. | In Place Density (% Compaction) | Class Q1 | 92.0% to 97.0% |
| | | Class Q2 | 92.0% to 97.0% |
| | | Class Q3 | 92.0% to 97.0% |
| | | Class Q4 | 92.0% to 97.0% |
| | | Class Q5 | 92.0% to 97.0% |

**Section 322.3 B.5.c.1) – Page 153 – Delete the 4th paragraph and replace with the following:**

If new materials are to be incorporated into the asphalt concrete or if any cold feed bin split percentage is adjusted by more than ±5 from the job mix formula, a new mix design will be required by the Contractor (unless waived by the Bituminous Engineer) with verification by the Department's Bituminous Mix Design Lab.

**Section 322.5 A – Page 162 – Delete the last sentence of the first paragraph.**

**Section 324.2 – Page 165 – Delete the 1st indented paragraph after the 3rd paragraph and replace with the following:**

The asphalt binder used in the mixture will be PG 64-28, PG 58-34, or PG 64-34 unless otherwise specified in the plans. In addition, PG 58-28 may be used on projects with a future truck AADT less than 250 trucks per day or projects with no mainline or turning lane paving areas. The Department will use the design designation information in the plans and following formula to calculate the future truck AADT:

Future AADT (future year) x AADT T% = Future Truck AADT

**Section 325.3 B – Page 167 – Delete the 1st sentence of the 2nd paragraph and replace with the following:**

There will be at least three steel faced tandem rollers for each paver in use.

**Section 325.3 C – Page 167 – Delete the 2nd sentence of the 2nd paragraph and replace with the following:**

Breakdown rolling, consisting of a minimum of two complete coverages with at least two self-propelled tandem smooth steel rollers, will proceed on the mat as soon as laydown is completed.

**Section 325.3 C – Page 167 – Delete the 4th sentence of the 2nd paragraph and replace with the following:**

Final or finish rolling will consist of a minimum of one complete coverage with at least one self-propelled tandem smooth steel roller.

**Section 330.3 A.3 – Page 172 – Add the following to this section:**

**c.** Fog seal application will begin after the asphalt surface treatment is cured and will not begin prior to completing final brooming. Fog seal application will be completed no later than 7 calendar days following asphalt surface treatment application.

**Section 330.3 B – Page 172 – Delete and replace with the following:**

**B. Dilution of Tack, Fog Seal, and Flush Seal:** Emulsified asphalt for tack, fog seal, and flush seal with a specified application rate of 0.07 gallons per square yard or less may be diluted.

The rate of dilution for tack will be at a ratio of at least 1 part emulsion to no more than 1 part added water (1:1 ratio minimum) by volume, unless otherwise approved by the Engineer. The rate of dilution for fog seal and flush seal will be at a ratio of not more than 3 parts emulsion to 1 part added water (3:1 ratio maximum) by volume to not less than 1 part emulsion to 1 part added water (1:1 ratio) by volume, unless otherwise approved by the Engineer.

The emulsion will be uniformly mixed by adding potable water and if necessary, agitating the mixture. The amount of emulsion and any added water will be included on the ticket delivered to the project. If the emulsion is diluted, the emulsified asphalt supplier will perform the dilution.

Dilution of asphalt emulsion in the field will not be allowed unless approved by the Engineer. Field dilution of the emulsified asphalt will only be allowed when the rate of dilution is accurately controlled and reported to the Engineer. Field dilution will be performed as recommended by the emulsified asphalt supplier.

The final rate of dilution will not be less than the minimum ratio of at least 1 part emulsion to no more than 1 part added water (1:1 ratio minimum).

Diluted emulsified asphalt for tack, fog seal, and flush seal will be applied at an adjusted rate proportional to the dilution ratio resulting in application of the specified rate of emulsion. Emulsified asphalt for tack, fog seal, or flush seal with a specified rate exceeding 0.07 gallons per square yard will not be diluted.

The storage tank for diluted emulsified asphalt must utilize a recirculation system or agitator that will prevent settlement or separation of the material.

**Section 330.3 E – Page 174 – Add the following sentence to the beginning of the last paragraph of this Section:**

The tack coat will be allowed to break (turn from brown to black) and will be allowed a cure period, as determined by the Engineer, ahead of mat laydown.

**Section 332.3 C – Page 177 – Delete the last sentence of the 1st paragraph and replace with the following:**

The difference between the ridge and valley of the mat surface will not exceed 1/4 inch when tested in accordance with SD 320.

**Section 332.3 C – Page 177 – Delete the last sentence of the 3rd paragraph on page 178 and replace with the following:**

The resultant transition will be of sufficient length to provide a slope no steeper than 20 feet: 1 inch.

**Section 360.3 A – Page 185 – Delete and replace with the following:**

**A. Weather and Seasonal Requirements:** Surface treatment operations will be permitted only during daylight hours, when conditions are dry, when wind does not adversely affect the spraying operation, and when overnight low air temperatures within 24 hours of the planned application are forecasted to be at least 45°F.

Minimum temperatures and seasonal limitations are as follows:

| **Minimum Temperature and Seasonal Limitations** | | |
|---|---|---|
| **Cover Aggregates** | **Air and Surface Temperature (in the shade and rising)** | **Seasonal Limitations (dates are inclusive)** |
| Type 1 | 60°F | May 15 – Aug. 31 |
| Type 2 | 60°F | May 15 – Aug. 31 |
| Type 3 | 60°F | May 15 – Sept. 15 |

**Section 360.3 D – Page 186 – Add the following paragraph to this section:**

The Contractor will ensure transverse rumble strips are not damaged or otherwise modified to lose their functionality during the application of the surface treatment. The Contractor will only apply a fog seal to the rumble strips. The Contractor will repair any damage or loss of functionality of rumble strips to the satisfaction of the Engineer at no additional cost to the Department.

**Section 360.3 F – Page 186 – Delete the 3rd paragraph on page 187 and replace with the following:**

When loading trucks, the Contractor will screen the cover aggregate to minimize segregation, eliminate oversize, reduce aggregate dust, and effectively break up or discard material bonded into chunks. At the discretion of the Engineer, if the cover aggregate does not prove the need for screening, the screening requirement may be waived provided all test results and visual inspections produce satisfactory results. If segregation, oversize material, excessive dust, or material bonded into chunks becomes evident during cover aggregate placement, the Contractor will immediately resume screening of the cover aggregate. When required, aggregate will be uniformly moistened before or during loading.

**Section 360.3 H – Page 187 – Delete the last sentence of the 1st paragraph and replace with the following:**

Traffic will be controlled by pilot cars and flaggers during application of the surface treatment on driving lanes with the speed of pilot cars not to exceed 20 miles per hour on the freshly applied surface treatment for a period of at least 1 hour after application or until the asphalt surface treatment is sufficiently cured. Prior to moving the pilot car operation from the section of roadway, the Contractor will perform initial brooming in accordance with Section 360.3 I.

**Section 360.3 I – Page 187 – Delete and replace with the following:**

**I. Brooming:** In curb and gutter sections and in areas where a finished and maintained lawn extends to the edge of the shoulder, the loose material will be swept up with a pickup broom. Brooming the material into a pile with a rotary broom for pickup will not be allowed. In sections without curb and gutter and in areas where a finished and maintained lawn does not extend to the edge of the shoulder, the loose material may be swept onto the roadway inslopes, as approved by the Engineer.

Broomed off material picked up by the Contractor will be disposed of at sites provided by the Contractor and approved by the Engineer.

**1. Initial Brooming:** The Contractor will perform initial brooming while traffic is maintained as described in Section 360.3 H. Initial brooming will consist of a light brooming of the surface to remove loose chips. The initial brooming will not cause damage to the asphalt surface treatment. If initial brooming causes damage to the asphalt surface treatment, the Engineer, in the Engineer's sole discretion, may require the Contractor to alter the initial brooming operation or to waive the initial brooming requirement.

**2. Final Brooming:** The Contractor will perform final brooming during a cool period of the following morning, within 24 hours of application, to remove all loose material remaining on the surface. The brooming will include the entire surface of the asphalt surface treatment application, additional lane widths, intersections, and shoulders.

**J. Maintenance and Repair:** Areas of the surface treatment, which peel or are otherwise unsatisfactory, will be repaired with additional asphalt, cover aggregate, and rolling. Compensation for repairs due to causes beyond the control of the Contractor will be paid at the contract unit price for asphalt surface treatment.

The finished surface treatment will be uniform and smooth riding. Transverse or horizontal ridges, raveled spots, wheel marks, depressions, abrupt color changes, and other inequalities will be corrected. Payment will not be made for this correction work.

Asphalt splattered on roadway appurtenances will be satisfactorily cleaned off by the Contractor.

**Section 871 – Page 541 – Delete and replace with the following:**

## 871 ASPHALT CONCRETE CRACK SEALANT

### A. Asphalt Concrete Crack Sealant Type IV:

The sealant will conform to the requirements of ASTM D6690 Type IV.

The sealant material will not weigh more than 9.35 pounds per gallon.

Only products that meet the above requirements and have performed satisfactorily based on Department analysis may be used. A listing of acceptable products meeting ASTM D6690 Type IV requirements may be obtained from the Department's Approved Products List. Products on the Department's Approved Products List for joint sealant for asphalt over long jointed concrete pavement may also be used.

The blocking medium will be an inert, compressible material which is compatible with the sealant.

### B. Asphalt Concrete Crack Sealant Type IV Modified:

The sealant will conform to the requirements of ASTM D6690 Type IV except as modified below.

The sealant material will not weigh more than 9.75 pounds per gallon.

Resilience % will be between 30 – 60%.

Only products that meet the above requirements and have performed satisfactorily based on Department analysis may be used. A listing of acceptable products meeting ASTM D6690 Type IV Modified requirements may be obtained from the Department's Approved Products List. Products on the Department's Approved Products List for joint sealant for asphalt over long jointed concrete pavement may also be used.

The blocking medium will be an inert, compressible material which is compatible with the sealant.

**Section 880.2 B – Page 543 – Delete Table 1 and the footnotes and replace with the following:**

**Table 1**

| Requirements | Class D | | Class E | | Class G | | Class S | |
|---|---|---|---|---|---|---|---|---|
| | Type 1 | Type 2 | Type 1 | Type 2 | Type 1 | Type 2 | Type 1*1 | Type 2*1 |
| **Sieve** | **Percent Passing** | | | | | | | |
| 1 inch | 100 | | 100 | | 100 | | | |
| 3/4 inch | 97-100 | 100 | 97-100 | 100 | 97-100 | 100 | 100 | |
| 5/8 inch | | | | | | | 97-100 | 100 |
| 1/2 inch | 75-95 | 97-100 | 75-95 | 97-100 | 75-95 | 97-100 | 86-100 | 97-100 |
| 3/8 inch | | | | | | | 66-80 | 80-100 |
| #4 | 45-75 | 60-80 | 45-75 | 60-80 | 45-75 | 60-80 | 24-34 | 24-45 |
| #8 | 30-55 | 40-60 | 30-55 | 40-60 | 30-55 | 40-60 | 10-20 | 10-22 |
| #16 | 20-45 | 25-50 | 20-45 | 25-50 | 20-45 | 25-50 | | |
| #40 | 10-30 | 15-35 | 10-30 | 15-35 | 10-30 | 15-35 | | |
| #200 | 3.0-7.0 | 4.0-8.0 | 3.0-7.0 | 4.0-8.0 | 3.0-7.0 | 4.0-8.0 | 6.0-10.0 | 4.0-8.0 |
| **Other Properties** | | | | | | | | |
| Processing Required | Crushed | | Crushed | | Crushed | | Crushed | |
| Fine Aggregate Angularity (min) | 41.5 | | 42.5 | | 44.0 | | NA | |
| Sand Equivalent (min) | 42 | | 45 | | 50 | | NA | |
| LA Abra. Loss, (max) | 45% | | 40% | | 35% | | 40% | |
| +#4 Absorption (max)*2 | | | | | | | 1.0% | |
| **Sodium Sulfate Soundness (Maximum)** | | | | | | | | |
| +#4 sieve | 15% | | 15% | | 12% | | 8% | |
| -#4 sieve | 15% | | 15% | | 12% | | 8% | |
| **Lightweight Particles (Maximum)** | | | | | | | | |
| +#4 sieve | 4.5% | | 3.0% | | 1.0% | | 1.0% | |
| -#4 sieve | 4.5% | | 3.0% | | 1.0% | | 1.0% | |
| **Crushed Particles (Minimum)** | | | | | | | | |
| +#4 sieve | 50% 1-CF | | 70% 2-CF | | 90% 2-CF | | 95% 2-CF | |

*1 Mineral aggregate will be produced from a ledge rock source.
*2 Will be evaluated at mix design by the Department's Central Materials Laboratory.

**Section 880.2 D – Page 544 – Delete the 2nd sentence.**

**Section 880.3 – Page 545 – Delete "Liquid Limit and Plasticity Index" and replace with the following:**

Fine Aggregate Angularity ........................................................SD 217
Sand Equivalent........................................................................SD 221

**Section 881.2 – Page 546 – Add the following requirements to the column for Type 1A cover aggregate:**

#40 0-4

Foot Notes *1

**Section 884.2 A – Page 549 – Delete the last sentence of this section.**

**Section 884.2 C – Page 549 – Add the following to this section:**

Prior to incorporation, RAP will be processed over a 1 ½ inch screen to remove large chunks. Material screened off will be crushed and reincorporated into the process. Scalping of the cold milled asphalt concrete stockpile to generate material meeting the RAP requirements will not be allowed.

**Section 884.2 D – Page 549 – Add the following to this section:**

Prior to incorporation, salvaged material will be processed over a 1 ½ inch screen to remove large chunks. Materials screened off will be crushed and reincorporated into the process. Scalping of the salvaged material stockpile will not be allowed.

**Section 890.2 E – Page 554 – Delete the table and replace with the following:**

| | AE150S | | AE150L | | AE200S | | AE300 | |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max |
| **TESTS ON EMULSIONS:** | | | | | | | | |
| Viscosity, Saybolt Furol at 122ºF, s | 35 | 150 | 35 | 150 | 35 | 150 | 35 | 150 |
| Sieve test, % | | 0.30 | | 0.30 | | 0.30 | | 0.30 |
| Oil Portion, % | 0.5 | 3 | | | 1 | 6 | | 8 |
| Residue by distillation, % | 62 | | 65*[1] | | 62 | | 65 | |
| **TESTS ON RESIDUE FROM DISTILLATION TESTS** | | | | | | | | |
| Penetration, 77ºF, 100 g, 5s | 140 | 225 | 140 | 225 | 250 | | 300 | |
| Ductility, 77ºF, 5 cm/min, cm | 40 | | 30 | | 40 | | 40 | |
| Ash Content, % | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| Float test, 140ºF, s | 1200 | | 1200 | | 1200 | | 1200 | |

**Section 890.2 G – Page 554 – Delete and replace with the following:**

**G. Polymer Modified Emulsified Asphalt** will conform to AASHTO M 316, with the following exceptions. The sieve test requirement on representative samples will be waived unless requested by the Engineer. If requested, a maximum percentage of 0.30% is acceptable for samples taken at the point of use.

The distillation test for CRS-2P emulsion will be in accordance with AASHTO T 59, except the distillation temperature will be the temperature recommended by the emulsion manufacturer.

The Elastic Recovery test will be in accordance with AASHTO T 301, except the residue will be obtained by distillation, not oven evaporation. The distillation temperature will be as recommended by the emulsion manufacturer.

**RSTC / MSTR**

**RSTC / MSTR**

**RSTC / MSTR**

Acceptable Tolerances for Comparison of Class Q Asphalt Concrete between QC, QA and IA

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

The Region Materials Engineer shall:

(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 shall 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.

# 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)

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.

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 Engineer. 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 |

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 quarry material (DOT-69).

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 quarry 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)

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.

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)

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.

(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.

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)

<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.
<u>Class D, E, G, HR,</u> one per 10,000 ton. None required for contract quantities less than 500 ton.

<u>Class Q</u>: 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.

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 maximum theoretical specific gravity (Rice) test. The Region Materials Laboratory will perform theoretical 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.

(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)

(5) 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.

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.

(4) Independent Assurance.
None required.

## 1.3 Asphalt Surface Treatment.

A. Cover Aggregate, Types 1 & 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.

(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. Mineral Aggregate for Microsurfacing

(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.

### 1.4 Asphalt Liquid.

A. Material.

(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)

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.

(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.

(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.

# Section Number 3

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# SOUTH DAKOTA
# DEPARTMENT OF TRANSPORTATION

# MATERIALS TESTING & INSPECTION CERTIFICATION PROGRAM MANUAL

Revised June 2024

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION

MATERIAL TESTING & INSPECTION
CERTIFICATION PROGRAM MANUAL

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ACI | American Concrete Institute |
| ASTM | American Society for Testing and Materials |
| CCRL | Cement and Concrete Reference Laboratory |
| CFR | Code of Federal Regulations |
| FHWA | Federal Highway Administration |
| IA | Independent Assurance |
| NHS | National Highway System |
| NIST | National Institute of Standards and Technology |
| QC | Quality Control |
| QA | Quality Assurance |
| QC/QA | Quality Control and Quality Assurance |
| SDDOT | South Dakota Department of Transportation |
| SDBHRA | South Dakota Bureau of Human Resources and Administration |

## REFERENCES

SDDOT Standard Specifications for Roads and Bridges, current edition

SDDOT Materials Manual, current edition

## GLOSSARY OF TERMS

AASHTO Accredited Laboratories - Laboratories that satisfy the quality system requirements specified in AASHTO Practice R 18 and received an on-site assessment from AASHTO re:source and/or CCRL for which test method accreditation is being sought.

Abuse - An intentional deviation from approved procedures.

Acceptance Testing – 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.

Certified Individual - An individual, who has successfully demonstrated through passing the required written and/or performance exams, with the knowledge and skills required to properly sample and test material or provide inspection of construction activities.

Certification Program - The process in-place that provides the requirements for those seeking certification and administration of the program.

Course Exam - An exam taken at the end of an approved course to gain certification.

Ethical Work - All work shall be accomplished honestly in a professional manner in accordance with the plans, specifications, contract, materials manual, or any other pertinent requirements. It shall be considered unprofessional and inconsistent with proper conduct and contrary to the public interest:

a) To act for his/her client or for his/her employer other than as a faithful agent or trustee.
b) To accept remuneration for services rendered other than from his/her client or his/her employer.
c) To attempt to injure (falsely or maliciously) the professional reputation of another individual or business.
d) To exert undue influence or to offer, solicit, or accept compensation for the purpose of affecting negotiations of a contract or contract item.
e) To act in any manner derogatory to honor, integrity, and dignity.

Independent Assurance (IA) Testing – Independent Assurance samples and tests are the samples taken, tests made, and other procedures performed for the expressed purpose of making independent checks on the reliability of the results of Acceptance sampling and testing. They do not provide test results for acceptance.

Inspection - The process of observing, measuring, examining, testing, gauging, or otherwise evaluating materials, products, services, testing activities, and equipment to determine their acceptability in meeting specification requirements.

Misconduct - An intentional wrongdoing or deliberate violation of the requirements of the certification program.

Negligence - A repeated unintentional deviation from approved procedures, which may or may not cause erroneous results.

Permanent Employee - A full time individual employed by a company or organization, who normally works 40 hours per week 52 weeks per year for the same company or organization.

Performance Checklist – A list of proficiency checks for testing procedures that is specific to the type of testing that is being performed that administered by a certified individual to a non-certified individual. Performance Checklist may be obtained from the Region Materials Engineer.

Performance Exam - An exam taken by an individual to show that he/she has the knowledge and ability to perform the specified test.

Proficiency Sample - A standardized sample given to multiple laboratories to evaluate the performance of the laboratories and those performing the tests.

Quality - Consistently conforming to mutually agreed upon requirements.

Quality Assurance - All those planned and systematic activities necessary to provide adequate confidence that a product or service will satisfy given requirements for quality. In the laboratory, quality assurance should provide adequate confidence in each test result reported by the laboratory.

Quality Control - The sum of total activities performed by the seller (producer, manufacturer, and/or contractor) to make sure that a product meets contract specification requirements. Within the context of highway construction this includes materials handling and construction procedures, calibration and maintenance of equipment, production process control, and any sampling, testing, and inspection that is done for these purposes.

Recertification Exam - An exam taken by an individual to obtain certification in those areas for another specified time frame.

Reciprocity - When the Certification is granted to an individual based on other certifications, licenses, etc.

Re-test Exam - A different exam, other than the one that was previously failed, given to an individual to obtain certification.

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION

MATERIALS TESTING & INSPECTION
CERTIFICATION PROGRAM MANUAL

I. Objective:

The Federal Highway Administration (per 23 CFR 637 Subpart B) requires that all individuals performing acceptance testing or independent assurance testing will be certified, and all testing equipment be calibrated at a specified frequency for all work on the National Highway System. The intent is to continually improve the quality of our highway system. With the adoption of quality control/quality assurance specifications, many more individuals are testing and inspecting, which requires training and good testing equipment to provide consistency and repeatability of results. The intent of the program is to assure that the quality of the inspection, testing, and testing equipment is uniform and consistent in providing quality results.

This Certification Program does not apply to the SDDOT Central Laboratory. The Central Laboratory shall meet the requirements of CFR 637.209(a)(2).

All activities must be conducted in accordance with this manual.

A. There are three major parts to the program:

1. Calibration of Testing Equipment includes calibrations, standardizations and checks of equipment.
2. Material Testing Certification of Individuals.
3. Inspection Certification of Individuals.

B. The Program applies to highway construction on all highway systems plus all informal/maintenance projects which require testing and inspection as determined by the Region Engineer or Region Materials Engineer.

C. Any individual, who is performing acceptance or independent assurance testing of material, will be certified.

D. Any individual, who is performing acceptance inspection of contract work in the areas designated by this program, will be certified.

E. Overall Program Responsibility: The SDDOT Materials & Surfacing Program has the overall responsibility to administer this program. The duties and responsibilities of those individuals in the Materials and Surfacing Program to meet the administrative requirements will be as outlined in this document.

F. The current edition of the SDDOT Materials Manual, Standard Specifications and Special Provisions will be used as the source for the following:

1. Minimum Acceptance, Quality Control and Quality Assurance Testing Frequencies.
2. Minimum Independent Assurance Testing Frequencies.
3. Sampling and Testing Procedures.
4. Procedures for handling failing test results.
5. Procedures for the identification, conditioning, storage, retention, and disposal of test samples.

II. Testing Equipment: All testing equipment will be calibrated to assure uniformity in the testing equipment and to provide more uniform test results. The Independent Assurance testing will be used to monitor uniformity of the testing equipment and procedures.

A. Requirements: All testing equipment identified by the Materials and Surfacing Program will:

1. Be calibrated at the required Frequency (Appendix 1).
2. Be calibrated according to the Equipment Calibration Procedures (Appendix 2).
3. The equipment calibration will be recorded on the Equipment Calibration Records (Appendix 2). Where large numbers of a particular type of equipment exist, it will be permissible to list as many items on one record document as it will accommodate provided all required documentation, measurements, and any other required information is shown for each equipment item.
4. Equipment Calibration Records will be retained for a period of three years.
5. No equipment will be used for testing if it does not meet the calibration requirements. This may require corrective work or disposing of the non-conforming equipment.

B. Responsibilities:

1. Materials and Surfacing Program:
   a) Develop and furnish equipment calibration frequencies, procedures, and records.

2. Region Materials:
   a) Calibrate SDDOT Region and Area equipment.
   b) Maintain equipment inventory.
   c) Maintain equipment calibration records.

3. Area Office:
   a) Ensure Area, Contractor, Consultant, or other's equipment is calibrated prior to use.

   b) Review contractor, consultant, or other entities' records. The Area Office will need to ensure that the consultant, contractor, or other entity's equipment calibration records are available for review on the project site. IA testing will be used to monitor accuracy of equipment calibration and uniformity of testing procedures.

4. Contractor, Consultant, or other entities:
    a) Calibrate their equipment prior to use on project.
    b) Maintain their equipment inventory.
    c) Maintain their equipment calibration records.
    d) Have a copy of current equipment calibration records available on project site.
    e) Cooperate in the inspection conducted by SDDOT of their facilities, equipment, and/or records.

5. Individual:
    a) Each individual will be responsible for keeping well-maintained and clean equipment and workspace.
    b) Each individual will assure that their equipment has been calibrated and is functioning as intended.

III. Individual Certification: Any individual, who is performing Acceptance, Quality Control, Quality Assurance, or Independent Assurance testing of materials and/or acceptance inspection in the areas designated by this program, will be certified.

Permanent SDDOT employees, who will be sampling and testing materials for acceptance, or performing acceptance inspection will become certified as soon as scheduling will permit. Until an individual is certified, they will function in accordance with the parameters established for temporary or seasonal personnel.

All Materials certifications are valid for four (4) years, except the ACI Certification and the DOT+ which is valid for five (5) years, after which time the individual must become recertified before the expiration date of the current certification.

Participation in conducting any of the Department sponsored certification testing and inspection courses as an instructor, will fulfill the requirement for certification or recertification for that course for a period not to exceed one year. Recertification will be allowed for individual who no longer participate as an instructor. The recertification will be valid for a period not to exceed four years.

A. Certification will be required for all personnel who will be performing Materials Testing or Project Inspection in the following areas:

1. Materials Testing:
    a) Soils - SD 103, SD 104, SD 105, SD 106, SD 108, SD 110, and SD 114.

    b) Aggregate - SD 201, SD 202, SD 203, SD 206, SD 207, SD 208, SD 211, SD 212, SD 213, SD 214, and SD 219.

    c) Asphalt Aggregate Testing - SD 108, SD 201, SD 202, SD 208, SD 211, SD 212, SD 213, SD 214, SD 217, and SD 221.

    d) Hot Mix Testing – SD 301, SD 305, SD 306, SD 307, SD 311, SD 312, SD 314, SD 315, SD 317, SD 318, SD 321, and SD 502.

    e) Fresh Concrete - SD 402, SD 403, SD 404, SD 405, SD 408, and SD 411.

