Aggregate Testing
Recertification

Quality Control / Quality Assurance
DOT Employee Timesheet Information

Charge to Office Overhead

AFE- 71B4

Function- 1174
**IMPORTANT**

Recertification is only for individuals currently certified and actively participating on Asphalt Concrete Projects (must attend certification class every 8 years)
Course Materials

- QC/QA Asphalt Concrete Training Manual
- Standard Specifications for Roads and Bridges (2015 Edition) - Sections 320 and 322
- South Dakota DOT Materials Manual - Minimum Sample and Test Requirements (MSTR)
- Example Problems Packet
Course Agenda

- Sampling and Splitting
- Gradation
- Crushed Particles
- Sand Equivalent
- Fine Aggregate Angularity
- Lightweight Particles
- Specifications
- Issues
- Recertification Exam
Asphalt Concrete Production Control

- Preconstruction meeting by Contractor
- Line of authority shown for both QC and QA personnel
- Certified testing personnel
- Calibrated test equipment
- Quality Control plan
Certification Requirements

• Testers must be QC/QA certified in SD and have proof of certification
• Testing equipment calibration records shall be available on National Highway System Projects
• Requirements on www.dot.sd.gov
Certified Technicians

• The certified technicians must be present at the plant and roadway whenever the plant is supplying asphalt concrete to the roadway.
Laboratory Requirements

- Lab at plant site, Type III lab required for DOT personnel as of January 2005
- Ovens, power, etc.
- Calibration records in QC lab
  - All major equipment used for testing
  - Internal angle on gyratory compactor
Mix Design Report

• Approved Mix Design Report from Central Materials Lab
• Posted in field labs
• Mix compaction temperatures
• Job Mix Formula
• Gyratory, Rice, & other Mix Design results
• Manufactured Fines %
• Aggregate Composite % $\text{H}_2\text{O}$ at SSD if lime is added
  – Must be 1.0% above SSD content or additional $\text{H}_2\text{O}$ at pug mill
Manufactured Fines

• **Definition:** fine aggregate produced by crushing rock or gravel.

• **Specification**

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Class D</th>
<th>Class E</th>
<th>Class G</th>
<th>Class S</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4 Manufactured Fines*</td>
<td>NA</td>
<td>20% Min.</td>
<td>70% Min.</td>
<td>95% Min.</td>
</tr>
</tbody>
</table>

*Manufactured fines shall be manufactured solely from material retained on the ¾ inch sieve, unless the aggregate material is produced from a ledge rock source.

• **What to do if it fails?**
  – Change Bin Splits
Crushed Particles (SD 211)

- Used for determining % of pieces having one or more crushed faces.
- **One crushed face:** has a projected area of at least 25% of the max. cross-sectional area of the particle and the face has sharp and well-defined edges.
- **Two crushed faces:** the largest crushed face has a projected area of at least 50% of the max. cross-sectional area of the particle and the other crushed face has a projected area of at least 25% of the max. cross-sectional area of the particle and the faces have sharp and well-defined edges.

(Particles with one crushed face)  
(Particles with two crushed faces)
1. Using the data below, calculate the percentage of 2 or more crushed particles for the QC and QA lab.

Does the QC result meet the specification for a Q3 mix?

Do the test results meet the QC and QA tolerance for test result comparison?

<table>
<thead>
<tr>
<th></th>
<th>QC Test Result</th>
<th>QA Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 or more crushed particles</td>
<td>615.3</td>
<td>590.8</td>
</tr>
<tr>
<td>weight (grams)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ #4 Sample Wt. (grams)</td>
<td>750.1</td>
<td>787.4</td>
</tr>
<tr>
<td>% Crushed Particles</td>
<td>???</td>
<td>???</td>
</tr>
</tbody>
</table>
Problem #1 - Answer
Crushed Particles (SD 211)

• QC: \[ \left( \frac{615.3 \text{ grams}}{750.1 \text{ grams}} \right) \times 100 = 82 \% \]

• QA: \[ \left( \frac{590.8 \text{ grams}}{787.4 \text{ grams}} \right) \times 100 = 75 \% \]

<table>
<thead>
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<th>QA Test Result</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>+ #4 Sample Wt. (grams)</td>
<td>750.1</td>
</tr>
<tr>
<td>% Crushed Particles</td>
<td>82</td>
</tr>
</tbody>
</table>

• Does the QC result meet the specification for a Q3 mix?
  – (Answer): Yes (75 % min) [Spec. Book Section 322]

• Do the test results meet the QC and QA tolerance?
PL, LL and PI (SD 207)