2. Project Inspection:
    a) Earthwork, Pipe Installation, Erosion Control.
    b) Structures.

c) Concrete Paving.
d) Concrete Plants.
e) Asphalt.
f) Erosion and Sediment Control/Storm Water Management.

B. Requirements for Permanent Personnel:

1. Initial certification:

a) Soils or Aggregate Testing: The individual must successfully complete each segment of the Department's Soils and Aggregate Testing Course.

b) Asphalt Testing and Inspection (Class Q): Individual must follow the procedures for certification contained in Appendix 3 of this document. The individual must attend the course and pass the required exams prior to sampling and testing, or inspection of materials associated with asphalt concrete construction.

c) Fresh Concrete Testing: Individual must be certified as an ACI Concrete Field-Testing Technician – Grade I prior to sampling and testing concrete. All personnel performing Acceptance testing are required to take the SDDOT+ course on DOT procedures in SDLearn. Contractors and Consultants may sign up at: https://dot.sd.gov/doingbusiness/certification-accreditation/training

d) Project Inspection: Individual must successfully complete each inspection course in which they will be inspecting.

2. Recertification:

a) Soils or Aggregate: Recertification must be accomplished by successfully completing the recertification exam or successfully completing the course on an alternating basis every four (4) years and before the expiration date of the current certification. Recertification exams will be scheduled through SDLearn.

Contractors and Consultants may sign up for recertification exams at:https://dot.sd.gov/doing-business/certification-accreditation/training.

b) Asphalt Testing and Inspection (Class Q): Individuals must follow the procedures for recertification contained in Appendix 3 of this document.

c) Fresh Concrete: Individuals certified by ACI must follow the current ACI procedures to become recertified.

d) Project Inspection: Recertification must be accomplished by completing the recertification process or successfully completing the course on an alternating basis every four (4) years and before the expiration date of the current certification. Recertification exams will be completed through SDLearn except for Concrete Plants which will be administered through the Region Materials Engineer.

Contractors and Consultants may sign up for recertification exams at:[https://dot.sd.gov/doing-business/certification-accreditation/training](https://dot.sd.gov/doing-business/certification-accreditation/training)

C. Requirements for Temporary and Seasonal Personnel:

1. Soils/Aggregate: Individuals will work on the same project under direct supervision of an individual certified in that area of testing.
   a) Temporary and seasonal personnel who are utilized to perform materials testing duties will obtain a copy of the test procedure(s) and become familiar with them.
   b) Will observe a certified technician perform the test procedure.
   c) Will perform the test procedure until proficiency is achieved.
   d) Will demonstrate the test procedure to a certified technician. The certified technician will use the Performance Checklist for the test being demonstrated to ascertain all steps are performed correctly. This document will be retained as verification of successful demonstration of the procedure.
   e) Will have a copy of the applicable test procedure available during the demonstration testing and while testing material on the project.
   f) A copy of the Performance Checklist for the test(s) in which a temporary or seasonal individual has demonstrated proficiency and the Training and Evaluation Record document for all non-DOT personnel used on a project will be available for review in the Project File at the Area Office and in the laboratory on the project. These records for temporary or seasonal DOT Personnel will be available for review at the Area office.
   g) Direct supervision (materials testing): A non-certified individual may perform tests or portions of tests only under direct observation of a certified technician until such time the non-certified technician demonstrates they can consistently perform the test or portion thereof in accordance with the outlined procedures. From that point on, the non-certified individual can perform the test or portion thereof whether or not a certified technician is physically present at the test site. The certified technician is however required to spend time at the project/laboratory on a daily basis. The certified technician assumes all responsibility for the accuracy of the test data and signifies so by placing their initials on the worksheet as the checker.

2. Fresh Concrete: Individuals must be certified as an ACI Concrete Field-Testing Technician – Grade I and successfully complete the SDDOT+ course on DOT procedures prior to testing concrete. Direct supervision will not be required.

3. Asphalt Testing and Inspection: Individuals on QC/QA asphalt projects must follow the procedures contained in Appendix 3 of this document.

4. Project Inspection:

a) An individual's qualifications (certifications, education, and experience) will be considered in determining their ability to provide proper inspection in a particular area.

b) The individual must work on the same project under direct supervision of an inspector certified in that inspection area. Direct Supervision (Inspection): A non-certified individual may perform inspection of a phase of work only under the direct observation of a certified individual until such time the non-certified individual demonstrates a thorough understanding and knowledge of the requirements and procedures for that phase of work. The certified individual assumes all responsibility for the accuracy of the documentation provided.

c) The certified individual will determine whether the temporary or seasonal person is qualified for a particular area of inspection.

d) The individual will review the applicable course manual and have it available for use on the project.

e) Temporary or seasonal personnel will not be required to take any of the inspection certification courses.

f) A copy of the Training and Evaluation Record document showing the area(s) in which a temporary or seasonal individual has demonstrated proficiency for inspection for non-DOT personnel used on a project will be available for review in the Project File at the Area Office, on the project, and submitted to the Region Materials Engineer. These records for temporary or seasonal DOT personnel will be available for review at the Area Office.

g) Individuals must be certified in Erosion and Sediment Control/Storm Water Management.

D. Responsibilities - Material Testing and Certification:

1. Materials and Surfacing Program will:

a) Assist in the development of the certification course material and/or provide instructors for the inspection and testing classes.
b) Ensure exams are graded by a course Instructor.
c) Maintain a list of certified individuals.
d) Retain records (exams) for five (5) years.
e) Retain all certification records.
f) Provide a letter of notification to all individuals who fail to achieve a passing score. (A copy of this letter will be provided to the Area Engineer and the Region Materials Engineer for DOT employees or to the employer and Region Materials Engineer if the individual is not a DOT Employee.)
g) Provide each individual a card at the beginning of the construction season indicating the areas in which they are certified and the expiration date of each certification.

h) At the beginning of each construction season, provide the Operations and Area Engineers with a tabulation of the personnel in their respective Regions/Areas that are certified, along with the expiration dates for those certifications.

i) Distinguish between the types of exams given to the individual (re-test, re-certification, provisional, or course exam) for each certification area.

2. Region Materials
   a) Monitor certified individual's test procedures and comparison results through Independent Assurance testing.
   b) Verify temporary and seasonal personnel test procedures and comparison results through Independent Assurance testing.
   c) Administer and grade the written re-certification and re-test exams for Soils & Aggregate Testing and applicable QC/QA levels to Area Office personnel, Contractors, Consultants, and other entities. The Region Materials Engineer may assign a designee to administer the written re-certification and re-test exams.
   d) Maintain a summary of Independent Assurance Testing to document proficiency of employees performing acceptance testing on DOT projects.
   e) Responsible for sending their individuals to the appropriate certification courses.
   f) Notify Area Office, Consultant, Contractor, or other entity of an individual's substandard test procedures or comparison results.
   g) Ensure all necessary equipment calibration records are complete and on file.

3. Area Office
   a) Ensure projects are staffed with properly certified Area personnel and verify Contractor, Consultant, or other entity personnel are certified in the area in which they are working.
   b) Responsible for sending their individuals to the appropriate certification course.
   c) Qualify SDDOT temporary and seasonal employees annually.
   d) Maintain documentation of seasonal qualifications on Training and Evaluation Record (Figure 1) and provide a copy to the Region Materials Engineer.
   e) Ensure that certified personnel are meeting the supervision requirements for temporary or seasonal personnel.
   f) Take appropriate action when notified of an individual's substandard test procedure or comparison results.

4. Contractors, Consultants and Other Entities
   a) Responsible for sending their individuals to the appropriate certification courses.
   b) Ensure properly certified individuals staff the project.
   c) Qualify their own temporary and seasonal employees annually.
   d) Maintain documentation on seasonal qualifications on *Training and Evaluation Record* (Figure 1).
   e) Take appropriate action when notified of an individual's substandard test procedures or comparison results.

f) Have a copy of the Equipment Calibration Records for all Testing equipment used on the project available for review in the Project Files at the Area Office and in the testing laboratory on the project.

5. Certified Individual

a) Ensure he/she works only in the areas for which he/she has been certified.

b) Ensure that certifications are kept current.

c) Ensure the material tests are performed in accordance with the material test procedures and material test results are reported to the required precision.

d) Ensure inspections are conducted to verify compliance with plans and specifications and that proper documentation is made.

e) Ensure the equipment has been calibrated and properly maintained.

f) Ensure that test samples are retained for the specified period of time. When a time period is not specified, passing samples will be disposed of in a safe and expeditious manner after the testing is complete and the test results have been approved. Ensure that applicable State or Federal guidelines or regulations for the disposal of materials are strictly adhered to.

g) The certified individual will be responsible for overseeing the temporary or seasonal employee's work and initial any reports.

h) Take corrective action when notified of substandard testing procedures or comparison results.

i) Ensure work is accomplished in an ethical manner and non-specification work is properly documented and reported to the Area Engineer.

j) Qualify temporary and seasonal employees based on education, experience, and/or successful completion of exam.

E. Conflict of Interest:

To avoid a conflict of interest, no individual or laboratory will perform more than one of the following types of testing on the same project:

- Acceptance Testing
- Quality Control Testing
- Quality Assurance Testing
- Independent Assurance Testing
- Dispute Resolution Testing

Note: The Region Materials Laboratory may perform Dispute Resolution Testing on QC/QA projects.

F. Dispute Resolution Testing:

Dispute resolution testing of materials will be accomplished by the SDDOT Central Testing Laboratory, AASHTO Accredited Laboratories, Region Materials Laboratory or other SDDOT Approved Accredited Laboratories. The dispute resolution system will be administered by the SDDOT.

H. Suspension/Revocation of Certification:

Any suspension or revocation of an individual's certification will be administered by the Oversight Committee. A meeting of the Oversight Committee may be called at any time by the Chair of the committee or by a written request to the Chair by at least three committee members. A majority of the members will be present for the transaction of official business.

1. Oversight Committee members are:
   a) Chief Materials & Surfacing Engineer - Chair.
   b) Construction Engineer Manager.
   c) Certification/Accreditation Program Administrator.
   d) Pavement and Materials Engineer, FHWA.
   e) One Region Operations Engineer rotated on a four (4) year basis.
   f) One Area Engineer rotated on a four (4) year basis.
   g) Region Materials Engineers.

   Note: A list of Oversight Committee members will be maintained by the Certification/Accreditation Program Administrator.

2. Oversight Committee responsibilities:
   a) The purpose of the Oversight Committee is to review the certification program on a bi-annual basis or as often as deemed necessary by the Chair of the Committee.

   b) Investigate and resolve (majority vote) written allegations of misconduct. Allegations of misconduct will be made to the Chair of the Oversight Committee in writing. The allegation will contain the name, phone number, address, and signature of the individual(s) making the allegation. The allegations will be investigated by the Oversight Committee. If warranted, the accused and the individual(s) making the allegation will be given the opportunity to appear before the Oversight Committee to resolve the allegation. The Chair of the Oversight Committee will provide written notification to all the involved parties of the decision of the Oversight Committee. Any warranted penalties may be imposed as determined by the Oversight Committee.

      For just cause the Oversight Committee may impose suspension or revocation of an individual's certification at any time. The reasons that an individual will be subject to revocation or suspension of their certification are falsification of records/tests/reports, negligence, or abuse of their responsibilities. The Oversight Committee may also suspend or revoke an individual's certification for other reasons of just cause, which may or may not be specifically defined.

      Negligence is defined as repeated unintentional deviations from approved procedures, which may or may not cause erroneous results. A reoccurring finding of negligence will result in a letter from the Oversight Committee to the Employer directing them to write a letter of reprimand to the individual. A continuing finding will result in a thirty (30) day suspension of the individual's certification. Any subsequent finding will be treated as abuse.

      Abuse is defined as intentional deviations from approved procedures. (Examples of abuse include but are not limited to: the falsification of test results or records, submittal of false information on certification applications, and/or unwillingness to follow prescribed test procedures.) The first instance of abuse will result in a one (1) year suspension of an individual's certification. Any subsequent finding of abuse will result in the permanent revocation of the individual's certification.

Any findings of abuse or negligence warranting the revocation or suspension of an individual's certification will result in the revocation or suspension of all certifications held by that individual in the various Material Testing or Inspection Areas. When the suspended individual is reinstated and prior to performing work, the individual will be required to pass the written and/or performance re-certification exams, as applicable, and the individual's recertification expiration date(s) will be that expiration date(s) held prior to the suspension.

Falsification of records/tests/reports: Any person who knowingly makes any false statements of records/tests/reports as to the quantity, quality, or cost of the material used on, or the work performed on any federal-aid project is also subject to be fined or imprisoned in accordance with Title 18, United States Code Section 1020.

c) Investigation and resolution (majority vote) of any appeals of exam scores due to ambiguous question(s) or problem(s) with the course exam(s). For just cause the Oversight Committee may adjust an exam score of an individual if investigation and resolution of the written request warrants such action. The individual must provide a written appeal with the justification(s) why the question(s) or problem(s) was/were ambiguous within 60 calendar days from the date of the exam.

d) The Oversight Committee will notify the employer of all actions taken.

e) Other duties as required to successfully implement and continue the Certification Program.

H. Reciprocity:

1. Reciprocity may be allowed for soil and aggregate material testing. The individual's qualifications will be reviewed by the Materials and Surfacing Program to see if they meet SDDOT standards of material testing and must be approved by the Chief Materials and Surfacing Engineer. The individual will also need to pass the respective SDDOT exam. Reciprocity will not be granted for inspection certification or asphalt and concrete material testing certification.

2. Reciprocity may also be granted for erosion & sediment control/storm water management when the individual provides documentation, he/she is certified in one or more of the following.
   a) Certified Professional in Erosion and Sediment Control (CPESC)
   b) Certified Professional in Storm Water Quality (CPSWQ)
   c) Certified Erosion, Sediment and Storm Water Inspector (CESSWI)
   d) Certified Storm Water Compliance Inspector (CSWCI)
   e) Certified Preparer of SWPPPs (CPSWPPP)
   f) Other States' certification in Erosion and Sediment Control/Storm Water Management contingent on the individual also passing the SDDOT exam.

Note: Individual certifications will be verified by a representative from SDDOT Office of Project Development, Environmental Program.

3. Reciprocity is only valid for the current construction season. Individuals who have been granted reciprocity will need to take the next available certification course.

IV. Exams

A. Types of Exams:

1. Written Exams:
   a) Types of written exams:
      1) Course Exam.
      2) Re-test Exam.
      3) Re-certification Exam.
      4) Provisional Exam.

   Note: A Provisional Certification is an exam opportunity made available upon approval by the Chairman of the Certification Advisory Committee for QC/QA Asphalt Projects or by the Chairman of the Oversight Committee for the Materials Testing and Inspection Program to provisionally certify an individual, so they may provide inspection or testing for only one construction season. A provisionally certified individual will need to attend the next available course for the applicable area of expertise to maintain that certification. This process is permitted only when there is a shortage of certified individuals as a result of a locally heavy workload in combination with unforeseen circumstances. This individual must pass the written examination for the area of work in which they are going to perform.

   b) Exams will be open book unless precluded by the approved testing entity.
   c) A minimum overall score of 70% on the written exam will be obtained to successfully pass the written exam or as deemed passing by the approval testing entity.
   d) If the written exam is failed, the individual will be given one more opportunity to pass another written exam. The re-test exams will be administered by the Region Materials Engineer or their designee and scheduled at their convenience. Re-test exams will need to be completed within 30 calendar days of the original written exam. The Region Materials Engineer cannot administer a re-test for the ACI course. This re-test must be rescheduled with a duly authorized ACI representative. If a re-test is failed, the individual will not be allowed to provide inspection, acceptance testing, or independent assurance testing for that certifiable area until the individual has taken the appropriate class and successfully completed the written exam(s).

      NOTE: Any individual failing the written exam in an attempt to become recertified will not be allowed to re-test and will be required to attend the appropriate class and successfully complete the written exam before being allowed to provide inspection, acceptance testing or independent assurance testing for that certifiable area. Individuals failing the written exam(s) may be utilized to provide inspection and acceptance testing provided the rules under “Requirements for Temporary and Seasonal Personnel” are followed and only at the discretion and approval of the Region Materials Engineer.

2. Performance Exams:
   a) Types of Performance Exams:
      1) Course Performance Exam.
      2) Re-test Performance Exam.
      3) Provisional Performance Exam.

   Note: A Provisional Performance Exam is an exam opportunity made available upon approval by the Chairman of the Certification Advisory Committee for QC/QA Asphalt Projects or by the Chairman of the Oversight Committee for the Materials Testing and Inspection Program to provisionally certify an individual, so they may provide inspection or testing for only one construction season. A provisionally certified individual will need to attend the next available course for the applicable area of expertise to maintain that certification. This process is permitted only when there is a shortage of certified individuals as a result of a locally heavy workload in combination with unforeseen circumstances. This individual must pass the performance examination for the area of work in which they are going to perform.

   b) The individual will be required to demonstrate and/or explain the material test procedure as determined by the testing agency.
   c) Individuals will successfully complete all of the items covered on the checklist for each test method within the test procedure time restraints. The omission of one or more of the prescribed procedures will constitute failure of the performance test method. The individual will be allowed two trials on the day of the performance examination for each test procedure. Failure of any one of the prescribed tests after two trials will constitute failure of the entire performance exam. Grading of the performance exam is on a Pass/Fail basis.
   d) Any individual failing the performance exam on the day of the examination has the opportunity to retake another exam at the scheduling convenience of the department.
   e) If the individual fails the performance exam a second time, they will not be allowed to provide testing in that certifiable area until the individual attends the appropriate class and successfully completes the exam(s).

B. Requirements:

1. Materials Testing Certification:
   a) Pass Written Exam.
   b) Pass Performance Exam.

2. Inspection Certification:
   a) Pass Written Exam.

V. Certification Courses:

Courses will be provided by SDDOT or other SDDOT approved entities. Each individual attending any of the certification courses or test outs will furnish their driver’s license or employee number. The number will be used as the key identifier for tracking each individual's certification record.

A. Instructors: SDDOT will provide instructors or other authorized individuals to teach the courses.

B. Enrollments: SDDOT will maintain course enrollment information and provide an accurate roster of those participants in attendance to the SDDOT Materials and Surfacing Program at the completion of each course.

1. SDDOT Employees: DOT approving authority will confirm enrollment and the AFE number and provide enrollment information: Employee name, department, employee work address, employee's or supervisor's phone number, employee's identification number, and course title, date, and location through SDLearn.

2. Non-DOT Persons: The SDDOT will announce the course prerequisites, cost, date(s), and time(s) on the DOT website by November 1. The individual can enroll in the certification course at the SDDOT website https://dot.sd.gov/doing-business/certification-accreditation/training. To enroll, individuals must create an account and receive a User ID from SDLearn. The User ID will be used as the key identifier for tracking each individual's certification record. Enrollment information includes employee name, company, employee home and course title, date, and location. Confirmation of enrollment will be sent to the employee's email address.

3. Attendance Cancellation Policy: If the individual enrolled in the course cannot attend, the individual, supervisor, or company is required to cancel their registration according to the course announcements. Failure to cancel according to the course announcements will result in forfeiture of the registration fee and may deprive a person on the waiting list from being able to attend. A refund of the registration fee(s), if prepaid, will be granted if the class is canceled by the SDDOT. If notified on the day of the course that an individual is unable to attend due to inclement weather or good cause email dotlms@state.sd.us, the registration fee may be refunded. To cancel an individual from the certification course please send an email to dotlms@state.sd.us.

C. Costs of Certification Courses: The SDDOT will determine the cost of the certification course for those they are conducting. Other entities providing certification courses (ACI and Asphalt QC/QA) will determine the cost of the certifications that they provide. These costs will be provided in the course announcements. The cost of course manuals may be billed separately.

# SDDOT Material Testing & Inspection Certification Program

Training and Evaluation Record

Temporary or Seasonal Name: ________________________

Employee Number: __________________

| Test Method and Inspection | Check One | | Evaluated By | Title | Date | Comments |
|---|---|---|---|---|---|---|
| | Pass | Fail | | | | |
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CC: Region Materials Engineer

Figure 1

APPENDIX 1

**SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION**
**REGION AND AREA/FIELD LABS**
**JUNE 2021**

| APPARATUS | REQUIREMENT | **IA** REGION CALIBRATION & VERIFICATION FREQUENCY | **ACCEPTANCE** AREA/FIELD CALIBRATION & VERIFICATION FREQUENCY | TEST METHOD | PROCEDURE NUMBER |
|---|---|---|---|---|---|
| Oven | Standardize thermometric device | Annually | Annually (Area Lab Only) | | 02 |
| Handheld Rammer, Proctor | Check weight & critical dimensions | Annually | Annually | T 99, T 180, SD 104 | 04 |
| Mold, Proctor | Check critical dimensions | Annually | Annually | T 99, T 180, SD 104 | 05 |
| Sieve, Coarse | Check physical condition and opening dimensions | Annually | Annually | E11 | 06 |
| Sieve, Fine | Check physical condition | Annually | Annually | E11 | 06 |
| Unit Weight Measure | Standardize | Annually | Annually | T 19, T 121, SD 205, SD 403, SD 411 | 07 |
| Vacuum System | Standardize | Annually | Annually | T 100, T 209 | 09 |
| Compression Testing Machine | Standardize | Annually (Contacted) | Annually (Contacted) | T 22 | 11 |
| Liquid Limit Device & Grooving Tool | Check wear & critical dimensions | Annually | Annually | T 89, SD 207 | 15 |
| Flakiness Index Slotted Plate | Checking Flakiness Index | Annually | Annually | SD 203 | 25 |
| Slump Cone | Check critical dimensions | Annually | Annually | T 119, SD 404 | 38 |
| Mechanical Shaker | Check sieving thoroughness | Annually | Annually (Area Lab Only) | T 27 | 40 |
| Thermometer | Standardize | Annually | Annually | T 88, T 100 | 44 |
| Scale, Balance | Standardize | Annually (Contracted) | | M 231 | 45 |
| Scale, Balance (Field) | Standardize | | Annually | M 231, ASTM E617, C138 NIST Handbook 44 | 46 |
| Gyratory Mold, Ram Head & Base Plate | Check critical dimensions | Annually (By Central Lab) | Annually (By Central Lab) | T 312, SD 318 | 49 |

**SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION**
**REGION AND AREA/FIELD LABS**
**JUNE 2021**

| APPARATUS | REQUIREMENT | **IA** REGION CALIBRATION & VERIFICATION FREQUENCY | **ACCEPTANCE** AREA/FIELD CALIBRATION & VERIFICATION FREQUENCY | TEST METHOD | PROCEDURE NUMBER |
|---|---|---|---|---|---|
| Mechanical Rammer, Proctor | Standardize | Annually | | D 2168, SD 104 | 67 |
| Rubber Balloon Density Apparatus | Calibrate | Annually | Annually | ASTM D2167, SD 106 | 68 |
| Straightedge | Check critical dimensions & planeness of edge | Annually | Annually | T 99, T 180, SD 104 | 70 |
| Concrete Cylinder Mold, Metal | Check critical dimensions | Annually | Annually | T 22, M 205, SD 405 | 71 |
| Air Meter Pressure, Type B | Standardize | Annually | Annually | T 152, SD 403 | 72 |
| Sand Equivalent Apparatus | Check critical dimensions | Annually | Annually (By Central Lab) | T 176, SD 221 | 75 |
| Fine Aggregate Angularity | Check dimensional tolerances | Annually | Annually (By Central Lab) | T 304, SD 217 | 76 |
| Gyratory Compactor | Standardize | Annually (By Central Lab) | Annually (By Central Lab) | T 312, SD 318 | 78 |
| Caliper | Standardize | Annually | | | 81 |
| 10’ Straightedge | Standardize | Annually | Annually | ASTM E 1703 | 82 |

Calibrations performed by the Region Materials office unless otherwise noted.

Appendix 2

**REGION AND AREA/FIELD LABS**
**CALIBRATION PROCEDURES & RECORDS**
**JUNE 2021**

| EQUIPMENT | PROCEDURE # | RECORD # |
|---|---|---|
| OVEN | 02 | 02 |
| HANDHELD RAMMER PROCTOR | 04 | 04 |
| MOLD PROCTOR | 05 | 05 |
| SIEVES, COARSE | 06 | 06-C |
| SIEVES, FINE | 06 | 06-F |
| UNIT WEIGHT MEASURE | 07 | 07 |
| VACUUM SYSTEM | 09 | 09 |
| COMPRESSION TESTING MACHINE (CONTRACTED) | 11 | 11 |
| LIQUID LIMIT DEVICE and GROOVING TOOL | 15 | 15 |
| FLAKINESS INDEX SLOTTED PLATE | 25 | 25 |
| SLUMP CONE | 38 | 38 |
| MECHANICAL SHAKER | 40 | 40 |
| THERMOMETER | 44 | 44 |
| SCALE, BALANCE | 45 | 45 |
| SCALE, BALANCE (FIELD) | 46 | 46 |
| GYRATORY MOLD, RAM HEAD and BASE PLATE (CENTRAL LAB) | 49 | 49 |
| AIR METER PRESSURE TYPE A | 59 | 59 |
| MECHANICAL RAMMER PROCTOR (CENTRAL LAB) | 67 | 67 |
| RUBBER BALLOON DENSITY APPARATUS | 68 | 68 |
| STRAIGHTEDGE | 70 | 70 |
| CONCRETE CYLINDER MOLD METAL | 71 | 71 |
| AIR METER PRESSURE TYPE B | 72 | 72 |
| SAND EQUIVALENT APPARATUS | 75 | 75 |
| FINE AGGREGATE ANGULARITY (CENTRAL LAB) | 76 | 76 |
| GYRATORY COMPACTOR (CENTRAL LAB) | 78 | 78 |
| CALIPER | 81 | 81 |
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Appendix 3

# SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION
# CLASS Q ASPHALT CONCRETE
# CERTIFICATION PROGRAM

## 1. SCOPE:

The purpose of this program is to develop and maintain a pool of well-trained technicians for the Department and its contractors, and to test and manage highway construction materials. The intent of this program is to improve the quality and performance of hot mixed asphalt pavements through knowledge and understanding of the products.

## 2. CERTIFICATION LEVELS:

Introduction to Asphalt Concrete (strongly recommended but not mandatory.)

Asphalt Concrete Aggregate Testing: SD 108, SD 201, SD 202, SD 208, SD 211, SD 212, SD 213, SD 214, SD 217, and SD 221.

Asphalt Concrete Hot Mix Testing: SD 301, SD 305, SD 306, SD 307, SD 312, SD 314, SD 315, SD 317, SD 318, SD 321, and SD 502.

Asphalt Concrete Roadway Inspection: SD 312, SD 315, and SD 320.

Asphalt Concrete Mix Design & Production Control: SD 203, SD 209, SD 210, SD 212, SD 309, SD 317, SD 319, SD 322.

Aggregate Testing, Asphalt Concrete Hot Mix Testing and Asphalt Concrete Roadway Inspection are prerequisites to Asphalt Concrete Mix Design and Production Control.

## 3. CERTIFICATION STANDARDS:

When the South Dakota Department of Transportation specifications require Quality Control / Quality Assurance testing, those technicians performing the sampling and testing must be certified in South Dakota. Certification may be attained in one of the following ways:

A. Technicians currently certified in a surrounding state may test out of Asphalt Concrete Roadway Inspection. In order to test out the candidate must request to test out of this specific certification level by writing to the South Dakota Department of Transportation Chief Materials and Surfacing Engineer their desire to test out. The candidate must furnish documented work history showing that the candidate has been involved in the specific work area the past four years that relates to the certification level and have a current applicable certification level from one of the surrounding states.

B. Candidates not eligible to test out must attend the certification course.

1. The candidate will successfully complete the class and laboratory evaluations (if required).

a. Classroom Evaluation – Candidates will successfully pass an open book examination administrated by a qualified evaluator.

i. Successfully passing the written examination will be defined as scoring a minimum of 70 percent.

ii. A candidate failing the examination will be given the opportunity to retest within a period of thirty (30) days. There will be no charge for the retest.

iii. Failure to pass the retest will be considered as failing the entire course. Students still desirable of becoming certified must retake the entire course.

b. Laboratory Evaluation – Candidates must successfully perform in the presence of a qualified evaluator, all necessary tests required to control hot mixed asphalt mixtures as outlined in the course manual.

2. No refund of course fees will be made for failure to successfully complete the course.

C. Provisional Certification may be allowed under special circumstances.

1. The applicant’s employer, whether SDDOT or contractor, must include the circumstances for the needed provisional status. These circumstances must outline the reasons for application and should be detailed enough for the Chief Materials and Surfacing Engineer to understand the organizational need for provisional certification.

2. A prior work history of the applicant must accompany the request for provisional status.

3. Whoever is applying for provisional certification in Asphalt Concrete Aggregate Testing, Asphalt Concrete Hot Mix Testing or Asphalt Concrete Roadway Inspection must pass the test for the area of work they are going to perform. This test would be administered by the SDDOT.

4. If the applicant successfully passes the test, they must work under the direction of an Asphalt Concrete Aggregate Testing, Asphalt Concrete Hot Mix Testing or Asphalt Concrete Roadway Inspection certified individual for a period of not less than two (2) days to ascertain familiarity with the project requirements and appropriate tests and procedures.

5. Provisional Certification is only valid for the remainder of the current construction season.

D. Non-certified temporary and seasonal individuals:

1. Non-certified individuals who test materials on a Project must demonstrate that they can correctly perform the test procedure by performing the procedure in front of a certified technician who completes a Performance Checklist. The certified technician will use the Performance Checklist for the test being demonstrated to ascertain that all steps are performed correctly. The performance Checklist will be retained in the laboratory and the Project file, copies will be provided to the Region Materials Engineer and the Project Engineer.

2. The non-certified individual must work under the supervision of a certified individual. The non-certified individual will not assist with or conduct any test unless a passing Performance Checklist has been completed for that test procedure and is on file.

3. The certified technician assumes all responsibility for the accuracy of the test data and signifies by placing their initials as the checker on the worksheet with the test data and signature of the non-certified individual.

4. The non-certified individual will not conduct the hot mix testing on Class Q Asphalt Concrete projects.

3. CERTIFICATION:

Final certification will be contingent upon the applicant passing all course requirements. The SDDOT Materials and Surfacing Certification/Accreditation Program Administrator in Pierre will maintain records of certification. Candidates are responsible for assuring that they work only in areas in which they are certified, that their certification does not expire, and that they are able to provide proof of certification when requested.

4. RECERTIFICATION:

A technician's certification is valid for not more than four (4) years, after which the individual must become recertified before the expiration date of the current certification. Recertification can be accomplished in one of the following ways.

a. Recertification can be accomplished by independent study of course materials and then successfully completing the recertification exam with a score of 70 percent or higher. If the candidate fails to pass the recertification exam, the candidate will attend a certification course and pass the course to become certified. After successfully passing the recertification course, the technician will be fully certified for an additional four (4) year period.

b. The candidate must attend the certification course every four (4) years or attend the certification course and the independent study and recertification test on an alternating basis every four (4) years and before the expiration of the current certification. After the end of a four (4) year recertification period the candidate must attend the certification class.

5. DECERTIFICATION:

Any suspension or revocation of an individual's certification will be administered by the Asphalt Certification Advisory Committee. A meeting of the Asphalt Certification Advisory Committee may be called at any time by the Chair of the committee or by a written request to the Chair.

Allegations of misconduct will be made to the Asphalt Certification Advisory Committee in writing. The allegation will contain the name, phone number, address and signature of the individual(s) making the allegation. Upon receipt of the written allegation, the Oversight Committee will investigate the matter. If warranted, the accused and the individual(s) making the allegation will be given the opportunity to appear before the Asphalt Certification Advisory Committee to resolve the allegation. The Chair of the Asphalt Certification Advisory Committee will provide written notification to all the involved parties of the decision of the Asphalt Certification Advisory Committee. Any warranted penalties may be imposed as determined by the Asphalt Certification Advisory Committee.

For just cause, the Asphalt Certification Advisory Committee may impose suspension or revocation of an individual's certification at any time. An individual may be subject to revocation or suspension of their certification based on falsification of records/tests/reports, negligence, or abuse of their responsibilities. The Asphalt Certification Advisory Committee may also suspend or revoke an individual's certification for other reasons of just cause, which may or may not be specifically defined. Two levels of misconduct which may result in decertification, along with the associated penalties, are defined as follows:

1. Negligence: Negligence is defined as repeated unintentional deviations from approved procedures, which may or may not cause erroneous results. A reoccurring finding of negligence will result in a letter from the Asphalt Certification Advisory Committee to the Employer directing them to write a letter of reprimand to the individual. A continuing finding will result in a suspension of not less than thirty (30) days of the individual's certification. Any subsequent finding will be treated as abuse.

2. Abuse: Abuse is defined as intentional deviations from approved procedures. (Examples of abuse include but are not limited to the falsification of test results or records, submittal of false information on certification applications, and/or unwillingness to follow prescribed test procedures). The first instance of abuse will result in a suspension of not less than one (1) year of an individual's certification. Any subsequent finding of abuse will result in the permanent revocation of the individual's certification.

Any findings of abuse or negligence warranting the revocation or suspension of an individual's certification will result in the revocation or suspension of all certifications held by that individual in the various Materials Testing or Inspection Areas. When the suspended individual is reinstated and prior to performing work, the individual will be required to pass the written and/or performance certification exams as applicable. Any individual whose suspension was for at least one (1) year will be required to attend the asphalt certification courses. Certification expiration date(s) will be the expiration date(s) held prior to suspension.

## 6. ASPHALT CERTIFICATION ADVISORY COMMITTEE:

The purpose of the Certification Advisory Committee is to investigate and resolve allegations of misconduct for Class Q Asphalt Concrete.

Membership: The membership of the Asphalt Certification Advisory Committee will be composed of the following individuals:

a) Construction Engineer Manager - Chair
b) Chief Materials and Surfacing Engineer
c) DAPA Executive Director

Note: A list of Asphalt Certification Advisory Committee members will be maintained by the Certification/Accreditation Program Administrator.

## 7. REGISTRATION:

Registration information for any of the asphalt certification or recertification courses can be obtained from the Dakota Asphalt Pavement Association (DAPA) at dakota-asphalt.org or the SDDOT at https://dot.sd.gov/doing-business/certification-accreditation/training .

# Section Number 4

# Section Number 4

# Section Number 4

## QC/QA SAMPLING AND TESTING
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## Procedure for Moisture Content Determination for Soils and Aggregate

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### 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.

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.

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.

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 will 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 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. 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.

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 will 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 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 % 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 will never be used for determination of in-place dry density.

J. Additional comparison checks against the oven dry method will be performed at a minimum of at least once per 20 moisture tests. Results will 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".

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.

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:

$$\text{Moisture content} = \frac{\text{Weight wet material} - \text{weight dry material} \times 100}{\text{Weight dry material}}$$

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

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 Sta. - Sta. | 27+00 - 53+40 | 27+00 - 53+40 | 27+00 - 53+40 | 27+00 - 53+40 | 27+00 - 53+40 | 27+00 - 53+40 | |
| Depth Below Grade or Top of Pipe | 4.5' Below Grade | 6' Below Grade | 5.5' Below Grade | 5' Below Grade | 2' Below Grade | 4.5' Below Grade | Below Grade |
| 1-Point not made - Refer to Moisture or Density No. | | | | | | | |
| Correction | | | | | | | |
| Field Comparison | | | | | | | |

### Field Moisture

| | | E001 | E002 | E003 | E004 | E005 | E006 | |
|---|---|---|---|---|---|---|---|---|
| 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) Speedy Reading | Standard Moisture Count | 22.0 | 21.2 | 22.9 | 656.0 | 656.0 | 656.0 | |
| 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 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |

# 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.

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.

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.

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.

## 4. Report:

None required.

## 5. References:

SD 213

# 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.

## 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.

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 |

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.

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.

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>

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 |

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:**

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.

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.

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:

| 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 |

$$\text{Fineness modulus (F.M.)} = \frac{265.6}{100} = 2.656 \text{ or } 2.66$$

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.

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.

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.

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.

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 | 0.776 | (H) |
| Chip | 396.00 | 0.224 | (I) |
| | | 0 | |
| | | 0 | |
| Total | 1770.0 | 1.0 | |

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.

**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 (1" rock)

Gradation Check==> 0.15 (Chip)

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==> | 1.14 | **(K)** | % - #200==> | 1.66 | **(M)** |
| Bin adj. - 200==> | 0.881 | **(L)** | Bin adj. - 200==> | 0.370 | **(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)**

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 |
| Chip | | x % Retain/Design | | = | |
| Fine | 1.45% | x % Pass/Design | 42.00 | = | 0.61 |
| 04 Referenced | | Total/Combined - #200 | | | 1.3 |

**(P)**

**(Q)**

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.

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**

**File No.** | 3-19

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 | |
|---|---|---|---|---|
| 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

**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** | | |

| | | | | | |
|---|---|---|---|---|---|
| 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 | |

Comments ______

Figure 1

**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 | | | | |

**Dust Check**

| | |
|---|---|
| wt. before washing (0.1g) | 1069.3 |
| wt. after washing (0.1g) | 1058.5 |
| loss from washing | 10.8 |
| % - #200 | 1.01 |

**+ #4 Gradation Check**

within 0.3% of original dry weight 0.06

**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.C | N.P. ☑ | |
| H. Plastic Limit (D / F x 100) | (0.1g) | | N.P | |
| I. Plasticity Index (G - H) | (0.1g) | | | Specification |
| **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 | wt before washing (0.1g) | | 521.8 |
| Pan wash | | 50.0 | 10.1 | | wt after washing (0.1g) | | 471.8 |
| Total | | 521.5 | | | 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

| | | | | | |
|---|---|---|---|---|---|
| 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 |

**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 |

Comments

Figure 2

**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

| 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

| Dust check | |
|---|---|
| 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 |

| Test | Result | Spec |
|---|---|---|
| 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 |

| Sieve Size mm | in | Total Sample Weight on Sieve | Weight of Tested Portion | Weight of Flat/ Elongated Particles | Percent Flat/ Elongated Individual Sieve | Percent Flat/ Elongated Weighted Average |
|---|---|---|---|---|---|---|
| 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 in the total sample (weighted average) 0.0 rounded 0

Comments 12" sieves used

Figure 3A

**Sample ID** 2203613

## Sieve 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 COARSE AGGREGATE Source Hills Materials, Rapid City Quarry

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)** 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 | | | | | |

**+ #4 Gradation Check**

within 0.3% of original dry weight: 0.18

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. | | | | | |
| 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. | - |

| 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: ____

**- #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
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 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

**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 | * 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

**- #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

Figure 5

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

**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

| Rock Size | 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

| Rock Size | 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

| Rock Size | 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 Source Pete Lein & Sons, Wasta

1155.0 cuyd, RT. 2805.0 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

| 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 | |

| 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

**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) | 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

**File No.**

3-19

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

**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** | | |

| | | | | | |
|---|---|---|---|---|---|
| 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 | |

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

# 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 E 11.

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 will be as follows:

| 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 |

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 E 11
ASTM C 131
SD 201
SD 202
SD 213

# 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 E 11.

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.

## 3. Procedure:

3.1 Obtain samples in accordance with SD 201.

3.2 The size of the specimen will 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:

$$\frac{(\text{Original dry weight - weight after washing})}{\text{Original dry weight}} \times 100 = \text{\% of material finer than \#200 sieve}$$

4.2 Percentages will be reported to the whole number or decimal required by the specification.

## 5. References:

ASTM E 11
SD 108
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 will mean the - #40 sieve material.

## 2. Apparatus:

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 will 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 will conform to ASTM E 11.

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.

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 will 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 will consist of a mortar and rubber covered pestle or a power driven muller) and carefully pulverize the material.

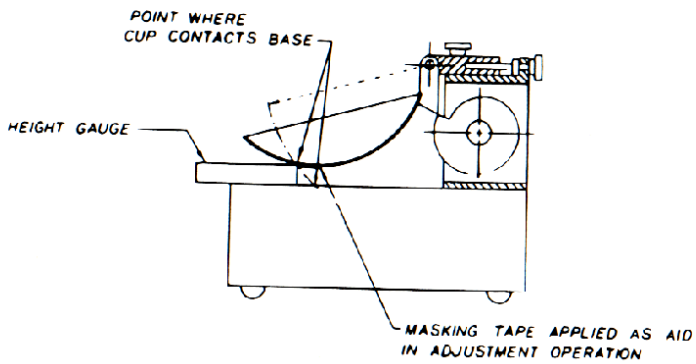
Alternately sieve and pulverize the material until not more than 1% will pass the #40 sieve during 1 minute of sieving.

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.




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 will be added to the moistened soil. The cup of the liquid limit device will 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) will be permitted.

**NOTE: At this point, spilled portions of moistened soil will 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.

**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 will 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.

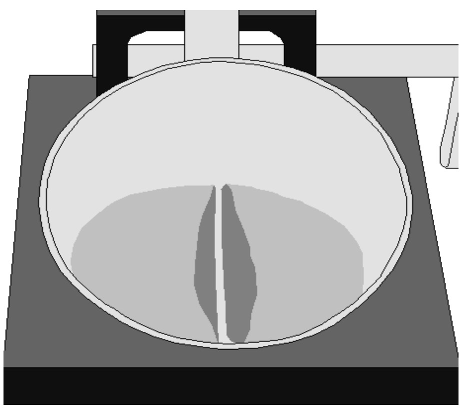


Figure 2
(Soil cake grooved for the test)

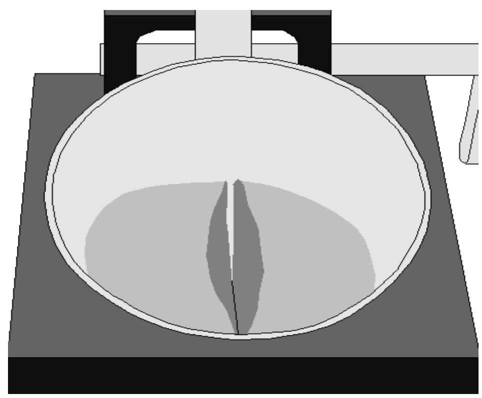


Figure 3
(Soil cake after normal test)

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 will 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.

**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 will be a satisfactory end point, provided the soil has been previously rolled into a 1/8” diameter thread.

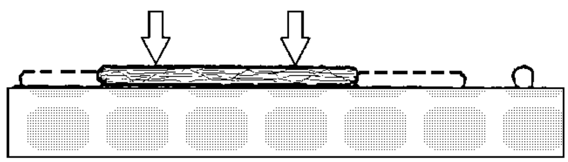


Figure 4

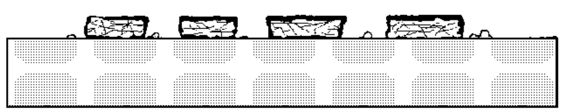


Figure 5

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** | | |

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 E 11
SD 108
SD 202
SD 213
DOT-3

**Sample ID** 2203565

## Sieve 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. 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 | |
|---|---|---|---|---|
| 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 6

# 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 E 11.

2.3 Strainer. A piece of #30 sieve cloth, conforming to ASTM E 11, 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.

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.

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:

$$\%\ \text{lightweight particles} = \frac{\text{wt. of decanted particles}}{\text{wt. of original dry sample}} \times 100$$

4.2 Report the percentage of lightweight particles to the nearest 0.1%.

## 5. References:

ASTM E 11
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.

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.

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 will 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.

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; and

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 C 125, 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

# 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 $ft^3$ 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.

2.4 Sieves. A #4 sieve conforming to ASTM E 11.

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 will 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).

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.

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:

$$A = (P_1A_1 / 100) + (P_2A_2 / 100) + \ldots (P_nA_n / 100)$$

Where:

$A$ = Average absorption, percent,

$A_1, A_2 \ldots A_n$ = Absorption percentages for each size fraction, and

$P_1, P_2 \ldots P_n$ = 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 E 11
SD 201

# 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 E 11.

2.3 Pans for washing and drying the samples.

2.4 Drying oven capable of maintaining a temperature of 230° ± 9°F.

## 3. Procedure:

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 will 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 will 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 will have sharp and well defined edges.

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)

## 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:

ASTM E 11
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:

3.1 Verification of Ratio: Ratio settings on the proportional caliper device will 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 will be combined with the material retained on the 1” sieve. If a 5/8” sieve is used for the sieving, the material retained on that sieve will be combined with the material retained on the 1/2” sieve. If a 1/4” sieve is used in the sieving, the material retained on that sieve will 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 Elongate 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).

| | (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

**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 Source Hills Materils, Rapid City Quarry

Paving 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 | | wt before washing (0.1g) | 3771.0 |
| Pan wash | 0.0 | 1.0 | | 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

| 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

**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

| Rock Size | Sieve Size mm | 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

| Rock Size | Sieve Size mm | 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

| Rock Size | Sieve Size mm | 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 | | | | |

**+ #4 Graduation Check:** within 0.3% of orig dry wt. 0.04

| Dust Check | |
|---|---|
| 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 |

| Test | Result | Spec |
|---|---|---|
| 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 | - |

| 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 |

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 mm | in | Total Sample Weight on Sieve | Weight of Tested Portion | Weight of Flat/ Elongated Particles | Percent Flat/ Elongated Individual Sieve | Percent Flat/ Elongated Weighted Average |
|---|---|---|---|---|---|---|
| 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 |

Total sample wt. 3176.7

Percent flat and enlongated particles in the total sample (weighted average) 1.1

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 will be equipped with 3 receptacles large enough to hold the sample following splitting. Only these receptacles will be used when reducing the sample to the required testing size.

B. Sample splitters will have an even number of equal width chutes. The number of chutes for coarse aggregate will not be less than 8, and for fine aggregate, not less than 12. The chutes will discharge alternately to each side of the splitter. The minimum width of the individual chutes will 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 will 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 will 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.

Fine aggregate is defined as an aggregate in which the entire sample will pass the 3/8" sieve.

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).

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.

C. Split the material by opening the gates of the hopper. The sample will 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).

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.

F. If eight samples are required then split samples (a), (b), (c) and (d) to have eight approximately equal samples.

Figure 1

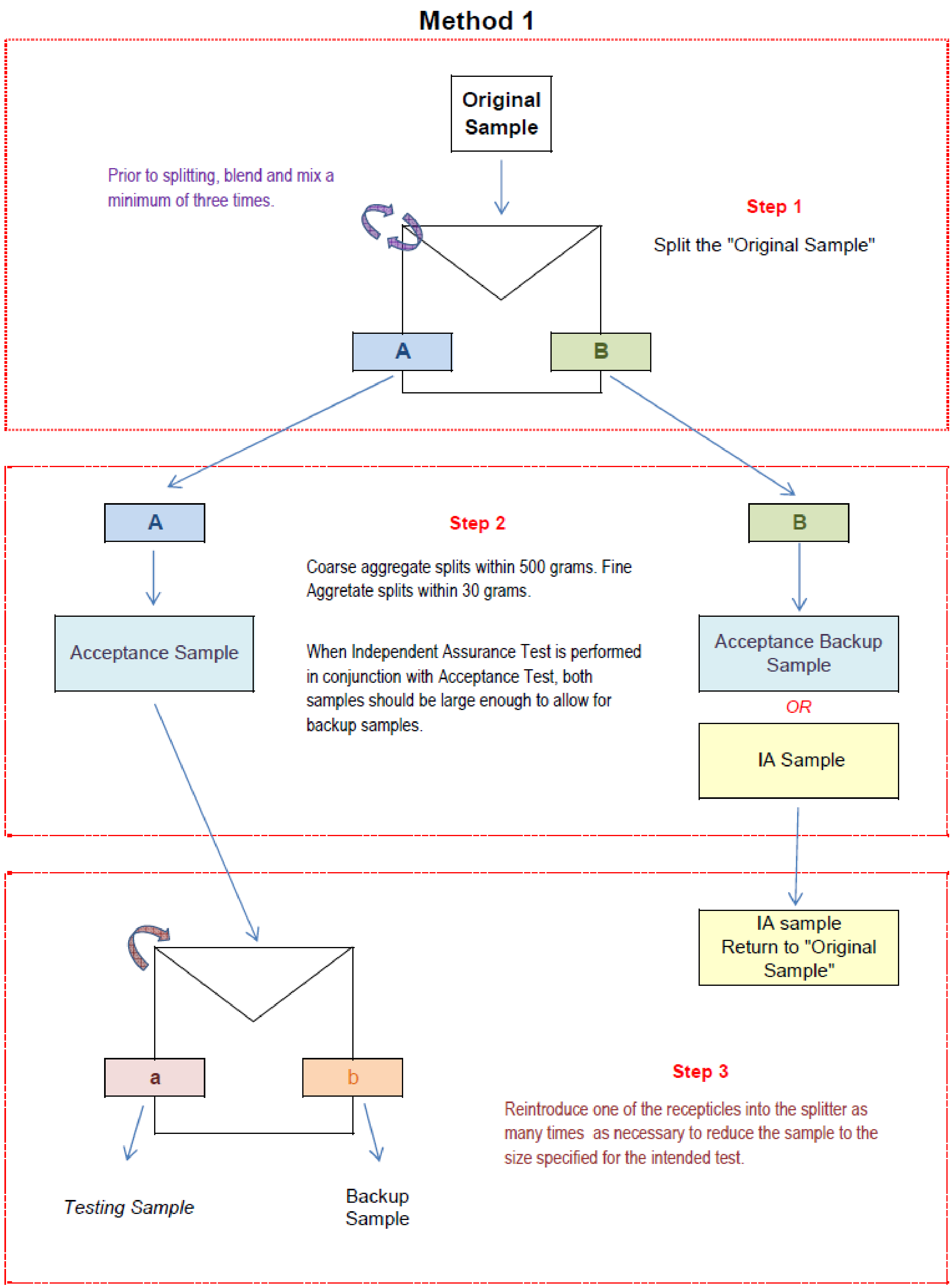

Method 1
Original Sample
Prior to splitting, blend and mix a minimum of three times.
Step 1
Split the "Original Sample"
A
B
A
Step 2
B
Coarse aggregate splits within 500 grams. Fine Aggretate splits within 30 grams.
Acceptance Sample
When Independent Assurance Test is performed in conjunction with Acceptance Test, both samples should be large enough to allow for backup samples.
Acceptance Backup Sample
OR
IA Sample
IA sample Return to "Original Sample"
a
b
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.
Testing Sample
Backup Sample

Figure 2

**METHOD 2**
**Class Q Asphalt**

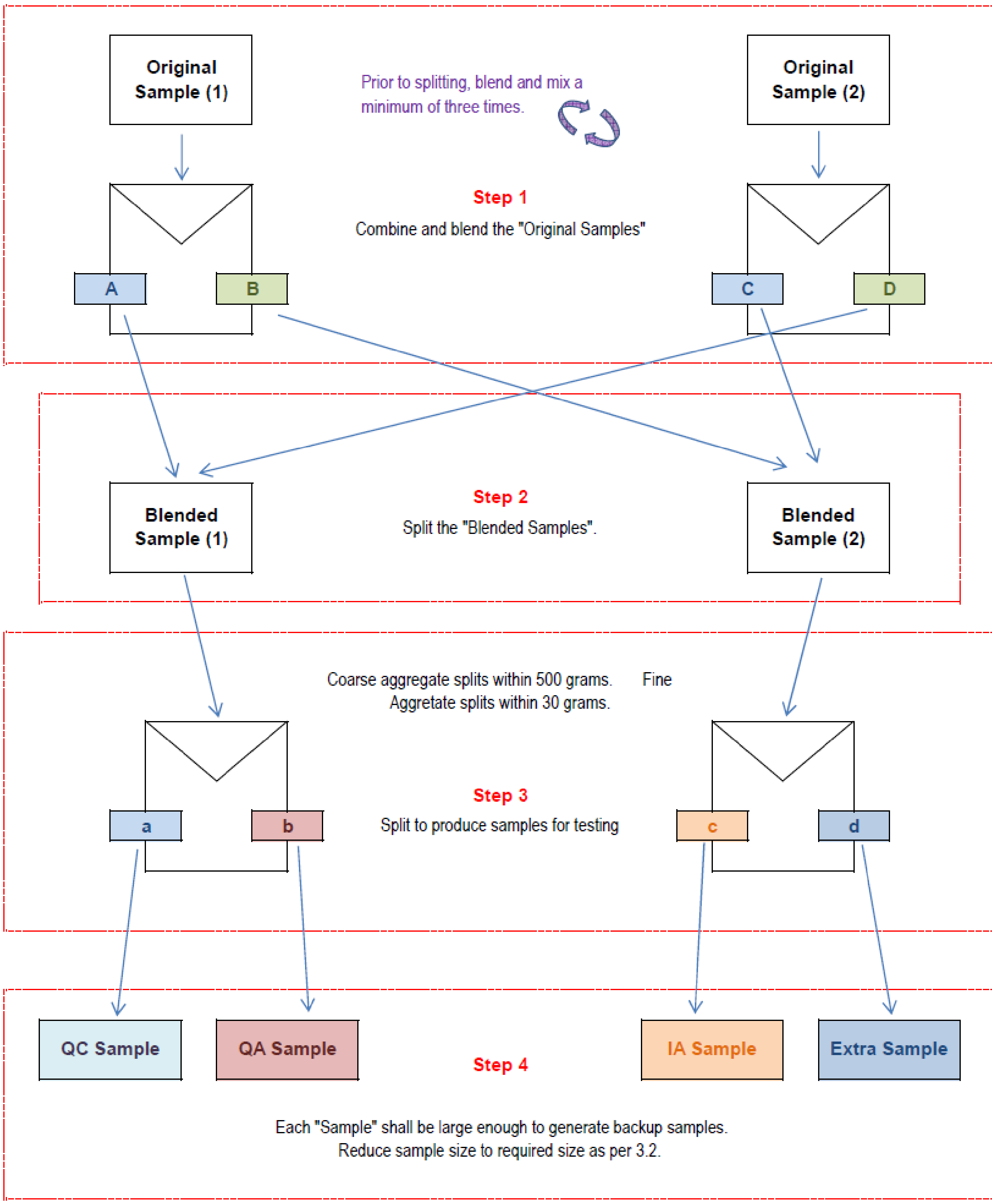
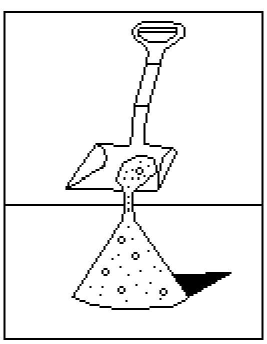



Figure 3

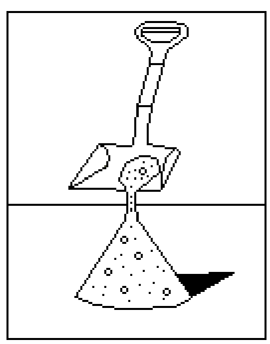
3.3 Quartering.