• Plastic Limit, Liquid Limit and Plasticity Index
• On Class D, E, G, HR and S mixes
  – 2020 Supplemental Spec Change to Sand Equivalent (SD 221) & Fine Aggregate Angularity Tests (SD 217)
• Specification in Standard Specifications for Roads and Bridges
Mix Design Report - Gyratory

- Approved Mix Design Report
- Posted in both QC and QA lab
- Mix compaction temperatures
- Job Mix Formula
- Gyratory, Rice, & other Mix Design results
- Aggregate moisture content at SSD
- Aggregate Composite Gsb, aggr. comp. -#4 Gsb
- Aggregate Composite % H₂O at SSD
Aggregate Cold Feed Sample

- Calibration test on cold feed sample ran by QC and QA testers
- Sample obtained from cold feed belt *(SD 201)*
- Belt or stream sampling. Most use stream sampling, *(SD 201 Sec. B)* sampling device
- Sample size *(Gyratory*), Enough to have 4 splits (6 if IA sample required) large enough to do all required tests
- Split down to testing size using *(SD 213)*, free flowing for splitter
- Dry sample before testing *(SD 217)*
- Frequency of needed tests, gradation and other applicable tests every 1,000 tons QC, minimum 1 per 5,000 tons QA, IA one per 15,000 tons
- Sample retention time for *(Gyratory*) samples is how long?
  - QC : Until IA and QA tests completed and Engineer approves disposal
  - QA : Until the Bituminous Engineer has completed the F-test and t-test statistical evaluation
Splitting Procedure

• Read Procedure in SD 213

Diagram:
- Mix and blend sample 3 times using splitter before reducing to testing size.
- Reverse a & b pans.
- Reduce further if more samples are needed.
- OR

Sample Distribution:
- S1 (Testing Samples)
- S2 (Backup Samples)
- IA1
- IA2
Gradation (SD 202)

- **Nominal Maximum Size**: the smallest sieve opening, through which 90% or more of the sample being tested will pass.
- Bin splits shown
- Moisture Percentage
- Dust test, combined - # 200 on DOT 3
- + #4 and - # 4 gradation check
- Adequacy of sieving
  - Not more than 0.5% by weight of the original dry sample weight on a sieve shall pass that sieve in one minute of hand sieving.
- Check for overloaded sieves
  - Chart in SD 202
- JMF specification compliance
- Manufactured Fines requirements
- Problem #2
Problem #2
Total Combined - #200

Calculate the total combined - # 200

- The coarse sieve analysis had 70.7% passing the #4 sieve.
- The washed coarse aggregate sample had 0.64% passing the #200 sieve.
- 5.01% passed the #200 sieve on the fine sieve analysis.

![Diagram]

\[
\text{Coarse} \times \% \text{ Retained/Design} = \\
\text{Fine} \times \% \text{ Passing/Design} = \\
\text{Total Combined} - \#200 = 
\]
Problem #2 - Answer

Calculate the total combined - # 200

- The coarse sieve analysis had 70.7% passing the #4 sieve.
- The washed coarse aggregate sample had 0.64 % passing the #200 sieve.
- 5.01% passed the #200 sieve on the fine sieve analysis.
- \% Retained/Design = 100 - \% Passing(Design) = 100 - 70.7 = 29.3 %

\[
\frac{0.64 \times 29.3}{100} = 0.19 \\
\frac{5.01 \times 70.7}{100} = 3.54
\]

0.19 + 3.54 = 3.73 or 3.7 %
Sand Equivalent (SD 221)

- Reference AASHTO T 176
- Stock solution is good for how long?
  - Working solution more than 30 days old shall be discarded
- Obtain sample from moistened material which a cast can be formed without free water
- Dry before testing
- Problem #3
### Problem #3

**Sand Equivalent**

**Class Q3**, Calculate Sand Equivalent. What is the spec?

<table>
<thead>
<tr>
<th>Sand Equiv Test</th>
<th>Sand Rdg.</th>
<th>Clay Rdg.</th>
<th>S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading #1</td>
<td>3.2</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Reading #2</td>
<td>3.2</td>
<td>4.5</td>
<td></td>
</tr>
</tbody>
</table>

**Sand Equivalent Test Results**
Problem #3 - Answer

Sand Equivalent

Class Q3

<table>
<thead>
<tr>
<th>Sand Equiv Test</th>
<th>Sand Rdg.</th>
<th>Clay Rdg.</th>
<th>S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading #1</td>
<td>3.2</td>
<td>4.4</td>
<td>73</td>
</tr>
<tr>
<td>Reading #2</td>
<td>3.2</td>
<td>4.5</td>
<td>72</td>
</tr>
</tbody>
</table>