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.

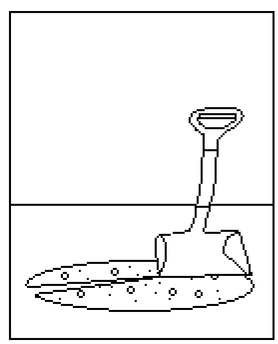
B. As an alternative when the floor surface is uneven, the field sample may be placed on a canvas blanket and mixed with a shovel as described in paragraph 3.3.A. or by alternately lifting each corner of the canvas and pulling it over the sample toward the diagonally opposite corner causing the material 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.



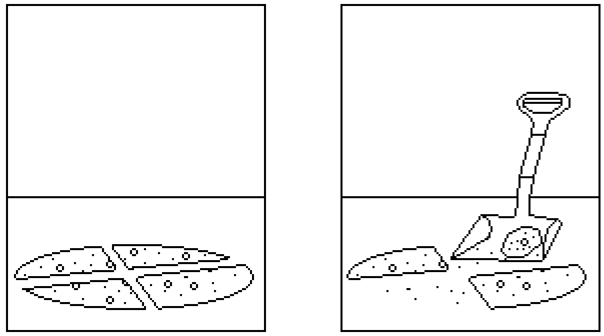
Cone sample on hard, clean level surface



Mix by forming new cone



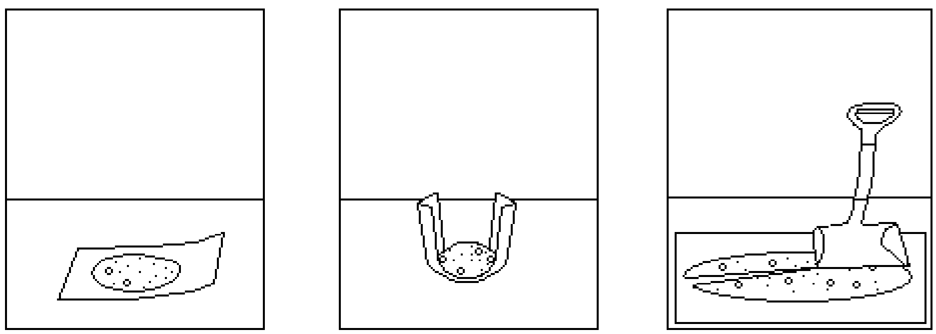
Quarter after flattening cone



Sample into quarters

Retain opposite quarters & Reject other two quarters

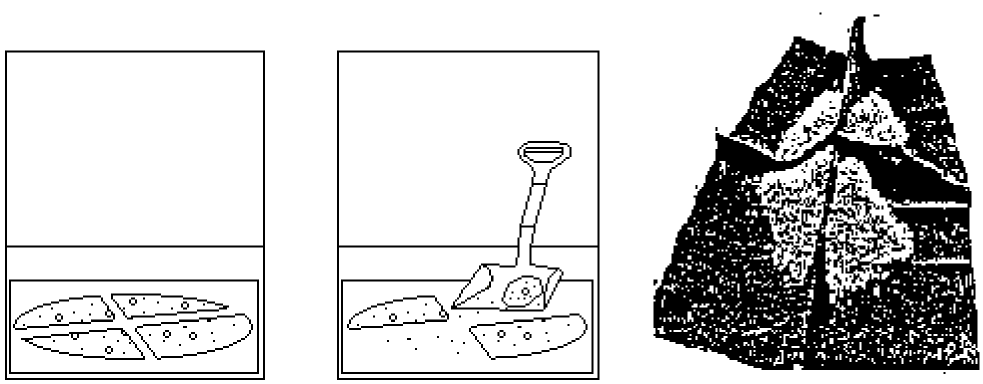
Figure 4



Mix by rolling on blanket

Form cone after mixing

Quarter after flattening cone



Sample into quarters

Retain opposite quarters Reject other Two Quarters

Figure 5

**4. Report:**

None required.

**5. References:**

AASHTO R 76

# 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 will have openings not larger than a #8 mesh.

2.3 A #4 sieve conforming to ASTM E 11.

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 $\pm$ 0.01.

2.7 Drying oven capable of maintaining a temperature of 230° $\pm$ 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.

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.

$$\% \text{ lightweight particles} = \frac{\text{Weight of lightweight particles} \times 100}{\text{Weight of + \#4 material}}$$

4.2 Report the percentage to the nearest 0.1%.

**5. References:**

ASTM E 11
SD 108
SD 201
DOT-3
DOT-68
DOT-69

# 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.

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. Weight the measuring cylinder and glass plate to the nearest 0.1 g.

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 $kg/m^3$ 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 |

$V = 1000\ M/D$

| | |
|---|---|
| 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 through 4.4 with same sample for 2nd trial.

## 5. Report:

5.1 Calculate the uncompacted voids (Us) for each trial as follows:

$$U = \frac{\text{Volume of cylinder – (Mass of aggr. / - \#4 Gsb of aggr.)}}{\text{Volume of cylinder}} \times 100$$

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 | |
|---|---|---|---|
| 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) | | | Average |
| 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

# 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.**

## Method of Test for Sand Equivalent of Fine Aggregate

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### 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.

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 ± 5ºF 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.

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.

4.6 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.

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 2nd 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.)

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:

$$Sand\ Equivalent\ (SE) = \frac{Sand\ Reading\ \times 100}{Clay\ Reading}$$

If the calculated sand equivalent is not a whole number, report the result to the next higher whole number.

$$\left(\frac{4.2}{7.9}\right) \times 100 = 53.16 = 54$$

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

# Method of Field Sampling Asphalt Materials

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## 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.

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.

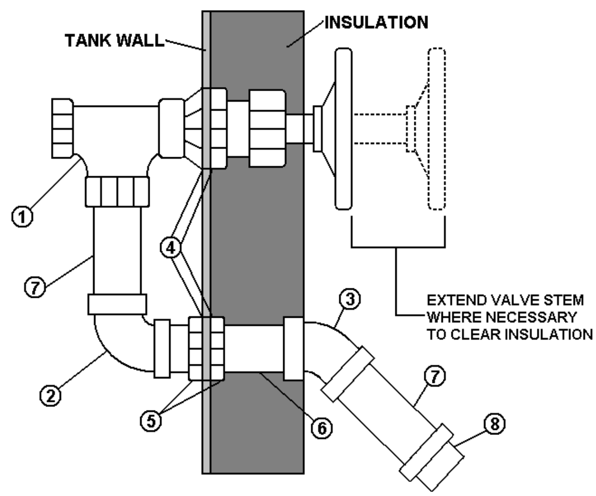
## 3. Procedure:

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.




Mount in Lower Half of the Bulkhead at Least 1' from the Shell

| 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<br>(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 | - |

Figure 1

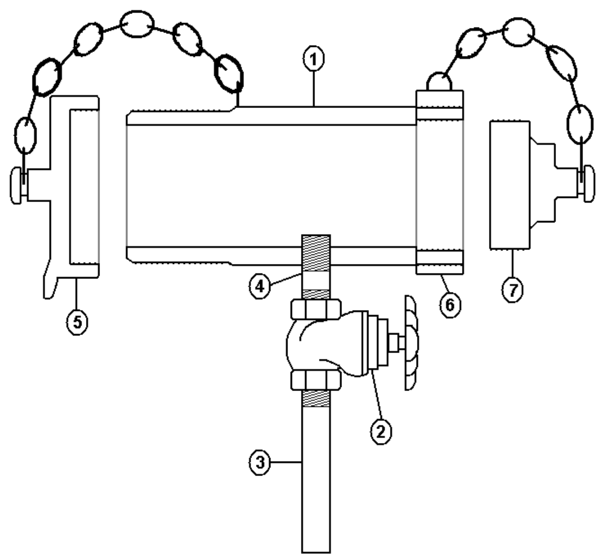
3.2 In-line Sampling Valve.

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

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 <u>both</u> of your samples from either one of the units. <u>Do not</u> 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.

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 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.

## 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.

$$\frac{A - B}{B} \times 100$$

A = Initial weight of uncompacted hot mix or RAP
B = Final dry weight of uncompacted hot mix or RAP

## 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.

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 will 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

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

# Method for Field Determination of the Daily Lime Content

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## 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. ($\mathbf{A}$)

3.3 Calculate the weight of lime added to the tank by taking the summation of all truckloads of lime received for the day. ($\mathbf{B}$)

3.4 Record the weight of lime in the tank at the end of the day. ($\mathbf{C}$)

3.5 Record the weight of asphalt hot mix produced for the day. ($\mathbf{E}$)

**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:

# 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.

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 will 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 will 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.

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.

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.

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

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 will be recorded to the nearest 0.1 gram. Bulk specific gravity and maximum specific gravity will be recorded to the nearest thousandth. Load will be recorded to the nearest pound.

4.3 Volume and percentage calculations will be reported to the nearest 0.01.

4.4 Tensile strength will 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

FILE NUMBER ______________

DOT - 48
3-19

| | |
|---|---|
| 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 |

| | | Spec.'s |
|---|---|---|
| DESIGN LEVEL | Q LVT | |
| DESIGN AIR VOIDS | 2.9 | |
| DESIGN AC CONTENT | 6.0 | |
| AVERAGE AIR VOIDS | 6.72 | 6-8 |
| AVERAGE SATURATION LEVEL | 65.0 | 55-80 |
| TENSILE STRENGTH RATIO | 82 | > 60 |

| 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

SATURATED: 3 MIN. 19 "HG

AVERAGE AIR VOIDS OF SAT. SUBSET: 6.96

| | | 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 | | | | 940 | | 1035 |
| DRY STRENGTH ((2P) / tDπ) | Std | 69.5 | 76.5 | | | | 75.9 | | | 78.0 | |
| WET STRENGTH((2P") / t"Dπ) | Stm | | | 61.0 | 63.5 | | | | 57.8 | | 61.9 |
| VISUAL MOISTURE DAMAGE | | | | | | | | | | | |
| CRACK / BREAK DAMAGE | | | | | | | | | | | |

π = 3.1416

TENSILE STRENGTH RATIO $\frac{\text{Average Wet Strength (psi)}}{\text{Average Dry Strength (psi)}}$ $\frac{Stm1 + Stm2 + .... + Stmn}{Std1 + Std2 + .... + Stdn} = \frac{61.1}{75.0} \times 100 =$ **81.5**

Figure 1

# Method of Test for Determining the Cutout Correction and In Place Density of Asphalt Concrete by the Nuclear Gauge Method

## 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.

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.

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

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).

(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)

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)

(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'.

| 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 $2^{nd}$ 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

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

**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 x 0.001) | 2.6 | 2.5 | 2.6 | | | | | | | | | | | | | | | |

Figure 1

## 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.

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**

## SD 311 - Facts

# Nuclear Density Gauge Facts.

Any department or organization possessing a gauge must be licensed by the NRC.

Follow all safety regulations and transportation rules when transporting and using a nuclear gauge.

All DOT operators of nuclear density gauges must take Troxler training (every 10 years) as well as Hazmat training (every 3 years). This applies to anyone who handles a gauge in any way.

Gauges must be locked when not in use. Other people must be kept 10' away when the gauge is in use.

All operators must wear some type of dosimeter or radiation badge while handling a gauge.

DOT - All gauges are calibrated annually at the Central Laboratory, or whenever the gauge is repaired.

Transportation documents, including the Bill of Lading and Emergency Response Information must travel within immediate accessibility of the driver.

Turn on the gauge and allow it to warm up for at least 10 minutes before taking a Standard Count. It is acceptable to turn the gauge on prior to leaving for a job to allow the gauge to go through its startup routine while locked in its case.

**Standard Counts.**
Prior to use, an operator should conduct a Standard Count daily. To do so, place the gauge's Reference Standard Block on a level surface at least 6 feet from any vehicle or structure, and 30' from any other radioactive source. It should be on concrete or asphalt or compacted aggregate or similar surfaces with a density of at least 100 pcf.

Set the gauge on the standard block, set the rod in the SAFE position and conduct a 4 minute standard count. The density count should be within 1% of the average of the previous 4 density counts and the moisture count should be within 2% of the average of the previous 4 moisture counts. If the gauge does not fall within these parameters, do not accept the counts and take a new standard count. If it fails again, discard and take 4 new standard counts using the manufacturer's guidelines to establish a new average.

Record all standard counts and the number of shots in the Daily Log for the gauge.

# 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 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 Vacuum pycnometer capable of holding 3000 grams of loose asphalt mix.

2.3 Vacuum pump or water aspirator for evacuating air from the container. If a vacuum pump is used a suitable trap will 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) will 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 will 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 will 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 will 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 will 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.

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 $2^{nd}$ 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.

**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 will 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.

C. Separate the particles of the sample on a clean surface, to prevent contamination. The fines portion of the hot mix will 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 will be installed inline to measure the amount of vacuum applied. A bleeder valve will 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.

(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 will be installed inline to measure the amount of vacuum applied. A bleeder valve will 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.

(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 | | | | |

| | 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

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 .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 |

Figure 3

# 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 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.

2.5 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 will 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 will 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.

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 will 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 will 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 will 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

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 will 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.**

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 | Q2 |
| PCN | 5415 | DESIGN AIR VOIDS | 4.0 |
| COUNTY | Harding | DESIGN AC CONTENT | 6.0 |
| 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 | | |

| | | 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 | | | | | | | | | | | |

$\pi$ = 3.1416

TENSILE STRENGTH RATIO $\dfrac{\text{Average Wet Strength (psi)}}{\text{Average Dry Strength (psi)}}$ $\dfrac{\text{Stm1+ Stm2 + ....+ Stmn}}{\text{Std1 + Std2 + .... + Stdn}} = \dfrac{61.2}{75.0} \times 100 =$ **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:

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:

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

| **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** (Spec. Gravity of Bitumen) **X** **0.9171** (Temp. Factor) **X 8.328 (1) =** **7.890** (Lbs. of Bitumen per Gallon @ Temp.)

2. **8.6034** (Wt. per Gallon @ 60°F) **X** **0.9171** (Temp. Factor) **=** **7.890** (Lbs. of Bitumen per Gallon @ Temp.)

| 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

**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) | |

**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

| TANK METHOD | 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) | |

**METER METHOD**

| | |
|---|---|
| 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.

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.**

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.

| Core site | | (Longitudinal location) 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 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

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 × 0.001) | 1.0 | 1.4 | 1.3 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.3 | | | | | | | | |

Figure 2

### 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 2A

# South Dakota Asphalt Concrete Marshall 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).

Contractors and consultants will 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 will witness and/or take the sample. 50 percent of the plan quantity of material or 15,000 tons whichever is less will 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.

## 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 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 $G_{sb}$. 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 $G_{sb}$ will be determined by conducting** $G_{sb}$ **tests on the extracted or ignition oven 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 & 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 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 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.

**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.

## 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.

**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: ______

Figure 1

# Method of Test for Density and Air Voids of Asphalt Concrete by the Gyratory Method

## 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.

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.

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 two 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)

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 ensure 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.

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 <u>carefully</u> 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.

* 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:**

<u>Calculations to be completed on the DOT-86:</u>

- $G_{mm}$ - 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 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 Standard Specifications or project plan notes (Field gyration values will be shown on the DOT-64 mix design form).

<u>Complete the following calculations in order as follows:</u>

**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).

$$Va = \left(\frac{Gmm - Gmb}{Gmm}\right) \times 100 \qquad [Report\ to\ nearest\ 0.1\%]$$

**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

**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.

## 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), if have previous tests from pit history.

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.**

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.

## 5. References

Listed in 2.2 above

## Procedure for Texture of Cold Milled and Micro-Milled Asphalt Concrete Surfaces

---

**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.

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

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.

# Method of Test for Calculating Percent Reclaimed Asphalt Pavement (RAP) in the Mix

## 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)

3.3 Calculate the Moisture in the mix in tons (**C**) (nearest 0.01 ton):

$$C = \frac{\mathbf{A} \times \left(\frac{\mathbf{B}}{\mathbf{100}}\right)}{\left[\mathbf{1} + \left(\frac{\mathbf{B}}{\mathbf{100}}\right)\right]}$$

3.4 Calculate the Total dry amount of hot mix produced for the day in tons (**D**) (nearest 0.01 ton).

$$D = \mathbf{A} - \mathbf{C}$$

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 (***F***) (nearest 0.01 ton):

$$F = \mathbf{A} \times \left(\frac{\mathbf{E}}{\mathbf{100}}\right)$$

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):

$$H = \mathbf{A} \times \left(\frac{\mathbf{G}}{\mathbf{100}}\right)$$

3.9 Calculate the Total dry Virgin MA and RAP from tickets and cutoffs in tons (**I**) (nearest 0.01 ton):

$$\mathrm{I} = \mathbf{D} - (\mathbf{F} + \mathbf{H})$$

<u>Weigh Bridge Entries</u>

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):

$$\mathrm{L} = \frac{\mathbf{J} \times \left(\frac{\mathbf{K}}{\mathbf{100}}\right)}{\left[\mathbf{1} + \left(\frac{\mathbf{K}}{\mathbf{100}}\right)\right]}$$

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**):

$$\mathrm{R} = \mathbf{M} + \mathbf{Q}$$

RAP percentages

3.19 Calculate the Percentage of RAP based on weigh bridges (**S**) (nearest 0.01 percent):

$$\mathrm{S} = \left(\frac{\mathbf{Q}}{\mathbf{R}}\right) \times \mathbf{100}$$

3.20 Calculate the Percentage of RAP based on weigh tickets (**T**) (nearest 0.01 percent):

$$\mathrm{T} = \left(\frac{\mathbf{Q}}{\mathbf{I}}\right) \times \mathbf{100}$$

3.21 Calculate the % Difference between scale tickets and weigh bridges (**U**) (nearest 0.01 percent):

$$\mathrm{U} = \left(\frac{\mathbf{I} - \mathbf{R}}{\mathbf{I}}\right) \times \mathbf{100}$$

**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

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 |

# 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:**

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.

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.

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
CERTIFICATE OF COMPLIANCE
LIME
FILE # ________________

**DOT-60**
**6-18**

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. _____________ | <u>For Truck Shipment</u> | Specimens and certificates sent with driver for delivery to the Project Engineer |
| 2. _____________ | <u>For Rail Shipment</u> | Specimens mailed directly to: South Dakota Department of Transportation, Central Testing Laboratory, Pierre, SD 57501. The Certificate is mailed to: Project Engineer. |

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. <u>SEALED SHIPMENTS BY TRUCK TRANSPORT</u> - 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. <u>SEALED SHIPMENTS BY RAILROAD CAR</u> - 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)

Figure 1

# Section Number 5

Section Number 5

Section Number 5

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| DOT-78Q | Temperature / Viscosity Chart |
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| DOT-86 | Gyratory Specific Gravity |
| DOT-89 | Asphalt Binder Content Determination |
| DOT-93 | Percent RAP in the Mix as a Percent of the Total Aggregate |
| DOT-94 | Stabilizing Additive Determination |
| DOT-97 | Certificate of Compliance for Asphalt Concrete Composite |

DOT-64

25-01

REPORT ON AGGREGATE-BITUMINOUS MATERIAL PROPORTIONS
SOUTH DAKOTA DOT BITUMINOUS MIX DESIGN LAB
MATERIALS & SURFACING
104 S. GARFIELD AVE, BLDG. B
PIERRE, SD 57501

Project : **EXAMPLE** County :

PCN : Reported: 10-Aug-23

Job Location :

Sample Submitted By : Aggr. Sub.: 12-Jul-23 All Data Sub.: 10-Aug-23

Aggregate Source : Quarry
Natural Fines
Recycled Asphalt Pavement (RAP) from Project

Type of Work : Asphalt Concrete Resurfacing **Class Q3R**

**Nominal Agg. Size : 12.5 mm**

Prime Contractor :

GRADATION OF MINERAL AGGREGATE USED FOR TRIAL MIXTURES
(Accumulative Percentages Passing)

| % Virgin | 15 | 20 | 31 | 34 | | Contractor Virgin | Virgin Aggregate |
|---|---|---|---|---|---|---|---|
| % Total => | 12 | 16 | 25 | 27 | 20 | Agg.Comp. | Gradation |
| Sieve | **3/4 Rk** | **9/16 Rk** | **MnSnd** | **NF** | **RAP** | % Passing | Requirements |
| 3/4 IN. | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | **100** | **100** |
| 1/2 IN. | 60.0 | 95.0 | 100.0 | 100.0 | 99.8 | **93** | **86-100** |
| 3/8 IN. | 31.0 | 82.0 | 100.0 | 100.0 | 99.2 | **85** | **78-92** |
| # 4 | 4.0 | 35.0 | 100.0 | 84.0 | 88.2 | | |
| # 8 | 3.0 | 11.0 | 88.0 | 60.0 | 68.3 | **53** | **48-58** |
| # 16 | 2.0 | 4.0 | 69.3 | 50.2 | 52.4 | | |
| # 30 | 1.8 | 7.0 | 52.0 | 33.1 | 39.8 | | |
| # 50 | 1.5 | 4.0 | 31.7 | 15.9 | 27.1 | | |
| # 200 | 1.0 | 1.0 | 2.2 | 5.0 | 9.6 | **2.5** | **0.5-4.5** |

**Virgin Binder by weight of total mix =** **4.3** **per cent** **PG 58-34**
**Total Binder by wt. of total mix (estimate) =** **5.8** **per cent**
**Hydrated Lime by weight of total mix =** **1.0** **per cent**

* Total binder estimate is calculated using **7.60 %** in the RAP x % RAP from daily cutoff (rounded) added to Virgin Binder cutoff.
*example : (7.60 X .19) = 1.44 (1.44 + 4.48 )= 5.92 % (5.9 % rounded) Total Binder for that day* (19% RAP 4.48 Binder Cutoff)

**Gyratory Mix Design Verification as follows:** **Nini 6 Ndes 50**

| | Gmb@ Ndes | Gmm @ Ndes | Va | %VMA | D/EB | Flat & Elong. | FAA | Snd Equiv. |
|---|---|---|---|---|---|---|---|---|
| SD DOT MIX LAB | 2.315 | 2.414 | 4.1 | 15.8 | 0.8 | 2.8 | 45.1 | 71 |
| CONTRACTOR LAB | 2.309 | 2.425 | 4.8 | 15.7 | 0.7 | 1.9 | 44.2 | 73 |

**Field Target Air Void Level :** **4.0 %** **Aggregate Moisture Content at SSD :** **1.3 %**

**Temperature of mixture when emptied from the drum:** **295 ± 20 ° F**
**Temperature of mixture on delivery to the road:** **285 + 30 or - 20 ° F**
**Asphalt application temperature at the mixer:** **300 ± 20 ° F**
**Gyratory compaction temperature:** **275 ± 5 ° F**

Aggr.Composite Gsb
2.581 (Average Results)
Aggr -#4 Gsb
2.570 (Average Results)

**Sample ID:**

# Sample Data Sheet

**DOT-1**
3-19

Certification ID ____________

Project ____________ County ______________________________ PCN ______

Submitted By ______________________ Project Engineer ______________________

Send Results to ______________________________________

Contractor ______________________________________

Sub-Contractor ______________________________________

CHARGE TO (if not above project) ____________________

Bid Item Number ______________________________________________________

Bid Item Description ______________________________________________________

This is a(n) ____________________ sample Material Type ______________________

Field Sample No. __________________ Date Sampled __________

This Sample Represents ______________________________ (quantity & unit of measurement)

Sample ID

File No.

# Sieve Analysis and P.I. Worksheet

DOT-3
3-19

PROJECT ________ COUNTY ________ PCN ________

Charge to (if not above project) ________

Field No. ________ Date Sampled ________ Date Tested ________

Sampled By ________ Tested By ________ Checked By ________

Material Type ________ Source ________

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. | * | | | | | |
| 1/4 in. | | | | | | |
| #4 | * | | | | | |
| 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 | |

False

**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.A. | N.P. | |
| H. Plastic Limit (D / F x 100) | (0.1g) | | N.A. | |
| I. Plasticity Index (G - H) | (0.1g) | | | |
| **Liquid Limit** N.C. ' | (G rounded) | | | - |
| **Plasticity Index** | (I rounded) | N.A. | | - |

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 | * | | | | | | |
| #10 | | | | | | | |
| #12 | | | | | | | |
| #16 | * | | | | | | |
| #20 | | | | | | | |
| #30 | * | | | | | | |
| #40 | | | | | | | |
| #50 | * | | | | | | |
| #80 | | | | | | | |
| #100 | * | | | | | | |
| #200 | | | | | | | |
| Pan dry | | | | | wt before washing (0.1g) | | |
| Pan wash | | | | | wt after washing (0.1g) | | |
| Total | | | | | loss from washing(-#200) | | |

Coarse ________ % 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) | |
| Weight of lightweight particles (0.1g) | |
| Weight of + #4 material (0.1g) | |
| % lightweight particles | |
| **Specification** | |

| | | |
|---|---|---|
| Cr. Fines | Na. Rock | |
| Filler | Ma. Sand | Natural Sand |
| Add Rock | Natural Fines | Cr. Rock |

Comments ________

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION
____________________MATERIALS LABORATORY
____________________, SOUTH DAKOTA
FILE NO. ____________

**DOT-4**
(09/2004)

Lab Test No. ________________

PROJECT NO.: ____________________ COUNTY: ________________________ PCN: ________________
SUBMITTED BY ________________________________________
REPORT TO ________________________________________
CONT. PROD. ________________________________________
SAMPLE OF ________________________________________
TO BE USED ________________________________________
SOURCE ________________________________________
QUAN. REPRSNTD. ________________________________________
DATE SAMPLED ________________________________________
DATE RECEIVED ________________________________________
DATE REPORTED ________________________________________
FIELD TEST NO. ________________________________________
COMMENTS ________________________________________

| Oversize Ret: | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sieve Sizes | | | | | | | | | | | | | |
| Inches | mm | Ret. | Ac.p | Ret. | Ac.p | Ret. | Ac.p | Ret. | Ac.p | Ret. | Ac.p | Ret. | Ac.p |
| 3" | 75 | | | | | | | | | | | | |
| 2-1/2" | 63 | | | | | | | | | | | | |
| 2" | 50 | | | | | | | | | | | | |
| 1-1/2" | 37.5 | | | | | | | | | | | | |
| 1-1/4" | 31.5 | | | | | | | | | | | | |
| 1" | 25.0 | | | | | | | | | | | | |
| 3/4" | 19.0 | | | | | | | | | | | | |
| 5/8" | 16.0 | | | | | | | | | | | | |
| 1/2" | 12.5 | | | | | | | | | | | | |
| 3/8" | 9.5 | | | | | | | | | | | | |
| 1/4" | 6.3 | | | | | | | | | | | | |
| #4 | 4.75 | | | | | | | | | | | | |
| #8 | 2.36 | | | | | | | | | | | | |
| #10 | 2.00 | | | | | | | | | | | | |
| #16 | 1.18 | | | | | | | | | | | | |
| #20 | 0.850 | | | | | | | | | | | | |
| #30 | 0.600 | | | | | | | | | | | | |
| #40 | 0.425 | | | | | | | | | | | | |
| #50 | 0.300 | | | | | | | | | | | | |
| #80 | 0.180 | | | | | | | | | | | | |
| #100 | 0.150 | | | | | | | | | | | | |
| #200 | 0.075 | | | | | | | | | | | | |
| Liquid Limit | | | | | | | | | | | | | |
| Plastic Index | | | | | | | | | | | | | |
| -4 Lt. Wt. Particle | | | | | | | | | | | | | |
| +4 Lt. Wt. Particle | | | | | | | | | | | | | |
| % Crushed PC's. | | | | | | | | | | | | | |
| F.M. | | | | | | | | | | | | | |
| Combined -#200 | | | | | | | | | | | | | |

Deviations/Comparison Results: ________________________________________
________________________________________
________________________________________

cc: Area Engineer
Cert. Engineer
Reg. Matl's Engineer

Respectfully submitted: ____________________________

DOT-5Q
(09/2004)

PROJECT NUMBER ______________________
PCN ______________________
COUNTY ______________________
DATE ______________________
ASPHALT GRADE ______________________
ASPHALT SP.GR. __________

SAND EQUIVALENT

| Sand | Clay | SE |
|---|---|---|
| | | |
| | | |
| | | |
| | Average SE | |

FINE AGGREGATE ANGULARITY

| | Method A | Method C |
|---|---|---|
| | | |
| | | |
| | | |
| Average FAA | | |

| Spec. No. | Ht. (in.) | Dry Wt. (0.1 g) | Sub. Wt. (0.1 g) | SSD Wt. (0.1 g) | Difference (0.1 g) | Bulk Sp. Gr. (0.001 g) | Ave. BSG (0.001 g) | Stability (lbs.) | Corr. Stab. (lbs.) | Flow (0.01 in.) | Av. Flow (0.01 in.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
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**Theoretical Maximum Specific Gravity of Asphalt Mix (Rice)**

| | #1 | #2 | FF 1 or more |
|---|---|---|---|
| (A) Wt. of dry sample | | | |
| (B) Wt. of pycn. and water | | | |
| (C) Wt. of pycn. + water + sample | | | |
| (D) Wt. of SSD sample | | | |
| (E) Temperature of water | | | FF 2 or more |
| (F) Temperature correction factor | | | |
| (G) Maximum theoretical sp.gr. | | | |
| (H) Average max.theo.sp.gr. | | | |

**Bulk Specific Gravity of the Mineral Aggregate**

**+ #4 (Rock)**

| | #1 |
|---|---|
| Dry Wt. | |
| SSD Wt. | |
| Sub. Wt. | |
| Bulk Sp. Gr. | |

**- #4 (Fines)**

| | #1 | #2 |
|---|---|---|
| Dry Weight | | |
| SSD Weight | | |
| Water temp. | | |
| Flask+water | | |
| Flask+water + sample | | |
| Bulk Sp. Gr. | | |

SHEET _______ OF ________

DOT-16
(09/2004)

SUMMARY OF AGGREGATE TEST RESULTS
*File Number* __________

ACCEPTANCE _______
INDEPENDENT ASSURANCE________

PROJECT ___________________________ COUNTY ___________________________ PCN _________________

AREA

MATERIAL TYPE ___________________________ SPECIFICATION REFERENCE ______________________ ENGINEER ___________________________

| TEST IDENTITY | | | | | | | SPECIFICATION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sequence | Number | Date 20__ | Entry By | | | | SIEVE SIZE | | | | | | | | | | FAILING TEST / Date of DOT-18 | STATION TO STATION AND/OR LOCATION | REMARKS |
| | | | | | | | | | | | | | | | | | | | |
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FILE NO. ____________

# SUMMARY OF MEASUREMENTS

PROJECT ______________________________ COUNTY ____________________ PCN ________________

BASE COURSE GRADING MAT SHOULDER SUBBASE ______________________________ DATE: ____________

(Circle designated use) (Other)

| TEST IDENTITY | | DATE 20__ | ENTRY BY | LOT NO. | STATION TO STATION | AT STA. | DIST-ANCE FROM ℄ | DENSITY | | | | | THICKNESS | | WIDTH | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | (lbs/ft$^3$) (kg/m$^3$) | | | % OF STANDARD | | (in) | (mm) | (ft) | (m) | |
| SEQ. | NO. | | | | | | | AVE.LAB UNIT WT | AVE.FLD UNIT WT | MOVING AVERAGE | REQ'D | OBT'D | SPEC. | FIELD | SPEC. | FIELD | |
| | | | | | | | | | | | | | | | | | |
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COPIES TO: Region Materials
Area Engineer

SUBMITTED BY: ______________________________

**DOT-17**
(09/2004)

# REPORT OF REMEDIAL ACTION

**File No.** ________________

| | | | |
|---|---|---|---|
| **Project No.** | ______________________ | **PCN** | ______________________ |
| **County** | ______________________ | **Date** | ______________________ |

| **TEST NO.** | **UNACCEPTABLE COMPARISON TEST RESULTS** |
|---|---|
| | |

| **TEST NO.** | **REMEDIAL ACTION TEST RESULTS** |
|---|---|
| | |

**REMEDIAL ACTION TAKEN:** (Attach additional sheets as necessary)

______________________________________
**Region Materials Engineer** **Date**

cc: Area Engineer
Certification Engineer

**Sample ID** **Test Strip Worksheet** **DOT-28**

**File No.** 3-19

PROJECT ______________ COUNTY ______________________________ PCN ______

Test No. ______________ Test Date ______________ Lift ____ of ____ Thickness ______________

Tested By ______________________________ Checked By ______________________________

Nuclear Gauge No. ______________ Test Mode ______________________________

## NUCLEAR GAUGE WET DENSITY

| | STATION | STATION | STATION | STATION | AVERAGE |
|---|---|---|---|---|---|
| 1st Reading<br>Total Passes ___ | | | | | |
| 2nd Reading<br>Total Passes ___ | | | | | |
| 3rd Reading<br>Total Passes ___ | | | | | |
| 4th Reading<br>Total Passes ___ | | | | | |
| 5th Reading<br>Total Passes ___ | | | | | |
| 6th Reading<br>Total Passes ___ | | | | | |
| 7th Reading<br>Total Passes ___ | | | | | |

## MOISTURE AND DRY DENSITY DETERMINATION

| | | | | |
|---|---|---|---|---|
| A. Final Wet Density | | | | |
| B. Weight of Can and Wet Material | | | | |
| C. Weight of Can and Dry Material | | | | |
| D. Weight of Moisture (B - C) | | | | |
| E. Weight of Can | | | | |
| F. Weight of Dry Material (C - E) | | | | |
| G. % Moisture (D x 100) / F | | | | |
| H. Dry Density (A x 100)/(100 + G) | | | | |

Average Dry Density ______________________________

Sample ID:

# Lime Content Determination - Asphalt Concrete

DOT-33Q
3-19

PROJECT ______ COUNTY ______ PCN ______

Field Nbr ______

Test Date ______ Inspector ______ Contractor ______

Percent Lime Desired ______

Hydrated Lime Type ______

**TANK METHOD**

A. Weight of Lime in Tank at Start (Tons) ______

☐ Tons at Start (at start of project only)

B. Weight of Lime Added to Tank (Tons) ______

C. Weight of Lime in Tank at End (Tons) ______

☐ Left in Storage (at end of project only)

D. Weight of Lime Used (A + B - C) (Tons) ______

E. Weight of Mix Produced (Tons) ______

F. Percent of Lime in Mix (D / E × 100) (%) ______

| | **Summary of Mix Produced** | | **Lime** |
|---|---|---|---|
| To Road | ______ | Tons | ______ |
| Plant Waste | ______ | Tons | ______ |
| Road Waste | ______ | Tons | ______ |
| To Others | ______ | Tons | ______ |
| Produced | ______ | Tons | |

REMARKS

| G. | Load # | Invoice # | Tons | Load Remarks |
|---|---|---|---|---|
| | | | | |

Sample ID:

# Density Report - Bituminous Surfacing

**DOT-42Q**
3-19

PROJECT ________ COUNTY ________ PCN ____

Class and Type ________ Lift ___ of ___ Thickness ____

% Asphalt Binder ____ Actual Finished Width ____ Station ________

Field Nbr ____ Tested By ________ Checked By ________ Date Tested ____

Specification Requirement - Percent of Standard Required ____

Lot No. ____ Lot Location Sta. ________

Core Site Length ____ Lot Width ____ Quantity Represented ________ tons

| Core Measurement Before Sawing | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A.** Sawed core thickness | | | | | | | | | | | | | | | | | | |
| **B.** Apparent dry weight in air | | | | | | | | | | | | | | | | | | |
| **C.** Submersed weight in water | | | | | | | | | | | | | | | | | | |
| **D.** SSD weight in air | | | | | | | | | | | | | | | | | | |
| **E.** Volume of the core (D - C) | | | | | | | | | | | | | | | | | | |
| **F.** Pan number | | | | | | | | | | | | | | | | | | |
| **G.** Weight of pan | | | | | | | | | | | | | | | | | | |
| **H.** Actual dry weight (N - G) | | | | | | | | | | | | | | | | | | |
| **I.** Core bulk specific gravity (H / E) | | | | | | | | | | | | | | | | | | |
| **K.** Moisture in core (D - H) | | | | | | | | | | | | | | | | | | |
| **L.** Percent water absorbed by volume (K / E) * 100 | | | | | | | | | | | | | | | | | | |
| **M.** Maximum allowable weight loss in 1 hour (B × 0.001) | | | | | | | | | | | | | | | | | | |

## Core Drying Weigh Back Area

| | Time (J) | 1A | 1B | 2A | 2B | 3A | 3B | 4A | 4B | 5A | 5B | 6A | 6B | 7A | 7B | 8A | 8B | 9A | 9B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| After reaching constant weight, allow the core & pan to cool to room temp. before weighing for the final time (N) | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | |
| N. Weight of cooled core and pan | | | | | | | | | | | | | | | | | | | |

## Theoretical Maximum Specific Gravity

| Sublot No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 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. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | | | | | | | | | | | | | |
| 1B | | | | | | | | | | | | | |
| 2A | | | | | | | | | | | | | |
| 2B | | | | | | | | | | | | | |
| 3A | | | | | | | | | | | | | |
| 3B | | | | | | | | | | | | | |
| 4A | | | | | | | | | | | | | |
| 4B | | | | | | | | | | | | | |
| 5A | | | | | | | | | | | | | |
| 5B | | | | | | | | | | | | | |

Percent Density ________

**Sample ID**

**File No.**

# Air Voids Report - Bituminous Surfacing

**DOT - 42QA**
**9-14**

County ______________________ PCN/PROJECT ______________________

Field # __________ Sublot Number __________ Date __________ Time __________ Lift ______ of ______

Lot No. __________ Sample Obtained From ______________ Distance ______________ of Centerline

Ticket No. ______________ Quantity Represented ______________ tons

Tested By ______________________ Checked By ______________________

## Theoretical Maximum Density (Rice)

| | 1 | 2 | Rerun |
|---|---|---|---|
| A. Weight of sample in air | | | |
| B. Weight of canister + water | | | |
| C. Weight of canister + water + sample | | | |
| Temperature of the water | | | |
| D. Water correction factor | | | |
| E. Maximum Specific Gravity | | | |
| [A / (A + B - C)] * D | | | |
| F. Average Maximum Specific Gravity | | | |

## Marshall Density Data

| | 1 | 2 | 3 |
|---|---|---|---|
| A. Height of Sample | | | |
| B. Weight of sample in air | | | |
| C. Weight of sample in water | | | |
| D. Weight of SSD sample in air | | | |
| E. Volume Displaced (D - C) | | | |
| F. Bulk Specific Gravity (B/E) | | | |
| G. Compaction temperature | | | |
| Columns Used for Average | | | |
| H. Average Bulk Specific Gravity | | | |

## Percent Air Voids Calculation

[ (Maximum Sp. Gr. - Marsh. Bulk Sp. Gr. ) / Maximum Sp. Gr. ] x 100 = ______________

# MOISTURE SENSITIVITY REPORT - BITUMINOUS SURFACING

DOT-48
9-14

FILE NUMBER ____________________

| | | | |
|---|---|---|---|
| PROJECT | | DESIGN LEVEL | |
| PCN | | DESIGN AIR VOIDS | |
| COUNTY | | DESIGN AC CONTENT | |
| DATE | | | Spec.'s |
| ASPHALT BINDER | | AVERAGE AIR VOIDS | |
| ADDITIVE & DOSAGE | | AVERAGE SATURATION LEVEL | |
| METHOD OF ADDING | | TENSILE STRENGTH RATION | |
| COMPACTION BLOWS | | | |

| SPECIMEN NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DIAMETER (0.01 in.) | D | | | | | | | | | | |
| THICKNESS (0.01 in.) | t | | | | | | | | | | |
| DRY MASS IN AIR(0.1 g) | A | | | | | | | | | | |
| MASS IN WATER (0.1g) | B | | | | | | | | | | |
| SSD MASS (0.1g) | C | | | | | | | | | | |
| VOLUME (C - B) | E | | | | | | | | | | |
| BULK SP. GR. (A / E) | F | | | | | | | | | | |
| THEO. MAX. SP. GR. | G | | | | | | | | | | |
| % AIR VOIDS ((G - F) / G) × 100 | H | | | | | | | | | | |
| VOLUME AIR VOIDS (HE)/100 | I | | | | | | | | | | |
| LOAD (LB.) | P | | | | | | | | | | |

AVERAGE AIR VOIDS OF DRY SUBSET ______

SATURATED ______ MIN. ______ "HG    AVERAGE AIR VOIDS OF SAT. SUBSET ______

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MASS IN WATER (0.1 g) | B' | | | | | | | | | | |
| SSD MASS (0.1 g) | C' | | | | | | | | | | |
| VOLUME (C' - B') | E' | | | | | | | | | | |
| VOL. ABS. WATER (C' - A') | J' | | | | | | | | | | |
| % SATURATION (J' / I) × 100 | | | | | | | | | | | |
| % SWELL ((E' - E) / E) × 100 | | | | | | | | | | | |

CONDITIONED 24 HOURS AT 140°F WATER

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| THICKNESS (0.1 in.) | t" | | | | | | | | | | |
| MASS IN WATER (0.1 g) | B" | | | | | | | | | | |
| SSD MASS (0.1 g) | C" | | | | | | | | | | |
| VOLUME (C" - B") | E" | | | | | | | | | | |
| VOL. ABS. WATER (C" - A) | J" | | | | | | | | | | |
| % SATURATION (J" / I) × 100 | | | | | | | | | | | |
| % SWELL ((E" - E) / E × 100 | | | | | | | | | | | |
| LOAD (LB.) | P" | | | | | | | | | | |
| DRY STRENGTH ((2P) / tDπ) | Std | | | | | | | | | | |
| WET STRENGTH ((2P") / t"Dπ) | Stm | | | | | | | | | | |
| VISUAL MOISTURE DAMAGE | | | | | | | | | | | |
| CRACK / BREAK DAMAGE | | | | | | | | | | | |

π = 3.1416

TENSILE STRENGTH RATIO $\frac{\text{Average Wet Strength (psi)}}{\text{Average Dry Strength (psi)}}$ $\frac{\text{Stm1 + Stm2 + ... + Stmn}}{\text{Std1 + Std2 + ... + Stdn}}$ = $\frac{}{}$ × 100 = ______

EQUIPMENT INSPECTION REPORT
INVENTORY OF CALIBRATED FIELD LAB EQUIPMENT

DOT-49
(09/2004)

PROJECT ____________ COUNTY ____________ PCN ____________

TYPE OF CONSTRUCTION ____________ CONTRACTOR ____________

AREA ENGINEER ____________ PROJECT ENGINEER ____________

LAB PERSONNEL ____________ LAB TYPE ____________

ORGANIZATION RESPONSIBLE FOR EQUIPMENT ____________

**CALIBRATION RECORDS IN FIELD LABORATORY: YES NO**

**TEST EQUIPMENT**

**12" Sieves**

| | | |
|---|---|---|
| 63 | 2 1/2 | ______ |
| 50 | 2 | ______ |
| 37.5 | 1 1/2 | ______ |
| 31.5 | 1 1/4 | ______ |
| 25.0 | 1 | ______ |
| 19.0 | 3/4 | ______ |
| 16.0 | 5/8 | ______ |
| 12.5 | 1/2 | ______ |
| 9.5 | 3/8 | ______ |
| 6.3 | 1/4 | ______ |
| 4.75 | #4 | ______ |
| PAN | | ______ |
| | | ______ |
| | | ______ |
| | | ______ |

**8" Sieves**

| | | |
|---|---|---|
| 9.5 | 3/8 | ______ |
| 6.3 | 1/4 | ______ |
| 4.75 | #4 | ______ |
| 2.36 | 8 | ______ |
| 2.00 | 10 | ______ |
| 1.18 | 16 | ______ |
| 0.850 | 20 | ______ |
| 0.600 | 30 | ______ |
| 0.425 | 40 | ______ |
| 0.300 | 50 | ______ |
| 0.180 | 80 | ______ |
| 0.150 | 100 | ______ |
| 0.075 | 200 | ______ |
| PAN | | ______ |
| | | ______ |
| | | ______ |
| | | ______ |

**Scales**

______
______
______
______
______
______

**Thermometers & Hydrometers**

______
______
______
______
______

**Measure**

______
______
______
______
______

**Molds**

______
______
______
______
______
______
______
______

**Pycnometers & Viscometers**

______
______
______
______
______
______

**Misc. Equip.**

______
______
______
______
______
______
______
______
______
______

**Meters**

Air ______
Volume ______
Density ______
______
______
______

**Liquid Limit Devices**

______
______
______
______
______

**Sieve Shakers**

______
______

**Hammers**

______
______
______
______
______
______

CALIBRATION & COMPARISONS ____________

SAMPLING &/OR TESTING PROCEDURES OBSERVED ____________

REMARKS ____________

cc: Area Engineer

INSPECTED BY ____________
Region Materials Engineer Date

DOT-49A
(09/2004)

# EQUIPMENT CHECKOUT LIST

PROJECT ______________________ PCN ______________________

COUNTY ______________________ ASSIGNED TO ______________________

SCALES ELECTRIC BALANCE __________ 5KG* ______ SET OF WEIGHTS ______
100G(PI) ______ 20KG** 
35LB/16KG ______ PLATFORM *** ______
2KG ______ SET OF WEIGHTS ______ ______
SPLITTERS LARGE 4> ______ MEDIUM 3/4"> ______ SMALL 1"> ______ MINI 1/4" ______

**************************************** G R A D A T I O N ****************************************

SHAKER ______________ TIMER ______

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SIEVE 12" | 3"/75mm | ______ | 1/14"/31.5mm | ______ | 1/2"/12.5mm | ______ | #8 | ______ |
| | 21/2"/63mm | ______ | 1"/25mm | ______ | 3/8"/9.5mm | ______ | PAN | ______ |
| | 2"/50mm | ______ | 3/4"/19mm | ______ | 1/4"/6.3mm | ______ | PAN | ______ |
| | 11/2"/37.5mm | ______ | 5/8"/16mm | ______ | #4/4.75mm | ______ | LID | ______ |
| SIEVE 8" | 3/8"/9.5mm | ______ | #10 | ______ | #40 | ______ | #200 | ______ |
| | 1/4"/6.3mm | ______ | #16 | ______ | #50 | ______ | PAN | ______ |
| | #4/4.75mm | ______ | #20 | ______ | #80 | ______ | LID | ______ |
| | #8 | ______ | #30 | ______ | #100 | ______ | | |

WASH #200 SIEVE ______ LIGHTWEIGHT #30 SIEVE ______ LL & PI #40 SIEVE ______
WASH PANS ______ HOG PANS ______ INSULATED GLOVES ______
BRASS BRUSH ______ STEEL BRISTLE BRUSH ______ SPOON ______
NAIL ______ PAINT BRUSHES ______ STEEL BURN PLATES ______
LIGHTWEIGHT PARTICLES
ZINC CHLORIDE ______ HYDROMETER ______ 250 ML GRAD. CYLINDER ______ RUBBER GLOVES ______
RETAINED #4(COARSE AGGREGATE)>>> BUCKET/BASKET ______ STRAINER ______ SPOON ______
PASSING #4(FINE AGGREGATE)>>> 1000 ML BEAKERS ______ STRAINER ______ SPOON ______
L.L. & P.I. LL MACHINE ______ GROOVING TOOL ______
HOT PLATE ______ PI CANS ______ APPARATUS (MOTOR BOWL & RUBBER PESTLE) ______

**************************************** D E N S I T Y ****************************************

SAND CONE ______ JARS ______ MODIFIED 10" CONE/BASE PLATE ______ SAND ______
VOLUME METER ______ BALLOONS ______ 1/10 FT3 BUCKET ______
4"(101.6 mm) MOLD ______ 6"(152.4mm) MOLD ______ 5.5lb(2.5 kg) RAMMER ______
KNIFE ______ STRAIGHT EDGE ______ #4 ROUGH SCREEN ______ PINE BOARD ______
SPOON ______ DRYING PANS ______ LARGE PAN ______ CEMENT CANS ______
INSULATED GLOVES ______ SPATULA ______ EXTRUDER(JACK) ______
200LB/90KG CONCRETE BLOCK FOR SETTING MOLD ON TO POUND OUT ______
PLASTIC BAGS ______ (SAMPLING & 100 FT/300 m - LL SAMPLES)
SPEEDY ______ (2 - 1 1/4" STEEL BALLS, 2 - 13 gm WEIGHTS, SCOOP, BRUSH, CLOTH) REAGENT ______

**************************************** A S P H A L T D E N S I T Y ****************************************

MARSHALL> MECHANICAL COMPACTION HAMMER/WOODEN BLOCK ______
SET MOLDS ______ PAPER DISC ______ COMPACTION HAMMERS ______
ROASTER OR HOT PLATE ______ BASKET ______ SCALE ______
RICE> VACUUM PUMP/OIL ______ VIBRATOR POT/C-CLAMP & HOLDER ______
PYCNOMETER (CANISTER ______ PRESSURE GAUGE LID ______ CALIB. LID ______
THERMOMETER ______ PRESSURE MANOMETER/DRIERITE UNIT ______
SCALE ___**___ RELEASE AGENT ______ THERMOMETER 50$^0$ - 400$^0$F ______
MISC.> INSULATED GLOVES ______ TROWEL ______ SCOOP ______ PANS ______
CUT OUT CALIB.> 6" MARK OUT BLOCK ______ TIN FOIL 4-12"x18" ______ NAILS ______

**************************************** F R E S H C O N C R E T E T E S T ****************************************

AIR METER ______ TAMPING ROD ______ MALLET ______ STRAIGHT EDGE ______
SLUMP CONE ______ SCOOP ______ POCKET THERMOMETER ______ TROWEL ______
SET CONC. CYLINDERS MOLDS ______
DENSITY/UNIT WEIGHTS> 1/2" PLASTIC COVER ______ SCALE ___***___

______________________ ______________
Signature Date

DOT-50
(09-2008)

File No. ______________

FIELD LABORATORY INSPECTION RECORD

TYPE OF LAB _______

Project ____________________ County ____________________ Contractor ____________________

This record is provided to determine compliance with specifications, to document acceptable deviations, and to record the initial and final condition of the contract Field Laboratory used on this project.