Sand Equivalent Test Results

\[
\text{S. E.} = \left( \frac{\text{Sand Rdg. } #1}{\text{Clay Rdg. } #1} \right) \times 100 = \left( \frac{3.2}{4.4} \right) \times 100 = 72.7 \text{ (* always round up) = 73}
\]

\[
\text{S. E.} = \left( \frac{\text{Sand Rdg. } #2}{\text{Clay Rdg. } #2} \right) \times 100 = \left( \frac{3.2}{4.5} \right) \times 100 = 71.1 \text{ (*always round up) = 72}
\]

Average the Results

Specification: Spec. Book Sect. 322 (Class Q3)
Fine Aggregate Angularity (SD 217)

- Reference AASHTO T 304
- Calibrated cylinder
- Sample obtained from material retained on #16, #30, #50 and #100 sieve sizes

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing the #8 and retained on the #16</td>
<td>44 grams</td>
</tr>
<tr>
<td>Passing the #16 and retained on the #30</td>
<td>57 grams</td>
</tr>
<tr>
<td>Passing the #30 and retained on the #50</td>
<td>72 grams</td>
</tr>
<tr>
<td>Passing the #50 and retained on the #100</td>
<td>17 grams</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>190 grams</strong></td>
</tr>
</tbody>
</table>

The tolerance for the sample is ±0.2 grams per sieve.

- What to do if it fails?
  - Cease operations, take corrective action and get a passing sample
- Problem #5
Problem #4  
Fine Aggregate Angularity

Class Q2R, Fill in the blanks and Calculate FAA. What is the spec?

### Fine Aggregate Angularity

**SD 217**  
**Method A**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Density of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 °F</td>
<td>0 °C</td>
</tr>
<tr>
<td></td>
<td>lb/ft³</td>
</tr>
<tr>
<td></td>
<td>kg/m³</td>
</tr>
<tr>
<td>60</td>
<td>15.6</td>
</tr>
<tr>
<td>65</td>
<td>18.3</td>
</tr>
<tr>
<td>65</td>
<td>21.1</td>
</tr>
<tr>
<td>70</td>
<td>23.9</td>
</tr>
<tr>
<td>75</td>
<td>26.7</td>
</tr>
<tr>
<td>80</td>
<td>29.4</td>
</tr>
<tr>
<td>85</td>
<td>32.3</td>
</tr>
</tbody>
</table>

V = 1000 M/D

- Weight of measure and glass plate: 284.8 g
- Weight of measure, glass plate & water: 385.6 g
- M = net mass of water: 997.97 g
- D = density of water at test temp.
- V = volume of cylinder, mL

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>1st trial</th>
<th>2nd trial</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry -#4 bulk specific gravity (Gsb)</td>
<td>2.591</td>
<td>2.591</td>
<td></td>
</tr>
<tr>
<td>Volume of cylinder, mL (V)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight of cylinder, g (A)</td>
<td>247.5</td>
<td>247.5</td>
<td></td>
</tr>
<tr>
<td>Wt. of cylinder + aggregate, g (B)</td>
<td>399.3</td>
<td>399.4</td>
<td></td>
</tr>
<tr>
<td>Wt. of aggregate, g (F = B - A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncompacted voids, (nearest 0.1%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ U = \left( \frac{V - (F / Gsb)}{V} \right) * 100 \]

From Job Mix Formula  
Aggr -#4 Gsb
Problem #4 - Answer

Fine Aggregate Angularity

- **M** (net mass of water) = 385.6 − 284.8 = 100.8
- **V** (volume of cylinder, mL) = 1000 × \(\left(\frac{M}{D}\right)\) = 1000 × \(\left(\frac{100.8}{997.97}\right)\) = 101.0
- **F**₁ (wt. of aggregate, g) = 399.3 − 247.5 = 151.8
- **F**₂ (wt. of aggregate, g) = 399.4 − 247.5 = 151.9

- **U**₁ (uncompacted voids) = \(\frac{V - \left(\frac{F}{Gsb}\right)}{V}\) × 100 = \(\frac{101.0 - \left(\frac{151.8}{2.591}\right)}{101.0}\) × 100 = 42.0

- **U**₂ (uncompacted voids) = \(\frac{V - \left(\frac{F}{Gsb}\right)}{V}\) × 100 = \(\frac{101.0 - \left(\frac{151.9}{2.591}\right)}{101.0}\) × 100 = 42.0

- **Specification**
  - Spec. Book Sect. 322 (Class Q2R)
    - Minimum 41.5 %
**Problem #4 - Answer**

*Fine Aggregate Angularity*

Class Q2R  Spec: Min. 41.5%

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**Fine Aggregate Angularity**  
SD 217  
Method A