**NOTE:** Representatives of the South Dakota Department of Transportation and the Contractor should make the initial inspection and record when the Field Laboratory is placed, ready for use, and the final report when the project is completed or the Laboratory released. Minor deviations which do not impair its usefulness, or are compensated for by related features exceeding minimum specification requirements, will be permitted when explained and documented herein. Changes made in locations of, malfunctions, damages, and/or repairs made to the Field Laboratory shall be recorded. Briefly describe, in column 9, or the summary, all notations made in columns 4, 6, and 8.

| ITEM | Quantity or Dimensions | SPECIFICATION COMPLIANCE | | CONDITION OF LABORATORY | | | | INSTRUCTIONS: Use numerical values, Col. 2. Indicate by "yes" or "no", Col. 3 & 4. Check ( ) proper column, Col. 5, 6, 7, 8. |
|---|---|---|---|---|---|---|---|---|
| | | | | Begin Proj. | | End Proj. | | |
| | | Satisfactory | Accepted as Noted | Satisfactory | Needs Repair | Satisfactory | Needs Repair | REMARKS |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 1. HEATING and/or COOLING SYSTEM | | | | | | | | |
| 2. CABINET (enclosed) | | | | | | | | |
| 3. CHAIRS/STOOLS | | | | | | | | |
| 4. DESK | | | | | | | | |
| 5. DIMENSIONS Length ______ Width ______ Height ______ | | | | | | | | |
| 6. DOORS | | | | | | | | |
| 7. EQUIPMENT (for concrete test specimens, if required) | | | | | | | | |
| 8. EXHAUST FANS | | | | | | | | |
| 9. LIGHTS (electric) | | | | | | | | |
| 10. OUTLETS (electric) | | | | | | | | |
| 11. POWER | | | | | | | | |
| 12. RANGE/OVEN Size ________ Burners ________ | | | | | | | | |
| 13. ROOMS OR SECTIONS | | | | | | | | |
| 14. SINK | | | | | | | | |
| 15. TABLES | | | | | | | | |

| (1) | | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| 16. WATER SYSTEM | Capacity ______<br>Pressure ______<br>Gravity | | | | | | | | |
| 17. WINDOWS | | | | | | | | | |
| 18. FIRE EXTINGUISHERS | | | | | | | | | |
| 19. MICROWAVE OVEN | | | | | | | | | |
| 20. FIRST AID KIT | | | | | | | | | |
| 21. EYEWASH | | | | | | | | | |
| 22. BROOM/DUSTPAN/GARBAGE | | | | | | | | | |
| 23. SANITARY FACILITY | | | | | | | | | |
| 24. PHONE/ANSWERING MACHINE/FAX/COPIER | | | | | | | | | |
| 25. CONVECTION OVENS (if applicable) | | | | | | | | | |
| 26. CONCRETE BASE (if applicable) | | | | | | | | | |
| 27. STEPS AND HAND RAILINGS | | | | | | | | | |
| 28. LAB ANCHORING SYSTEM | | | | | | | | | |
| 29. NO SMOKING FACILITY SIGNS POSTED | | | | | | | | | |

SUMMARY AND ADDITIONAL COMMENTS:

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

DEPARTMENT OF TRANSPORTATION | CONTRACTOR

Initial Inspection ____________________ ________ ________ ____________________ ________ ________
Name Title Date Name Title Date

Final Inspection ____________________ ________ ________ ____________________ ________ ________
Name Title Date Name Title Date

ACCEPTED FOR FINAL PAYMENT ____________________ ____________
Name Date

____________________
Title

# BULK SPECIFIC GRAVITY OF MINERAL AGGREGATE

| | | | |
|---|---|---|---|
| PROJECT: | | AGGREGATE TYPE: | |
| PCN: | | PIT LOCATION: | |
| COUNTY: | | % RETAINED #4: | |
| | | % PASSING #4: | |

## - #4 Bulk Specific Gravity

| | #1 | #2 |
|---|---|---|
| (A) weight of oven dry sample in air: | | |
| (B) weight of pycnometer filled with water: | | |
| (C) weight of pycn. + water + sample: | | |
| (S) weight of saturated surface dry sample: | | |
| temperature of the water: | | |

BULK SP. GR. $\frac{A}{(B + S - C)}$ ______ ______

AVERAGE = [ ]

APPARENT SP. GR. $\frac{A}{(B + A - C)}$ ______ ______

AVERAGE = [ ]

WATER ABSORPTION (percent) (S-A / A) * 100 ______ ______

AVERAGE = [ ]

## + #4 Bulk Specific Gravity

| | |
|---|---|
| (A) weight of oven dry sample in air: | |
| (B) weight of sat. surf. dry sample in air: | |
| (C) weight of saturated sample in water: | |
| Temperature of the water: | |

BULK SP. GR. $\frac{A}{(B - C)}$ ______ [ ]

APPARENT SP. GR. $\frac{A}{(A - C)}$ ______ [ ]

WATER ABSORPTION (percent) $\frac{(B - A) * 100}{A}$ ______ [ ]

SAMPLE BULK SPECIFIC GRAVITY
Gsb = bulk specific gravity for the total sample
P1, P2, Pn = individual percentages by weight of aggregate
G1, G2, Gn = individual bulk specific gravities of aggregate

$$Gsb = \frac{P1 + P2 + \ldots\ldots + Pn}{P1/G1 + P2/G2 + \ldots\ldots + Pn/Gn}$$

Bulk Sp. Gr. (Gsb) = [ ]

SAMPLE APPARENT SPECIFIC GRAVITY
Gsa = apparent specific gravity for the total sample
P1, P2, Pn = individual percentages by weight of aggregate
G1, G2, Gn = individual apparent specific gravities of aggregate

$$Gsa = \frac{P1 + P2 + \ldots\ldots + Pn}{P1/G1 + P2/G2 + \ldots\ldots + Pn/Gn}$$

Apparent Sp. Gr. (Gsa) = [ ]

WATER ABSORPTION (percent)
Aw = water absorption for the total sample
P1, P2, Pn = individual percentages by weight of aggregate
A1, A2, An = absorption percentages for each size fractions

$$Aw = (P1*A1/100) + (P2*A2/100) + \ldots\ldots + (Pn*An/100)$$

Water Absorption (Aw) = [ ]

Sample ID

# Surface Texture Measurements of Asphalt Concrete Surfaces

DOT - 55A
3-21

PROJECT ____________ COUNTY ____________ PCN ____________

Date Tested ____________ Tested by ____________ Checked by ____________

Test No. ____________

Area Represented Station ____________ to Station ____________ Road Width ____________

| | | | | | |
|---|---|---|---|---|---|
| SITE NO. | | | | | |
| STATION | | | | | |
| Dist. to CL | | | | | |
| | Depth (X/32) | Depth (X/32) | Depth (X/32) | Depth (X/32) | Depth (X/32) |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| TOTAL | | | | | |
| Avg. Depth | | | | | |
| | Is spacing Within Spec (Enter Y or N below) | | | | |
| SPACING | | | | | |

Lot Average: ____________

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.

**DOT-62**
(09/2004)

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION
CERTIFICATE OF COMPLIANCE FOR ASPHALT
File # ____________________

*PROJECT____________________________ COUNTY_____________________________ PCN ______________

SUPPLIER __________________________________ CONSIGNEE ______________________________________

Bill of Lading or Invoice No. ___________________ Tank Car or Truck No. ______________________________

**Type & Grade of Material _____________ Specific Gravity @ $60^0$F. _________ Net Weight ______________

DESTINATION ____________________________________ DATE SHIPPED ____________________________

**TEMPERATURE FOR KINEMATIC VISCOSITY**

| FOR MIXING APPLICATION | FOR SPRAY APPLICATION |
|---|---|
| 300 Centistokes = __________ $^0$F | 200 Centistokes = __________ $^0$F. |
| 150 Centistokes = __________ $^0$F | 50 Centistokes = ___________ $^0$F. |

This shipment of asphalt material complies with specification requirements of the South Dakota Department of Transportation. The transporting conveyance has been inspected and found free of contaminating material.

SIGNED ___________________________________________
Supplier's Authorized Representative

* Information may be supplied at destination, if not known when loading.

** If material contains anti-stripping additive, the grade shall be indicated with the notation "with anti-stripping additive".

NOTE: The specimen shown here details the information required.
Such data may be forwarded on the supplier's own invoice, Bill of Lading, or on his own reproductions of the specimen format.

Two (2) copies with each conveyance.

Original - To project file
Duplicate - To Central Testing Laboratory

File No. ___________

DOT-65
(09/2004)

# ASPHALT CONCRETE
## JOB MIX FORMULA - BITUMINOUS SURFACING

Project ______________________ County ___________________________ PCN ________________

Contractor ______________________________ Asphalt Concrete Type __________________________

Area Engineer ____________________________ Time ______ Date __________________, 20 ________

The following job mix formula with permissible tolerances as set forth in the specifications shall apply to the Bituminous Plant Mix on the above project effective this date until otherwise notified.

| | | |
|---|---|---|
| 1 1/4" sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| 1.0" sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| 3/4" sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| 1/2" sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| 3/8" sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| No. 4 sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| No. 8 sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| No. 16 sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| No. 40 sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| No. 80 sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| No. 200 Sieve - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | % Passing | ___________ |
| ) - - - - Hot Mix-Main Line | % Total Mix | ___________ |
| Asphalt Content ) | | |
| ) - - - - Hot Mix-Shoulders | % Total Mix | ___________ |
| Temperature of mixture when emptied from mixer | | ________________ |
| Temperature of mixture on delivery to the road | | ________________ |
| Asphalt application temperature (at mixer) | | ________________ |

______________________________
AREA ENGINEER

cc: Bituminous Engineer
Region
Region Materials
Contractor

Sample ID

File No.

# Asphalt Plant Mix - Spot Check

DOT-66

7-19

PROJECT ____________ COUNTY ____________ PCN ________

Field # ____________ Date Sampled ____________ Date Tested ________

Inspector ____________ Contractor ________________

| **TANK METHOD** | **Tank #1** | **Tank #2** |
|---|---|---|
| A. Beginning Specific Gravity of Bitumen @ 60 F | ________ | ________ |
| B. Beginning Weight Per Gallon @ 60 F | ________ | ________ |
| C. Temperature of Bitumen in Tank When Check Starts | ________ | ________ |
| 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) | ________ | |
| 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) | ________ | |
| P. Percent Bitumen in Mix (N / O x 100) | ________ | |

**METER METHOD**

Q. Applied Temperature of Bitumen ________

R. Weight Per Gallon (D) of BItumen at Applied Temperature ________

S. Weight of Mix Produced (tons) ________

| 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 ________________________________________

## DETERMINING POUNDS OF BITUMEN PER GALLON

1. ________________ X ____________ = X 8.328 (1) = _____________ lbs. of Bitumen per
   Spec. Gravity of Bitumen Temp. Factor
   Gallon @ temperature

2. ______________________ X __________________ = ________ lbs. of Bitumen per
   Wt./Gal. @ 60°F Temp. Factor
   Gallon @ temperature

| Temp. °F | 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)

DOT-67
(11/2005)

# DISTRIBUTOR "SHOT" RECORD SHEET

File No. ____________

PROJECT ______________________ COUNTY ______________________ PCN ______________

AREA ENGINEER ______________________________ INSPECTOR ______________________________

MATERIAL __________ SPECIFIC GRAVITY ____________ PLAN RATE __________ LBS., GALS OR SQ. YDS.

| Sta to Sta | Car or Transp Number | Wt or Gal Start | Wt or Gal Stop | Wt or Gal Used | Oil Temp $^0$F | Convers. Factor | Comp Gal 60$^0$F | Width | Lin. Ft. Actual | Lin. Ft. Comp | Sq Yds | Actual Lbs, Gals or Sq Yd | Sec | Date | * Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

REMARKS ________________________________________________

________________________________________________

* Weather Code 1. CLEAR 2. PARTLY CLOUDY 3. CLOUDY 4. MIST 5. RAIN 6. SNOW

**Sample ID** | **Sieve Analysis** | **DOT-68**

**Mineral Aggregate** | **Stationary Plant Mix** | 3-19

| Mix Batch Ticket | lbs./cu. yd. | Total Agg% |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| Total | | |

Test# ____________ File Number ____________

PCN ____________ Project ____________

County ____________

Charge to (if not above project) ____________

Sample Represents ____________ Cu. Yd. Class and Type ____________

Date Sampled ____________ Sampled By ____________

Date Tested ____________ Tested By ____________

Checked By ____________

Contractor ____________

**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==>

**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==>

Sample ID

**Composite Coarse Aggregate**

| **Sieve Size** | | | | | Retained Total | Cumulative Passing | Specification Gradation | Job Mix Formula |
|---|---|---|---|---|---|---|---|---|
| 2 | | | | | | | | |
| 1 1/2 | | | | | | | | |
| 1 1/4 | | | | | | | | |
| 1 | | | | | | | | |
| 3/4 | | | | | | | | |
| 5/8 | | | | | | | | |
| 1/2 | | | | | | | | |
| 3/8 | | | | | | | | |
| 1/4 | | | | | | | | |
| #4 | | | | | | | | |
| #8 | | | | | | | | |
| Pan | | | | | | | | |
| Total | | | | | | | | |

**Total Combined - #200 ==>** ________

Coarse ________ % x % Retain/Design ________ = ________

Fine ________ % x % Pass/Design ________ = ________

**Total/Combined - #200**

**+ #4 % Particles less than 1.95 SP. GR.**

Specific gravity of solution (1.95 ± 0.01) ________ ________

wt. of lightweight particles (0.1g) ________ ________

weight of + #4 material (0.1g) ________ ________

% lightweight particles ________ ________

Bin Adj. % lightweight particles ________ ________

**Composite % lightweight particles** [ ]

SPECIFICATION ________

Sample ID

| Rock Size / % of Rock | 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: ______

| Rock Size / % of Rock | 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: ______

| Rock Size / % of Rock | 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:** ______

Rounded: ______

**Specifications:** -

**Sample ID**
**File No.**

# Gyratory Aggregate Worksheet

DOT-69
3-19

PROJECT ______ COUNTY ______ PCN ______

**Field No.** ______ Date Sampled ______ Date Tested ______

Sampled By ______ Tested By ______ Checked By ______

Material Type ______ Lot No. ______ Sublot No. ______

Lift ______ of ______

Weight Ticket Number or Station ______ Source ______

% moist. = (wet wt. ______ - dry wt.) / dry wt. x 100 = [ ]

**Original Dry Sample Wt.** (.1g) [ ]

| 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 | | | | | |
| 16 | 5/8 | | | | | |
| 12.5 | 1/2 | | | | | |
| 9.5 | 3/8 | | | | | |
| 6.25 | 1/4 | | | | | |
| 4.75 | #4 | | | | | |
| Pan | | | | | | |
| Total | | | | | | |

**+ #4 Graduation Check:** within 0.3% of orig dry wt.

| Dust check | |
|---|---|
| wt. before washing(0.1g) | |
| wt. after washing(0.1g) | |
| loss from washing | |
| % - #200 | |

| Sand Equiv. Test | Sand Rdg. | Clay Rdg. | S.E. |
|---|---|---|---|
| Reading #1 | | | |
| Reading #2 | | | |
| | | | |

Sand Equivalent Tests Results [ ] ______

Fine Aggregate Angularity Test Results [ ] ______

Flat and Elongated Particles Test Results [ ] ______

| 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 | | | | | | |
| 2.00 | 10 | | | | | | |
| 1.70 | 12 | | | | | | |
| 1.18 | 16 | | | | | | |
| 0.850 | 20 | | | | | | |
| 0.600 | 30 | | | | | | |
| 0.425 | 40 | | | | | | |
| 0.300 | 50 | | | | | | |
| 0.180 | 80 | | | | | | |
| 0.150 | 100 | | | | | | |
| 0.075 | 200 | | | | | | |
| Pan dry | | | | | wt before washing (0.1g) | | |
| Pan wash | | | | | wt after washing (0.1g) | | |
| Total | | | | | loss from washing(-#200) | | |

Coarse ______ % x % Retain/Design ______ = ______
Fine ______ % x % Retain/Design ______ = ______
Total/Combined - #200 ______

**- #4 Gradation check:** within 0.3% of the wt before washing [ ]

| Filler | Natural Sand | Na. Rock |
|---|---|---|
| Cr. Rock | Cr. Fines | Ma. Sand |
| Natural Fines | | |

**+ #4 % Particles less than 1.95 SP. GR.**

| | | |
|---|---|---|
| Specific gravity of solution | (1.95 ± 0.01) | ______ |
| wt. of lightweight particles | (0.1 g) | ______ |
| weight of + #4 material | (0.1 g) | ______ |
| % lightweight particles | | ______ |
| SPECIFICATION | | ______ |

**- #4 % Particles less than 1.95 SP. GR.**

| | | |
|---|---|---|
| Specific gravity of solution | (1.95 ± 0.01) | ______ |
| wt. of lightweight particles | (0.1 g) | ______ |
| weight of - #4 material | (0.1 g) | ______ |
| % lightweight particles | | ______ |
| SPECIFICATION | | ______ |

**Crushed Particles Test**

weight of crushed particles ______
weight of total + #4 sample ______
percent of crushed particles ______
SPECIFICATION ______ or more FF, min ______

| | | |
|---|---|---|
| Weight of measure and glass plate | | |
| Weight of measure, glass plate & water | | |
| M = net mass of water | | |
| Water Temperature / Density | | |
| V = volume of cylinder, mL | | |

| | | | |
|---|---|---|---|
| Dry - #4 bulk specific gravity (Gsb) | | | |
| Volume of cylinder, mL(V) | | | |
| Weight of cylinder, g (A) | | | |
| Wt of cylinder + aggregate, g (B) | | | |
| Wt. aggregate, g (F=B-A) | | | Average |
| Uncompacted voids, (nearest 0.1%) U=((V-(F/Gsb))/V) x 100 | | | |

| Sieve Size mm | in | Total Sample Weight on Sieve | Weight of Tested Portion | Weight of Flat/ Elongated Particles | Percent Flat/ Elongated Individual Sieve | Percent Flat/ Elongated Weighted Average |
|---|---|---|---|---|---|---|
| 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. _____

Percent flat and enlongated particles
in the total sample (weighted average) _____ rounded _____

**Specifications** _____

Comments ________________________________________

DOT-70
(09/2004)

# LETTER OF TRANSFER FOR MATERIALS

File # ____________________

FROM ________________________ TO ____________________________ DATE _________________________
Area Area

RE: Material Transfer From Project (A) ______________________________ PCN _________________

To Project (B) ______________________________________________ PCN _________________

As requested by ____________________________________________, this letter of transfer will provide the data
Contractor

required for permission to transfer the material represented and previously accepted for use.

Material description, producer and remarks ________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Date(s) used on previous Project (A) _______________________________________________

Identity (Type, size, grade, model, catalogue No., etc.) _______________________________

Batch, Lot No., Tag No., Stamp No. ________________________________________________

Original Quantity ______________________________________________________________

Transfer Quantity ______________________________________________________________

Date of Transfer _______________________________________________________________

Basis for Acceptance, Project (A): Test No. ________________________ Date ____________________

Other ____________________________________________________

For Asphalt Materials Include the following:

*A. Specific Gravity @ $60^0$ F. ________________________________________

*B. Temperature for Kinematic Viscosities:
300 Centistokes =
150 Centistokes =
200 Centistokes =
50 Centistokes =

C. Transfer Vehicle No. ____________________________________________

*A copy of the test may be attached to this sheet.

______________________________________ENGINEER

cc: Contractor
Project File
Region Materials
Certification Engineer

**DOT-71**
(09/2004)

SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION

FILE NO. __________

## RECORD OF ORAL COMMUNICATION

PROJECT ____________________ COUNTY ____________________ PCN __________

______________________________________________ DATE __________

WITH ______________________________________________

TEL. __________, VISIT __________, RADIO __________, CONFERENCE __________

PLACE ______________________________________________

1) PURPOSE ______________________________________________

2) PERTINENT FACTS ______________________________________________

3) CONCLUSIONS OR RECOMMENDATIONS ______________________________

cc:

By ____________________
Title ____________________

DOT-74
(09/2004)

SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION

FILE NO. __________

**PROJECT SUMMARY OF BITUMEN APPLIED**

PROJECT __________________________ COUNTY ____________________________ PCN ________________

SUPPLIER(S) ________________ CONTRACTOR ________________ AREA ENGINEER ________________

| Weigh Ticket No.* | | NET POUNDS BY GRADE | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Contractor Carrier On Hand | Commercial Carrier In Storage | | | | | | | | Start of Project |
| | | | | | | | | | |
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| | | | | | | | | | |
| Sub-Total – Pounds | | | | | | | | | |
| **DEDUCTIONS:** | | | | | | | | | |
| Rejected | | | | | | | | | |
| Wasted | | | | | | | | | |
| Used off Project | | | | | | | | | |
| Left in Storage | | | | | | | | | |
| Net Total Pounds | | | | | | | | | |
| Net Total Tons | | | | | | | | | |

_______________________________________________
Inspector Date

DETERMINING POUNDS OF BITUMEN PER GALLON

1. __________ x ____________ = ________ x 8.328 = __________ Lbs. Of Bitumen per gallon at temperature
   Sp. Gravity of Bitumen    Temp. Factor

2. ________________ x ________________ = __________ Lbs. of Bitumen per gallon at temperature
   Wt/Gal. @ $60^0$ F. of Bitumen    Temp. Factor

T = Temperature at which bitumen will be pumped

F = Temperature factor

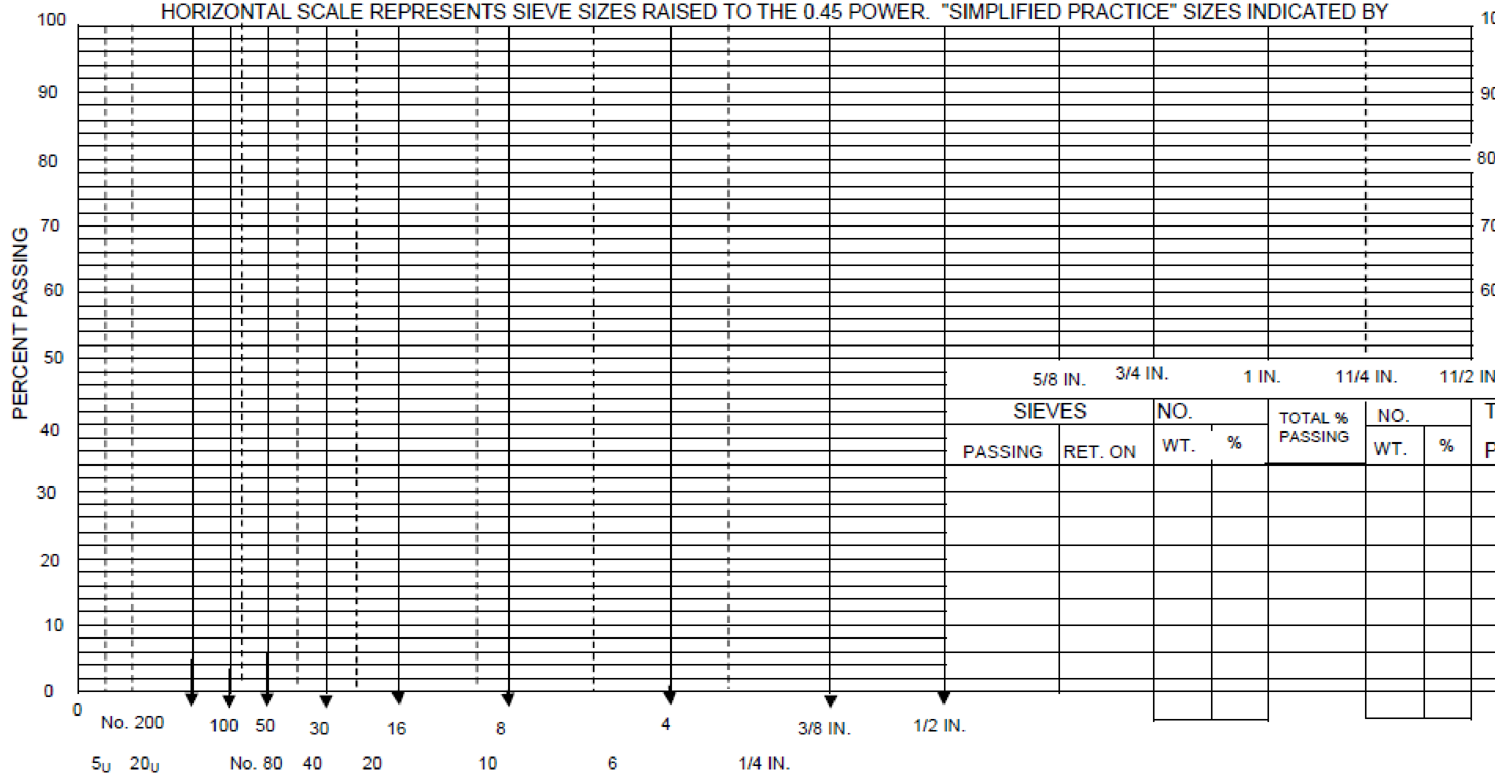
| T | F |
|---|---|
| 225 | 0.9436 |
| 230 | 0.9419 |
| 235 | 0.9402 |
| 240 | 0.9385 |
| 245 | 0.9369 |
| 250 | 0.9352 |
| 255 | 0.9336 |
| 260 | 0.9319 |
| 265 | 0.9302 |
| 270 | 0.9286 |

| T | F |
|---|---|
| 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 |

DOT-76Q
(09/2001)

## GRADATION CHART

HORIZONTAL SCALE REPRESENTS SIEVE SIZES RAISED TO THE 0.45 POWER. "SIMPLIFIED PRACTICE" SIZES INDICATED BY




| SIEVES | | NO. | | TOTAL % PASSING | NO. | | TOTAL % |
|---|---|---|---|---|---|---|---|
| PASSING | RET. ON | WT. | % | | WT. | % | PASSING |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
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| | | | | | | | |
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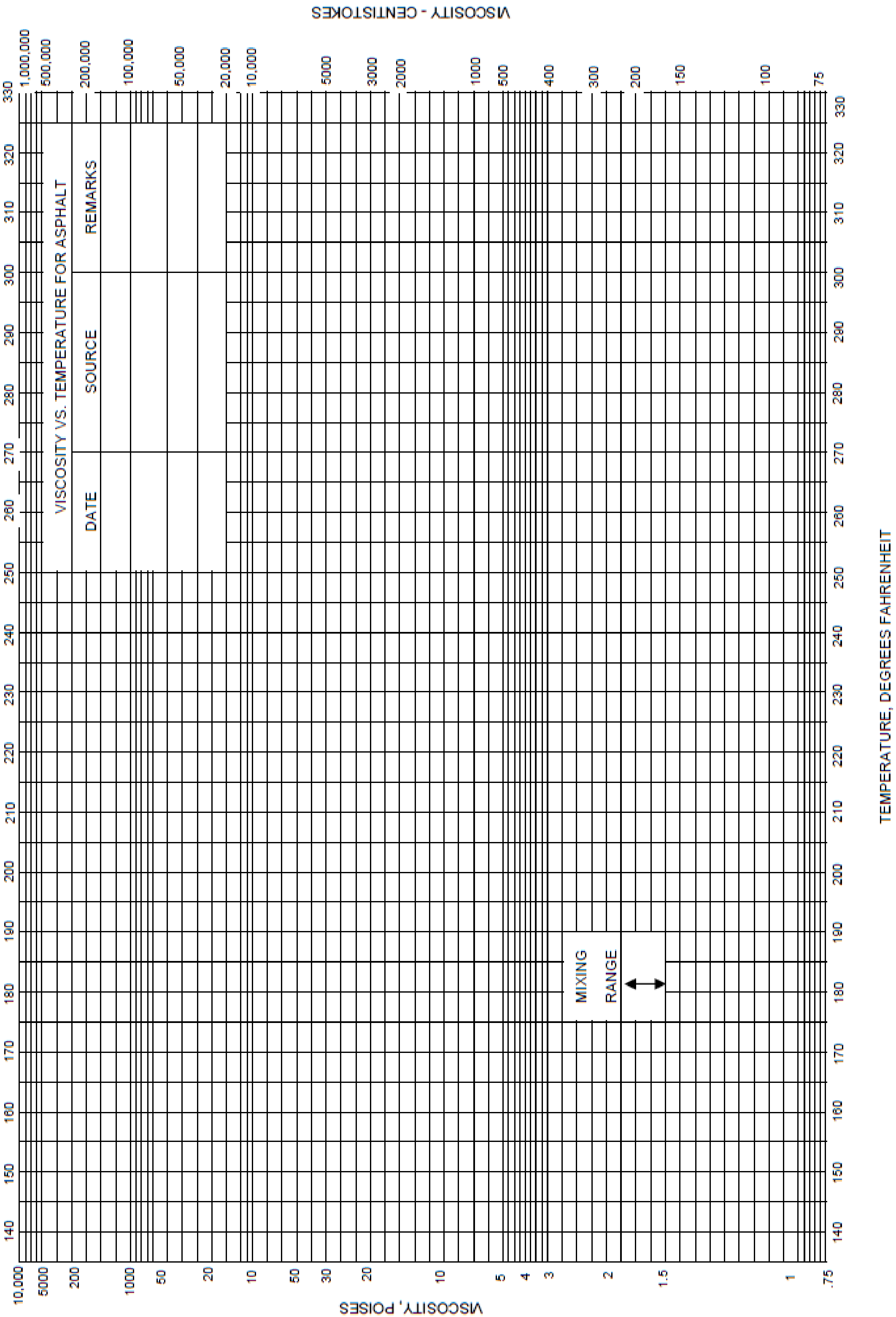
| | | | | | | | |

| STATE | PROJECT NO. | | | | | TYPE CONST; LOCATION ON PROJECT | |
|---|---|---|---|---|---|---|---|
| TYPE, SOURCE, PRODUCER OF AGG. | | | | | | | |
| SAMPLED FROM | SAMPLED BY | DATE | QUANT. REPRESENTED | SIEVED BY | DATE | SIEVE METHOD<br>☐ WET<br>☐ DRY | REMARKS |

ATTACHMENT 2



PROJECT:
PCN:
COUNTY

ASPHALT GRADATION
*ADD SHEETS AS NECESSARY

**DOT-79Q**
(09/2004)

1/2" SIEVE SIZE ___ + -7

#4 SIEVE ___ SIZE + -5

#8 SIEVE ___ SIZE + -5

#16 SIEVE ___ SIZE + -5

#40 SIEVE ___ SIZE + -5

#200 SIEVE ___ SIZE + -2.0

% A.C. ___ + -0.3

DENSITY > 9_ ___ < 96

* PLEASE POST IN PLANT LABORATORY

Sample ID:

# Gyratory Specific Gravity

**DOT-86**
3-19

PROJECT ____________ COUNTY ______________________________ PCN ____

Field No. ____________ Date Sampled __________ Date Tested __________

Sampled by ______________ Tested by ______________ Checked by ______________

Material Type ________________________________________ Ticket No. __________

Source ________________________________________ Lift ____ of ____

Lot No. ________ Sublot No. ______

Mix Temp. ______________ Offset ______________ ESAL's ______________

Daily Ton ______________ Total Ton ______________ Oil Type ______________

| | | | No. of gyrations | | |
|---|---|---|---|---|---|
| % binder Pb | | N initial | | Gse | |
| Gsb | | N design | | Pba | |
| binder Gb | | N max | | Pbe | |
| dust (-#200) | | | | | |
| lime | | | | | |
| dust (-#200) + lime | | | | | |

| | 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 | | | | | | | |
| b) Weight in air | | | | | | | |
| c) Weight in water | | | | | | | |
| d) SSD weight | | | | | | | |
| e) Bulk SpGr meas b / (d - c) | | | | | | | |
| f) Bulk SpGr calc (Gmb) | | | | | | | |
| Waiver | | ☐ | | ☐ | | | ☐ |

| | Gmm #1 | Gmm #2 |
|---|---|---|
| Weight of sample in air | | |
| Weight of canister + water | | |
| Weight of canister + water + sample | | |
| Temperature of the water | | |
| Water correction factor | | |
| Rice SpGr (Gmm) | | |

**Average Maximum SpGr (Gmm)** ________

| | **N initial** | **N design** | **N maximum** |
|---|---|---|---|
| **Average Gmb** | | | |
| **% of Rice SpGr (Gmm)** | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| % Air Voids (Va) | | % VMA | | % VFA | | Dust to binder ratio | |
| **Specifications** | | | | | | | |

Sample ID

# Bitumen Content Determination

DOT-89
3-19

Report No. ______________________

County ______________________ PCN/PROJECT ______________________

Test Date ________________ Inspector ________________ Contractor ________________

Percent Bitumen Desired ________________ Percent Used By Test ________________

Bitumen Type ______________________

| **TANK METHOD** | **Tank #1** | **Tank #2** |
|---|---|---|
| A. Beginning Specific Gravity of Bitumen @ 60 F | ______ | ______ |
| B. Beginning Weight Per Gallon @ 60 F | ______ | ______ |
| C. Temperature of Bitumen in Tank When Check Starts | ______ | ______ |
| 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) | ______ | |
| 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) | ______ | |
| P. Percent Bitumen in Mix (N / O x 100) | ______ | |

| G. Load # | Invoice # | Tons |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

| | **Summary of Mix Produced** | **Bitumen** |
|---|---|---|
| To Road | ______ Tons | ______ Tons |
| Plant Waste | ______ Tons | ______ Tons |
| Road Waste | ______ Tons | ______ Tons |
| To Others | ______ Tons | ______ Tons |
| Produced | ______ Tons | |

REMARKS

Comments ______________________________________________

**DETERMINING POUNDS OF BITUMEN PER GALLON**

1. ________________ X _____________ = X 8.328 (1) = ______________ lbs. of Bitumen per
Spec. Gravity of Bitumen                Temp. Factor
Gallon @ temperature

2. ________________________ X ___________________ = _________ lbs. of Bitumen per
Wt./Gal. @ 60°F                Temp. Factor
Gallon @ temperature

| Temp. °F | 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:

# Percent Reclaimed Asphalt Pavement (RAP) in the Mix as Percent of Total Aggregate

DOT-93
3-19

Report No __________

PROJECT __________ COUNTY __________ PCN _____

Field Nbr __________ Date ________ Inspector __________

Contractor __________

Percent RAP Desired ______ Percent RAP by Test ______ Material Type __________

**Weigh Ticket Entries**

A. Total of hot mix produced by tickets (tons) ______
B. Moisture in the mix percentage (most recent one tested) ______
C. Moisture in the mix (tons) ______
D. Total dry amount of hot mix produced for the day (tons) ______
E. Added binder percentage by cutoff (DOT-89) ______
F. Total amount of added binder (tons) ______
G. Added lime percentage by cutoff (DOT-33Q) ______
H. Total amount of added lime (tons) ______
I. Total dry Virgin MA and RAP from tickets & cutoffs (tons) ______

**Weigh Bridge Entries**

J. Weight of Virgin MA from weight bridge totalizer (tons) ______
K. Percent moisture in Virgin MA ______
L. Weight of water in Virgin MA (tons) ______
M. Weight of dry Virgin MA (tons) ______
N. Weight of RAP from weigh bridge totalizer (tons) ______
O. Percent moisture in RAP ______
P. Weight of water in the RAP mixture (tons) ______
Q. Weight of dry RAP from weigh bridge totalizer (tons) ______
R. Total dry Virgin MA and RAP from weigh bridges (tons) ______

**RAP Percentages**

S. Percentage of RAP based on weigh bridges ______
T. Percentage of RAP based on weigh tickets ______
U. % difference between scale tickets and weigh bridges ______

Sample ID:

# Stabilizing Additive Determination

**DOT-94**
8-22

PROJECT ____________. COUNTY ______________________________ PCN ____.

Field No. ______________ Tested by ______________ Test Date __________

Material Type ______________________________________________

**Summary Of Mix Produced**

**Lbs Fiber**

**Tons Of Mix to Road**

**To Other**

**Plate Waste**

**Road Waste**

**Tons Of Mix Produced**

**Percent Fiber**

**To Road Fiber**

**Remarks:**

DOT-97
(7-10)

SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION
FILE NO. ______

**CERTIFICATE OF COMPLIANCE FOR ASPHALT CONCRETE COMPOSITE**

PROJECT ______ COUNTY ______ PCN ______

CONTRACTOR ______ AREA ENGINEER ______ DATE ______

Asphalt Concrete Class ______ Type ______

Supplier of Asphalt Concrete ______

Grade of Asphalt Binder ______

Source of Mineral Aggregate ______

**JOB MIX FORMULA**

3/4" Sieve ........................................ % Passing ______

1/2" Sieve ........................................ % Passing ______

#4 Sieve ........................................ % Passing ______

#8 Sieve ........................................ % Passing ______

#16 Sieve ........................................ % Passing ______

#40 Sieve ........................................ % Passing ______

#200 Sieve ........................................ % Passing ______

Percent of Asphalt Binder (% By Weight of Total Mix) ______

Asphalt Binder Application Temperature ______

Temperature of Mixture When Emptied from Mixer (Drum) ______

Temperature of Mixture on Delivery to the Road ______

This Certificate of Compliance certifies that the materials for Asphalt Concrete complies with specifications requirements of the South Dakota Department of Transportation.

Signed: ______
Supplier's Authorized Representative

# Section Number 6

# Section Number 6

# Section Number 6

# APPENDIX F

# COMPARISON OF QUALITY CONTROL AND ACCEPTANCE TESTS

## Purpose

The purpose of this procedure is to provide a method of comparing two different data sets of multiple test results - say contractor QC test results and Agency acceptance or verification test results to determine if the material tested came from the same population. The statistical tests used to make the comparisons are called *Hypothesis Tests* and are described in the following paragraphs.

## Analysis

To compare two populations that are assumed normally distributed, you may compare their means (averages) and their variabilities (standard deviations or variances). A different test is used for each of these properties. The ***F-test*** provides a method for comparing the variance (standard deviation squared) of two sets of data. Possible differences in means are assessed by a ***t-test***.

The F-test is based on the ratio of the variances of two sets of data. In this case, the F-test is based on the ratio of the variances of the QC test results, $s_c^2$, and the acceptance test results, $s_a^2$. The t-test compares sample means, and in this case, is based on the means of the QC test results, $\bar{X}_c$ and the acceptance test results, $\bar{X}_a$.

Hypothesis tests, i.e., the F-test and t-test, are conducted at a selected level of significance, $\alpha$. The level of significance is the probability of incorrectly deciding the data sets are different when they actually come from the same population. The value of $\alpha$ is typically selected as either 0.05 or 0.01. The following analysis is based on an $\alpha$ of 0.01 so as to minimize the likelihood of incorrectly concluding that the test results are different when they are not.

For the analysis to be meaningful, all of the samples must be obtained in a random manner, the two sets of test results must have been sampled over the same time period, and the same sampling and testing procedures must have been used for both QC and acceptance tests. If it is determined that a significant difference is likely between either the mean or the variance, the source of the difference should be identified. Although it is beyond the scope of the analysis presented here, a computer program could be developed that could identify the existence of significant differences once the test results are input.

If the analysis indicates there is no reason to believe the results came from different populations, then the mean and variance (or standard deviation) could be determined from the combined set of test results to provide a better estimate of the populations parameters than would be obtained from either of the sets individually.

For information on how the Operating Characteristics curves for these tests can be developed, the reader is referred to statistics text books such as Reference 2.

**Procedure**

**F-test for the Sample Variances**

Since the values used in the t-test are dependent upon whether or not the variances are equal for the two sets of data, it is necessary to test the variances of the test results before the means. The intent is to determine whether the difference in the variability of the contractor's QC tests and that of the State's acceptance tests is larger than might be expected from chance if they came from the same population. In this case, it does not matter which variance is larger. After comparing the test results, one of the following will be concluded.

- The two sets of data have different variances because the difference between the two sets of test results is greater than is likely to occur from chance if their variances are actually equal.

- There is no reason to believe the variances are different because the difference is not so great as to be unlikely to have occurred from chance if the variances are actually equal.

First, compute the variance (the standard deviation squared) for the QC tests, $s_c^2$, and the acceptance tests, $s_a^2$. Next, compute F, where $F = s_c^2/s_a^2$ or $F = s_a^2/s_c^2$. *Always use the larger of the two variances in the numerator.* Now, choose $\alpha$, the level of significance for the test. As mentioned previously, the recommended $\alpha$ is 0.01. Next, a critical F value is determined from Table 1 using the degrees of freedom associated with each set of test results. The degrees of freedom for each set of results is the number of test results in the set, less one. If the number of QC tests is $n_c$ and the number of acceptance test is $n_a$, then the degrees of freedom associated with $s_c^2$ is $(n_c$-1) and the degrees of freedom associated with $s_a^2$ is $(n_c$-1). The values in Table 1 are tabulated to test if there is a difference (either larger or smaller) between two variance estimates. This is known as a two-sided or two-tailed test. Care must be taken when using other tables of the F distribution, since they are usually based on a one-tailed test, i.e., testing specifically whether one variance is larger than another.

Once the value for $F_{crit}$ is determined from Table 1 (be sure that the appropriate degrees of freedom for the numerator and denominator are used when obtaining the value from Table 1), if $F \geq F_{crit}$, then decide that the two sets of tests have significantly different variabilities. If $F < F_{crit}$ then decide that there is no reason to believe that the variabilities are significantly different.

**t-test for Sample Means**

Once the variances have been tested and been assumed to be either equal or not equal, the means of the test results can be tested to determine whether they differ from one another or can be assumed equal. The desire is to determine whether it is reasonable to assume that the QC tests came from the same population as the acceptance tests. A t-test is used to compare the sample means. Two approaches for the t-test are necessary. If the sample variances are assumed equal, then the t-test is conducted based on the two samples using a *pooled* estimate for the variance and the *pooled* degrees of freedom. This approach is ***Case 1*** described below. If the sample variances are assumed to be different, then the t-test is conducted using the individual sample variances, the individual sample sizes, and the *effective* degrees of freedom (estimated from the sample variances and sample sizes). This approach is ***Case 2*** presented below.

In either of the two cases discussed in the previous paragraph, one of the following decisions is made:

- The two sets of data have different means because the difference in the sample means is greater than is likely to occur from chance if their means are actually equal.

- There is no reason to believe the means are different because the difference in the sample means is not so great as to be unlikely to have occurred from chance if the means are actually equal.

**Case 1: Sample Variances Assumed to Be Equal**

To conduct the t-test when the sample variances are assumed equal, equation 1 is used to calculate the t value from which the decision is reached.

$$t=\frac{|\bar{X}_c-\bar{X}_a|}{\sqrt{\frac{s_p^2}{n_c}+\frac{s_p^2}{n_a}}} \qquad (1)$$

Where:

| | | | |
|---|---|---|---|
| | $\bar{X}_c$ | = | mean of QC tests |
| | $\bar{X}_a$ | = | mean of acceptance tests |
| | $s_p^2$ | = | pooled estimate for the variance (described below) |
| | $n_c$ | = | number of QC tests |
| | $n_a$ | = | number of acceptance tests |

The pooled variance, which is the weighted average, using the degrees of freedom for each sample as the weighting factor, is computed from the sample variances using equation 2.

$$S_p^2=\frac{S_c^2(n_c-1)+S_a^2(n_a-1)}{n_c+n_a-2} \qquad (2)$$

Where:

| | | |
|---|---|---|
| $s_p^2$ | = | pooled estimate for the variance |
| $n_c$ | = | number of QC tests |
| $n_a$ | = | number of acceptance tests |
| $s_c^2$ | = | variance of the QC tests |
| $s_a^2$ | = | variance of the acceptance tests |

Once the pooled variance is estimated, the value of t is computed using equation 1.

To determine the critical t value against which to compare the computed t value, it is necessary to select the level of significance, $\alpha$. As discussed above, a value of $\alpha = 0.01$ is recommended. Next, determine the critical t value, $t_{crit}$, from Table 2 for the pooled degrees of freedom. The pooled degrees of freedom for the case where the sample variances are assumed equal is ( $n_c + n_a$ -2). If $t \geq t_{crit}$, then decide that the two sets of tests have significantly different means. If $t < t_{crit}$ then decide that there is no reason to believe that the means are significantly different.

**Case 2: Sample Variances Assumed to Be Not Equal**

If the sample variances are not assumed to be equal, then the individual sample variances, rather than the pooled variance, are used to calculate t, and the degrees of freedom used are an estimated effective degrees of freedom rather than the pooled degrees of freedom.To conduct the t-test when the sample variances are assumed not equal, equation 3 is used to calculate the t value from which the decision is reached.

$$t=\frac{|\bar{X}_c-\bar{X}_a|}{\sqrt{\frac{s_c^2}{n_c}+\frac{s_a^2}{n_a}}} \qquad (3)$$

Where:

| | | |
|---|---|---|
| $\bar{X}_c$ | = | mean of QC tests |
| $\bar{X}_a$ | = | mean of acceptance tests |

| | | |
|---|---|---|
| $s_c^2$ | = | variance of the QC tests |
| $s_a^2$ | = | variance of the acceptance tests |
| $n_c$ | = | number of QC tests |
| $n_a$ | = | number of acceptance tests |

To determine the critical t value against which to compare the computed t value, it is necessary to select the level of significance, $\alpha$. As discussed above, a value of $\alpha = 0.01$ is recommended. Next, determine the critical t value, $t_{crit}$, from Table 2 for the effective degrees of freedom. The effective degrees of freedom, f', for the case where the sample variances are assumed not equal is determined from equation 4.

$$f' = \frac{\left(\frac{s_c^2}{n_c} + \frac{s_a^2}{n_a}\right)^2}{\left(\frac{\left(\frac{s_c^2}{n_c}\right)^2}{n_c+1} + \frac{\left(\frac{s_a^2}{n_a}\right)^2}{n_a+1}\right)} - 2 \qquad (4)$$

Where all the symbols are as described previously.

If $t \geq t_{crit}$, then decide that the two sets of tests have significantly different means. If $t < t_{crit}$ then decide that there is no reason to believe that the means are significantly different.

**Example Problem - Case 1.**

A contractor has run 21 QC tests for asphalt content and the State highway agency (SHA) has run 8 acceptance tests over the same period of time for the same material property. The results are shown below. Is it likely that the tests came from the same population?

| QC Test Results | Acceptance Test Results |
|---|---|
| 6.4 | 5.4 |
| 6.2 | 5.8 |
| 6.0 | 6.2 |
| 6.6 | 5.4 |
| 6.1 | 5.4 |
| 6.0 | 5.8 |
| 6.3 | 5.7 |
| 6.1 | 5.4 |
| 5.9 | |
| 5.8 | |
| 6.0 | |

5.7
6.3
6.5
6.4
6.0
6.2
6.5
6.0
5.9
6.3

First, use the F-test to determine whether or not to assume the variances of the QC tests differ from the acceptance tests.

***Step 1.*** Compute the variance, $s^2$, for each set of tests.

$s_c^2 = 0.0606 \qquad s_a^2 = 0.0855$

***Step 2.*** Compute F, using the largest $s^2$ in the numerator.

$$F = \frac{s_a^2}{s_c^2} = \frac{0.0855}{0.0606} = 1.41$$

***Step 3.*** Determine $F_{crit}$ from Table 1 being sure to use the correct degrees of freedom for the numerator ($n_a$-1=8-1=7) and the denominator ($n_c$-1=21-1=20). From Table 1, $F_{crit}$ = 4.26.

***Conclusion:*** Since $F < F_{crit}$ (i.e., 1.41 < 4.26), there is no reason to believe that the two sets of tests have different variabilities. That is, they could have come from the same population. Since we can assume that the variances are equal, we can use the pooled variance to calculate the t-test statistic, and the pooled degrees of freedom to determine the critical t value, $t_{crit}$.

***Step 4.*** Compute the mean, $\bar{X}$, for each set of tests.

$\bar{X}_c = 6.15 \qquad \bar{X}_a = 5.64$

***Step 5.*** Compute the pooled variance, $s_p^2$, using the sample variances from above.

$$S_p^2 = \frac{S_c^2(n_c-1)+S_a^2(n_a-1)}{n_c+n_a-2}$$

$$S_p^2 = \frac{(0.0606)(20)+(0.0855)(7)}{21+8-2} = 0.067$$

***Step 6.*** Compute the t-test statistic, t.

$$t=\frac{|\bar{X}_c-\bar{X}_a|}{\sqrt{\frac{s_p^2}{n_c}+\frac{s_p^2}{n_a}}}$$

$$t=\frac{|6.15-5.64|}{\sqrt{\frac{0.067}{21}+\frac{0.067}{8}}}=\frac{0.51}{\sqrt{0.0116}}=4.735$$

***Step 7.*** Determine the critical t value, $t_{crit}$, for the pooled degrees of freedom.

degrees of freedom = $(n_c+n_a-2)=(21+8-2)=27.$

From Table 2, for $\alpha=0.01$ and 27 degrees of freedom, $t_{crit}$ = 2.771.

***Conclusion:*** Since 4.735 > 2.771, we assume that the sample means are not equal. It is therefore probable that the two sets of tests did not come from the same population.

**Example Problem - Case 2:**

A contractor has run 25 QC tests and the SHA has run 10 acceptance tests over the same period of time for the same material property. The results are shown below. Is it likely that the test came from the same population?

| QC Test Results | Acceptance Test Results |
|---|---|
| 21.4 | 34.7 |
| 20.2 | 16.8 |
| 24.5 | 16.2 |
| 24.2 | 27.7 |
| 23.1 | 20.3 |
| 22.7 | 16.8 |
| 23.5 | 20.0 |
| 15.5 | 19.0 |
| 17.9 | 11.3 |
| 24.1 | 22.3 |
| 18.6 | |
| 15.9 | |
| 17.0 | |
| 20.0 | |
| 24.2 | |
| 14.6 | |
| 19.7 | |
| 16.0 | |
| 23.1 | |
| 20.8 | |
| 14.6 | |
| 16.4 | |
| 22.0 | |
| 18.7 | |
| 24.2 | |

First, use the F-test to determine whether or not to assume the variances of the QC tests differ from the acceptance tests.