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Density of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°F 0°C</td>
<td>62.366</td>
</tr>
<tr>
<td>60 15.6</td>
<td>62.336</td>
</tr>
<tr>
<td>65 18.3</td>
<td>62.301</td>
</tr>
<tr>
<td>70 21.1</td>
<td>62.261</td>
</tr>
<tr>
<td>75 23.9</td>
<td>62.216</td>
</tr>
<tr>
<td>80 26.7</td>
<td>62.166</td>
</tr>
<tr>
<td>85 29.4</td>
<td>62.116</td>
</tr>
</tbody>
</table>

**V = 1000 M/D**

| Weight of measure and glass plate | 284.8 |
| Weight of measure, glass plate & water | 385.6 |
| M = net mass of water | 100.8 |
| D = density of water at test temp. | 997.97 |
| V = volume of cylinder, mL | 101.0 |

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</tr>
<tr>
<td>Volume of cylinder, mL (V)</td>
<td>101.0</td>
<td>101.0</td>
<td></td>
</tr>
<tr>
<td>Weight of cylinder, g (A)</td>
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<td>247.5</td>
<td></td>
</tr>
<tr>
<td>Wt. of cylinder + aggregate, g (B)</td>
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<td>399.4</td>
<td></td>
</tr>
<tr>
<td>Wt. of aggregate, g (F = B - A)</td>
<td>151.8</td>
<td>151.9</td>
<td></td>
</tr>
<tr>
<td>Uncompacted voids, (nearest 0.1%)</td>
<td>42.0</td>
<td>42.0</td>
<td><strong>42.0</strong></td>
</tr>
</tbody>
</table>

U = ((V - (F / Gsb)) / V) * 100
- #4 Lightweight Particles (SD 208)

- 250 to 350 gram sample
- Previously washed material may not be used
- Screen material on a #30 sieve
- Zinc chloride solution with a specific gravity of 1.95 ± 0.01
1. 1500 to 2000 gram sample
2. Previously washed material may not be used
3. Zinc chloride solution with a specific gravity of 1.95 ± 0.01
Flat and Elongated Particles (SD 212)

- Now only on mix design sample & production control
- Reference ASTM D 4791
Specification Compliance

• QC checks, compliance with all specifications, sign form, someone else check form and initial or sign, correct test size, overloaded sieves, provisions if any spec fails
• QA checks above items and compliance between QC and QA,
• IA checks, compliance between IA and QA or between IA and QC
• Similar/dissimilar, (SD 317)
• Provisions for reduction in test frequency
Test Reports and Control Charts

- (ACTM) Section 5 are the test forms,
  - results must be furnished on DOT test forms unless approved by the Engineer
- (Gyratory) numbering, reporting, and calculating procedures of the DOT
- Control Charts are to be maintained by the Contractor
Specification

- Reclaimed Asphalt Pavement (RAP) (plan note %)
- Dust to Binder (uses effective asphalt content)
- Burner Fuel up to #6 allowed (used motor oil allowed), need cert with delivery
- Adding Lime, aggregate must have at least 1.0 % moisture above SSD condition, enclosed twin-shaft pug mill must be used
- Bin splits adjusted only up to 5 percent
- Split companion tolerance will be 10 % on crushed particles test, 7 % on sand equivalent test
Construction

- Standard Spec Book 2015 (black)
- Newest tests and mix design procedures are in the Materials Manual or dot.sd.gov
- Gyratory Projects (about 50% have RAP)
- M S & T, automated part of Construction Management System (CMS) that deals with test forms and data for SDDOT employees
- Ride Specification on most Projects
Plant Site - Issues

• Stockpile contamination or segregation
• Bulkheads not used, material flowing into 2 bins
• Poor or unsafe aggregate sampling device
• Poor splitting procedures
• Not having proper scale and meter certs and checks
• Lime in air at plant site
• Burner fuel cert missing or incorrect material
Stockpile Contamination
No Bulkheads on Bins
With Bulkheads on Bins
QC Lab - Issues

• Incomplete records of equipment calibration
• No bulk specific gravity reheat test done
• Diaries not completed or lacking information and documentation
• Control charts not posted or updated in lab
• Back up samples not labeled or kept for correct amount of time
QA Lab - Issues

- Not taking Verification (QA) samples
- Not conducting QA sample and splitting
- Bulk specific gravity reheat not done
- Moisture in mix test not completed
- Back up samples not being retained
- Oil and lime cutoffs not witnessed
Recertification Exam

• Once the exam has started, you will have 2 hours to complete the exam.


• A score of 70% or better is required to pass the exam.