***Step 1.*** Compute the variance, $S^2$, for each set of tests.

$$S_c^2 = 11.50 \qquad S_a^2 = 43.30$$

***Step 2.*** Compute F, using the largest $S^2$ in the numerator.

$$F = \frac{S_a^2}{S_c^2} = \frac{43.30}{11.50} = 3.76$$

**Step 3.** Determine $F_{crit}$ from Table 1 being sure to use the correct degrees of freedom for the numerator ($n_a$-1=10-1=9) and the denominator ($n_c$-1=25-1=24). From Table 1, $F_{crit}$ = 3.69.

**Conclusion:** Since $F > F_{crit}$ (i.e., 3.76 > 3.69), there is reason to believe that the two sets of tests have different variabilities. That is, it is likely that they came from populations with different variances. Since we assume that the variances are not equal, we use the individual sample variances to calculate the t-test statistic, and the approximate degrees of freedom to determine the critical t value, $t_{crit}$.

**Step 4.** Compute the mean, $\bar{X}$, for each set of tests.

$$\bar{X}_c = 20.1 \qquad \bar{X}_a = 20.5$$

**Step 5.** Compute the t-test statistic, t.

$$t=\frac{|\bar{X}_c-\bar{X}_a|}{\sqrt{\frac{S_c^2}{n_c}+\frac{S_a^2}{n_a}}}$$

$$t=\frac{|20.5-20.1|}{\sqrt{\frac{11.50}{25}+\frac{43.30}{10}}}=\frac{0.4}{\sqrt{4.79}}=0.183$$

**Step 6.** Determine the critical t value, $t_{crit}$, for the approximate degrees of freedom, $f'$. Remember that the calculated effective degrees of freedom is rounded down to a whole number.

$$f'=\frac{\left(\frac{s_c^2}{n_c}+\frac{s_a^2}{n_a}\right)^2}{\left(\frac{\left(\frac{s_c^2}{n_c}\right)^2}{n_c+1}+\frac{\left(\frac{s_a^2}{n_a}\right)^2}{n_a+1}\right)}-2$$

$$f' = \frac{\left(\frac{11.50}{25} + \frac{43.30}{10}\right)^2}{\left(\frac{\left(\frac{11.50}{25}\right)^2}{26} + \frac{\left(\frac{43.30}{10}\right)^2}{11}\right)} - 2 = \frac{(4.79)^2}{1.713} - 2 = 11$$

From Table 2, for $\alpha = 0.01$ and 11 degrees of freedom, $t_{crit} = 3.106$.

***Conclusion:*** Since $t < t_{crit}$, (i.e., $0.183 < 3.106$), there is no reason to assume that the sample means are not equal. It is therefore reasonable to assume that the sets of test results came from populations that had the same mean.

**Table 1. Critical Values, $F_{crit}$, for the F-test for a Level of Significance, $\alpha = 0.01$*.**

DEGREES OF FREEDOM FOR NUMERATOR

DEGREES OF FREEDOM FOR DENOMINATOR

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 16200 | 20000 | 21600 | 22500 | 23100 | 23400 | 23700 | 23900 | 24100 | 24200 | 24300 | 24400 |
| 2 | 198 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 199 |
| 3 | 55.6 | 49.8 | 47.5 | 46.2 | 45.4 | 44.8 | 44.4 | 44.1 | 43.9 | 43.7 | 43.5 | 43.4 |
| 4 | 31.3 | 26.3 | 24.3 | 23.2 | 22.5 | 22.0 | 21.6 | 21.4 | 21.1 | 21.0 | 20.8 | 20.7 |
| 5 | 22.8 | 18.3 | 16.5 | 15.6 | 14.9 | 14.5 | 14.2 | 14.0 | 13.8 | 13.6 | 13.5 | 13.4 |
| 6 | 18.6 | 14.5 | 12.9 | 12.0 | 11.5 | 11.1 | 10.8 | 10.6 | 10.4 | 10.2 | 10.1 | 10.0 |
| 7 | 16.2 | 12.4 | 10.9 | 10.0 | 9.52 | 9.16 | 8.89 | 8.68 | 8.51 | 8.38 | 8.27 | 8.18 |
| 8 | 14.7 | 11.0 | 9.60 | 8.81 | 8.30 | 7.95 | 7.69 | 7.50 | 7.34 | 7.21 | 7.10 | 7.01 |
| 9 | 13.6 | 10.1 | 8.72 | 7.96 | 7.47 | 7.13 | 6.88 | 6.69 | 6.54 | 6.42 | 6.31 | 6.23 |
| 10 | 12.8 | 9.43 | 8.08 | 7.34 | 6.87 | 6.54 | 6.30 | 6.12 | 5.97 | 5.85 | 5.75 | 5.66 |
| 11 | 12.2 | 8.91 | 7.60 | 6.88 | 6.42 | 6.10 | 5.86 | 5.68 | 5.54 | 5.42 | 5.32 | 5.24 |
| 12 | 11.8 | 8.51 | 7.23 | 6.52 | 6.07 | 5.76 | 5.52 | 5.35 | 5.20 | 5.09 | 4.99 | 4.91 |
| 15 | 10.8 | 7.70 | 6.48 | 5.80 | 5.37 | 5.07 | 4.85 | 4.67 | 4.54 | 4.42 | 4.33 | 4.25 |
| 20 | 9.94 | 6.99 | 5.82 | 5.17 | 4.76 | 4.47 | 4.26 | 4.09 | 3.96 | 3.85 | 3.76 | 3.68 |
| 24 | 9.55 | 6.66 | 5.52 | 4.89 | 4.49 | 4.20 | 3.99 | 3.83 | 3.69 | 3.59 | 3.50 | 3.42 |
| 30 | 9.18 | 6.35 | 5.24 | 4.62 | 4.23 | 3.95 | 3.74 | 3.58 | 3.45 | 3.34 | 3.25 | 3.18 |
| 40 | 8.83 | 6.07 | 4.98 | 4.37 | 3.99 | 3.71 | 3.51 | 3.35 | 3.22 | 3.12 | 3.03 | 2.95 |
| 60 | 8.49 | 5.80 | 4.73 | 4.14 | 3.76 | 3.49 | 3.29 | 3.13 | 3.01 | 2.90 | 2.82 | 2.74 |
| 120 | 8.18 | 5.54 | 4.50 | 3.92 | 3.55 | 3.28 | 3.09 | 2.93 | 2.81 | 2.71 | 2.62 | 2.54 |
| ∞ | 7.88 | 5.30 | 4.28 | 3.72 | 3.35 | 3.09 | 2.90 | 2.74 | 2.62 | 2.52 | 2.43 | 2.36 |

* **NOTE:** This is for a two-tailed test with the null and alternate hypotheses shown below:

$$H_o: S_c^2 = S_a^2$$

$$H_a: S_c^2 \neq S_a^2$$

## Table 1. Critical Values, $F_{crit}$, for the F-test for a Level of Significance, $\alpha = 0.01$*. *(continued)*

DEGREES OF FREEDOM FOR NUMERATOR

| DEGREES OF FREEDOM FOR DENOMINATOR | 15 | 20 | 24 | 30 | 40 | 50 | 60 | 100 | 120 | 200 | 500 | ∞ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24600 | 24800 | 24900 | 25000 | 25100 | 25200 | 25300 | 25300 | 25400 | 25400 | 25400 | 25500 |
| 2 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 199 | 200 |
| 3 | 43.1 | 42.8 | 42.6 | 42.5 | 42.3 | 42.2 | 42.1 | 42.0 | 42.0 | 41.9 | 41.9 | 41.8 |
| 4 | 20.4 | 20.2 | 20.0 | 19.9 | 19.8 | 19.7 | 19.6 | 19.5 | 19.5 | 19.4 | 19.4 | 19.3 |
| 5 | 13.1 | 12.9 | 12.8 | 12.7 | 12.5 | 12.5 | 12.4 | 12.3 | 12.3 | 12.2 | 12.2 | 12.1 |
| 6 | 9.81 | 9.59 | 9.47 | 9.36 | 9.24 | 9.17 | 9.12 | 9.03 | 9.00 | 8.95 | 8.91 | 8.88 |
| 7 | 7.97 | 7.75 | 7.65 | 7.53 | 7.42 | 7.35 | 7.31 | 7.22 | 7.19 | 7.15 | 7.10 | 7.08 |
| 8 | 6.81 | 6.61 | 6.50 | 6.40 | 6.29 | 6.22 | 6.18 | 6.09 | 6.06 | 6.02 | 5.98 | 5.95 |
| 9 | 6.03 | 5.83 | 5.73 | 5.62 | 5.52 | 5.45 | 5.41 | 5.32 | 5.30 | 5.26 | 5.21 | 5.19 |
| 10 | 5.47 | 5.27 | 5.17 | 5.07 | 4.97 | 4.90 | 4.86 | 4.77 | 4.75 | 4.71 | 4.67 | 4.64 |
| 11 | 5.05 | 4.86 | 4.76 | 4.65 | 4.55 | 4.49 | 4.45 | 4.36 | 4.34 | 4.29 | 4.25 | 4.23 |
| 12 | 4.72 | 4.53 | 4.43 | 4.33 | 4.23 | 4.17 | 4.12 | 4.04 | 4.01 | 3.97 | 3.93 | 3.90 |
| 15 | 4.07 | 3.88 | 3.79 | 3.69 | 3.59 | 3.52 | 3.48 | 3.39 | 3.37 | 3.33 | 3.29 | 3.26 |
| 20 | 3.50 | 3.32 | 3.22 | 3.12 | 3.02 | 2.96 | 2.92 | 2.83 | 2.81 | 2.76 | 2.72 | 2.69 |
| 24 | 3.25 | 3.06 | 2.97 | 2.87 | 2.77 | 2.70 | 2.66 | 2.57 | 2.55 | 2.50 | 2.46 | 2.43 |
| 30 | 3.01 | 2.82 | 2.73 | 2.63 | 2.52 | 2.46 | 2.42 | 2.32 | 2.30 | 2.25 | 2.21 | 2.18 |
| 40 | 2.78 | 2.60 | 2.50 | 2.40 | 2.30 | 2.23 | 2.18 | 2.09 | 2.06 | 2.01 | 1.96 | 1.93 |
| 60 | 2.57 | 2.39 | 2.29 | 2.19 | 2.08 | 2.01 | 1.96 | 1.86 | 1.83 | 1.78 | 1.73 | 1.69 |
| 120 | 2.37 | 2.19 | 2.09 | 1.98 | 1.87 | 1.80 | 1.75 | 1.64 | 1.61 | 1.54 | 1.48 | 1.43 |
| ∞ | 2.19 | 2.00 | 1.90 | 1.79 | 1.67 | 1.59 | 1.53 | 1.40 | 1.36 | 1.28 | 1.17 | 1.00 |

*** NOTE:** This is for a two-tailed test with null and alternate hypotheses shown below:

$$H_o: S_c^2 = S_a^2$$
$$H_a: S_c^2 \neq S_a^2$$

Table 2. Critical Values, $t_{crit}$, for the t-test* for Various Levels of Significance.

| degrees of freedom | $\alpha = 0.01$ | $\alpha = 0.05$ | $\alpha = 0.10$ |
|---|---|---|---|
| 1 | 63.657 | 12.706 | 6.314 |
| 2 | 9.925 | 4.303 | 2.920 |
| 3 | 5.841 | 3.182 | 2.353 |
| 4 | 4.604 | 2.776 | 2.132 |
| 5 | 4.032 | 2.571 | 2.015 |
| 6 | 3.707 | 2.447 | 1.943 |
| 7 | 3.499 | 2.365 | 1.895 |
| 8 | 3.355 | 2.306 | 1.860 |
| 9 | 3.250 | 2.262 | 1.833 |
| 10 | 3.169 | 2.228 | 1.812 |
| 11 | 3.106 | 2.201 | 1.796 |
| 12 | 3.055 | 2.179 | 1.782 |
| 13 | 3.012 | 2.160 | 1.771 |
| 14 | 2.977 | 2.145 | 1.761 |
| 15 | 2.947 | 2.131 | 1.753 |
| 16 | 2.921 | 2.120 | 1.746 |
| 17 | 2.898 | 2.110 | 1.740 |
| 18 | 2.878 | 2.101 | 1.734 |
| 19 | 2.861 | 2.093 | 1.729 |
| 20 | 2.845 | 2.086 | 1.725 |
| 21 | 2.831 | 2.080 | 1.721 |
| 22 | 2.819 | 2.074 | 1.717 |
| 23 | 2.807 | 2.069 | 1.714 |
| 24 | 2.797 | 2.064 | 1.711 |
| 25 | 2.787 | 2.060 | 1.708 |
| 26 | 2.779 | 2.056 | 1.706 |
| 27 | 2.771 | 2.052 | 1.703 |
| 28 | 2.763 | 2.048 | 1.701 |
| 29 | 2.756 | 2.045 | 1.699 |
| 30 | 2.750 | 2.042 | 1.697 |
| 40 | 2.704 | 2.021 | 1.684 |
| 60 | 2.660 | 2.000 | 1.671 |
| 120 | 2.617 | 1.980 | 1.658 |
| ∞ | 2.576 | 1.960 | 1.645 |

*** NOTE:** This is for a two-tailed test with the null and alternate hypotheses shown below:

$$H_0: \bar{X}_c = \bar{X}_a$$
$$H_a: \bar{X}_c \neq \bar{X}_a$$

# Section Number 7

# Section Number 7

# Section Number 7

# SDDOT PROFICIENCY SAMPLE PROGRAM

In an effort to improve the Quality Control / Quality Assurance mix design verification process, the SDDOT Bituminous Mix Design Laboratory started a Proficiency Sample Program and developed a standard mix design submittal spreadsheet for Contractors to use. All Contractors/Consultants submitting mix designs to the SDDOT are required to participate in the Proficiency Sample Program.

SDDOT's Proficiency Sample Program allows the Bituminous Mix Design lab, Contractor's labs, and Consultant's labs to compare equipment and technician proficiency under actual testing conditions using samples sent out from the Bituminous Mix Design lab in Pierre. In the late fall or winter, samples will be sent to all Contractors and Consultants who have submitted mix designs to the SDDOT. Others wishing to participate in the Proficiency Sample Program can request to be included by contacting Jim Costello at 605-773-3700 or Shea Lemmel at 605-773-2730.

South Dakota's round robin Proficiency Sample Program is set up in a manner similar to the AASHTO re:source Proficiency Sample Program. SDDOT has been a member of the AASHTO re:source Proficiency Sample Program for many years. Participants in SDDOT's Proficiency Sample Program will receive a summary showing their results, SDDOT results, and the average results from all participants.

Current South Dakota Test Procedures are in the South Dakota DOT Materials Manual and are at the SDDOT website. These SDDOT test procedures and, if required by specification, the current AASHTO/ASTM test procedures should be followed when conducting all of the required tests.

# Section Number 8

# Section Number 8

# Section Number 8

**QC/QA Project Inspection Report** 10/24

Project Number ____________________________________________ PCN _________ Date _______________

County___________________Project Engineer _____________________ Lab Site Phone Number: _______________

| Quality Assurance Lab | Comments |
|---|---|
| Types of mix being produced? | |
| Source and types of binders being used? | |
| Are the mix design(s) posted in the lab? | |
| Any changes to the original mix design(s)? | |
| Are current test procedures & specs in lab? | |
| Lab type, size and # of rooms provided | |
| Lab meets requirements? (DOT 50) exceptions? | |
| Can technicians see plant operations from lab? | |
| Gyratory compactor: SDDOT ID # and condition? | |
| Condition of gyratory molds and plates? | |
| Thermometers (type, ID number, calibrated?) | |
| Thermometers of correct type for applications? | |
| Scales leveled and checked after setup? | |
| Calibration records for testing equipment in lab? | |
| All testing equipment provided? Region checked? | |
| All equipment meets SDDOT testing requirements? | |
| Weighing in water apparatus with overflow setup? | |
| Passing cold feed aggregate sample? | |
| Correlation testing (mix from Project, Y/N? ) | |
| Correlation within tolerances? | |
| Is correct MS&T numbering & procedures used? | |
| What process used to notify QC to get sample? | |
| Is random number procedure used for samples? | |
| Is random QA sampling being done by QA? | |
| Does QA watch QC sampling and splitting? | |
| QC and QA test results entered into MS&T? | |
| QA test results given to QC upon completion? | |
| Any bin split changes shown on DOT-69? | |
| Was bulk specific gravity reheat done? Results | |
| Is moisture in the mix test done? Frequency? | |
| Cores cored by QC and taken back to lab by QA? | |
| Is core dryback procedure used correctly (SD315)? | |
| Oil content and density results given to QC? | |
| IA witness sampling and splitting procedures? | |
| IA test results available in lab? Added to QC charts? | |
| Oil samples & cert entered in MS&T? Look at cert. | |
| PG binder & emulsion samples. Witness or take? | |
| Receiving daily chart or print out of mix temps.? | |
| How is daily PG binder cutoff done? Witness or do? | |
| Any out of spec. (0.3) tolerance? Action taken? | |
| How is daily lime cutoff done? Is Aggr. 1.0% > SSD? | |
| Any out of spec. (0.10) tolerance? Action taken? | |
| RAP cutoff (DOT-93) within ± 5% of target ? | |
| Any other failing tests on the Project? | |
| What action was taken? | |
| Any QC split samples out of tolerance? Action? | |
| Any IA split samples out of tolerance? Action? | |
| Similiar/Dissimiliar test procedure being used (SD317)? | |
| Any dissimilar? Action taken? | |
| Are all backup samples being retained? For entire job? | |
| Certified tester name and Cert expiration date: | |
| Certified tester name and Cert expiration date: | |
| Non-certified helpers (names): | |
| Non-certified work checked? Perf. √ lists completed? | |
| Diary? oil%, tons, changes, problems, etc. | |
| QA comments? | |

**QC/QA Project Inspection Report** 10/24

Mix Type ________________Project Tonnage ________________________ Lab location ______________________

Binder Type __________________Testing Firm ________________________ Lab Site Phone #: ____________

| Quality Control Lab | Comments |
|---|---|
| Firm doing testing? | |
| Copy of current testing procedures in lab? | |
| Are the mix design(s) posted in the lab? | |
| Copy of current spec _______________in lab? | |
| Testing equipment calibration records in lab:<br>Scales___, Ovens___ , Thermometers___ , SE___<br>Sieves___, Manometer___ , Gyratory___ , FAA___ | |
| Type and size of lab provided? | |
| Can see plant operations from lab? | |
| Gyratory compactor serial # and internal angle cal. | |
| Condition of molds and plates? | |
| Thermometers (type, number, calibrated) | |
| Thermometer of correct type for application? | |
| Rice test conducted above or below water? | |
| Water calibration curve provided? | |
| Weighing in water apparatus with overflow setup? | |
| Correlation testing (mix from Project, Y/N) | |
| Correlation within tolerances? | |
| All testing equipment provided? Region checked? | |
| Equipment meets SDDOT test requirements? | |
| What process used to notify QC to get sample? | |
| What procedure is used to get samples? | |
| Is sampling and splitting witnessed by QA? | |
| Test results and original worksheets in lab? | |
| Have any bin split changes been made? DOT-69 | |
| Is each bin within 5% of original mix design? | |
| Are correct calculations and rounding being used? | |
| Is the correct numbering system used? | |
| All test results on DOT-69 including % moist.? | |
| Signed test results to QA upon test completion? | |
| Any test frequency reductions? | |
| Bulk specific gravity reheat done? Results | |
| Control charts posted (grad., gyratory, rice, air voids)? | |
| Control charts posted (binder %, lime, density)? | |
| When does QC get QA test results? | |
| QA and IA test results added to Control Charts? | |
| Are cores sawed with a diamond tipped blade? | |
| Are backup samples being retained? | |
| How long are backup samples being retained? | |
| Average air voids (last ___ days) | |
| Average oil content (last ___ days) | |
| Average in-place density (last ___ days) | |
| Any failing tests on the Project? Action taken? | |
| Any split samples out of tolerance? Action? | |
| Certified tester name and Cert expiration date: | |
| Certified tester name and Cert expiration date: | |
| Non-certified helpers (names): | |
| Non-certified work checked? Perf. √ lists completed? | |
| Diary contains? Start and stops, changes, spot checks, test results, problems, weather, etc. | |
| Documentation of any mix design adjustments? | |
| QC comments? | |

**QC/QA Project Inspection Report** 10/24

Plant Site Location:______________________________ Plant # _________ Superint. ______________

Contractor:______________________________ Phone No. _____________ Plant Operator's Name: __________________

| Plant Site | Comments |
|---|---|
| Enough room at stockpile site? | |
| Are stockpiles separated? | |
| Are stockpiles segregated ? | |
| Are stockpiles contaminated? | |
| Loader operator working entire stockpile? | |
| Bulk heads provided on cold feed bins? | |
| Number of cold feed bins? | |
| Number of different stockpiles used? | |
| Size and type of oversize screen used? | |
| Type of material being rejected by screen? | |
| Type of aggregate sampling device used? | |
| Belt scale type, Date last checked and by? | |
| Type and brand of plant? Year? | |
| Brand name of automated plant controls? | |
| Plant maximum production (tph): | |
| Plant running (tons per hour): | |
| Mix temp. when leaving the plant: | |
| Oil content setting: | |
| PG Binder temp. at application in plant: | |
| Moisture content in aggregate setting: | |
| Plant bin split settings: | |
| Scale for mix pay quantity last cert. date and by? | |
| Asphalt meter type, last checked, date and by? | |
| Chart or computer printout of mix temperatures? | |
| Wet wash or baghouse system? | |
| Baghouse fines put back in mix, yes or no? | |
| Burner fuel supplier? | |
| Type of burner fuel and cert? Get copy | |
| Preheated if type > 2? To temperature? | |
| Number of asphalt binder storage tanks? | |
| Are they level with chart (1/4") for capacity? | |
| Type of measuring device for storage tanks? | |
| Thermometer works for storage tanks? | |
| Sample location for PG binder? | |
| Truck loading procedure? | |
| Are truck boxes clean when returning from road? | |
| Truck cleaning. What is used to spray boxes? | |
| Scale or weigh pod on lime silo? | |
| Entire silo on load cells? | |
| Lime scale last checked, date and by? | |
| 4.5 foot min. twin shaft pugmill for lime addition? | |
| Water setup to add lime at pugmill? | |
| Aggregate is 1.0 % above SSD condition? | |
| Water spray bar and water system set up? | |
| Water spray bar used at exit end of pugmill? | |
| How often is moisture content of aggr. checked? | |
| Is fugitive lime dust in the air at plant site? | |
| RAP added? Max. size? Belt scale calibration? | |
| Total RAP by weighbridge? | |
| Total Virgin MA by weighbridge? | |
| Moisture content in RAP setting? Virgin MA? | |
| Amount of dry RAP added? | |
| Amount of dry virgin MA added? | |
| RAP percentage? ± 5% of target? | |
| Air quality permit present at plant site? | |

**QC/QA Project Inspection Report** 10/24

Road Site Location:_______________________________________________ Road Foreman: ________________________

Plan Typical Sections _________________________ Distance from road to plant (miles): _______________

| Road Site | Comments |
|---|---|
| Type of surface asphalt being placed on? | |
| Condition of surface being paved on? | |
| Tack rate? | |
| Distributor type: | |
| Emulsion diluted? Ratio __? Rate shot___? Cured? | |
| Vertical faces being tacked? | |
| Width of pavement being placed? | |
| Type and length of bevel, payfactor mix? | |
| Paving toward plant on top lift or away? | |
| Temperature of mix at paver is documented? | |
| Temperature of mix in windrow? | |
| Temperature variability in truck load delivered? | |
| Samples taken from windrow, or witnessed (QC)? | |
| Pickup machine being used, brand & size? | |
| Is the pickup machine picking up all material? | |
| Contractor or State checker (name & title)? | |
| Are the trucks tarped? Length of haul? | |
| Type of release agent being used at paver? | |
| Type and model of paver being used: | |
| Auto grade and slope controls working? | |
| Is vibrating screed being used? | |
| Material height at auger location: | |
| Augers within 12-18" of the edge of the paver screed? | |
| Type of traveling stringline and length: | |
| Type & brand of sensor and number used: | |
| Samples taken (precon) ________ witness? | |
| Temperature immediately behind paver? | |
| Temperature variability across mat behind paver? | |
| Number of breakdown rollers and type: | |
| Frequency of vibratory rollers and speed? | |
| Amplitude of vibratory rollers and speed? | |
| Number of intermediate rollers and type: | |
| Compaction rolling completed by 175° F ? | |
| Number of finish rollers and type: | |
| Is the bevel being compacted? | |
| Are correct plans typical section being obtained? | |
| Was a test strip used? Discussed at precon meeting? | |
| Roller pattern established and documented? | |
| Roller pattern checked by geo or nuclear gauge? | |
| Consistent paving operation? | |
| Segregation present? | |
| Corrective action taken to correct segregation: | |
| Surface texture? Tearing, checking, marks? | |
| Joints are matching after rolling? | |
| Joints at centerline on top lift? Offset __ bottom lift? | |
| Any other irregularities? | |
| Cores taken at random locations next day? | |
| Witnessed by QA? | |
| Core holes filled properly? When? | |
| Ride Spec. (notify DOT Central Lab of compl. date) | |
| QA Roadway Insp. Certified Field Inspector's name: | |
| QC Roadway Insp. Certified Field Inspector's name: | |
| Number of staff on roadway at inspection time: | |
| Diary contains: Hours paved, equip. ,location, width, crown, tons, weather, mix delays, temps, etc. ? | |
| Traffic control? | |
| Flaggers? Multicolored vest? Long shaft paddle? | |
| Bevels at end of days paving? How long? | |