Driving Surface Aggregate Update

What is New with DSA

Potential Upcoming Additions to Specification

Information for PM Field Trip

Dave Shearer, Tim Ziegler, Eric Nevel

Center for Dirt and Gravel Road Studies
Driving Surface Aggregate Update

OUTLINE

• Introduction
• DSA Issues
• Plasticity Index
• Results of Center DSA testing
• DSA Testing Overview
• DSA placement this afternoon
What is Driving Surface Aggregate DSA:

1. Well-graded aggregate for surfacing roads

2. Created by Center in 2000.

3. Only approved surface material in Dirt and Gravel Road Program (Forestry and Cons Dist)

4. Approved for purchase by Liquid Fuels.

PennDOT Publication 447 (MS-0450-0004)
Driving Surface Aggregate

Introduction

Picture taken just after aggregate placement and compaction

DSA 2A
Driving Surface Aggregate

Picture taken 2½ years after aggregates were placed with a paver

Introduction

DSA 2A
What is in the DSA Spec:

1. Gradation (size) Specification
2. Hardness
3. Optimum Moisture
4. pH
SCC Certification

A certification is **REQUIRED**
- for each job.
- anytime the source material changes.
- **MUST** be collected by project manager with first load of DSA delivered.
- Certification applies to source pile of aggregate, not the quarry as a whole.
- Defensible

### Driving Surface Aggregate Certification

**Dirt and Gravel Road Maintenance Program**

**Company:**

**Plant Location:**

**Parent Stone Type:**

**Tonnage Represented:**

**Project:**

This record is to certify that the aggregate shipped to the above-referenced job site meets all Dirt and Gravel Road Maintenance Program specifications and quality requirements.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Specification Range</th>
<th>Gradation for This Lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5&quot;</td>
<td>100</td>
<td>% Passing</td>
</tr>
<tr>
<td>0.75&quot;</td>
<td>65 – 95</td>
<td>% Passing</td>
</tr>
<tr>
<td>#4</td>
<td>30 – 65</td>
<td>% Passing</td>
</tr>
<tr>
<td>#16</td>
<td>15 – 30</td>
<td>% Passing</td>
</tr>
<tr>
<td>#200</td>
<td>10 – 15</td>
<td>% Passing</td>
</tr>
</tbody>
</table>

**pH:**

**L.A. Abrasion:**

**Optimum Moisture %:**

**Authorizing Agent Signature:**

**Date:**

**Note:** The authorizing agent or responsible party should sign their name and print their name below their signature. If the signatory is a Penn-DOT certified Aggregate Technician, add the certification number on the line and no notary is required.

Sworn and subscribed before me

This day

Notary Public

My commission expires

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SCC Specification

Complete certification includes DSA specification on back of page.

**Driving Surface Aggregate Specifications**

Dirt and Gravel Road Maintenance Program

Pursuant to Section 9106 of the PA Vehicle Code, all dirt and gravel road maintenance organizations are required to use materials that meet the specifications for abrasion resistance, pH, and freedom from contaminants.

**Minus #200 Fine Composition:**

<table>
<thead>
<tr>
<th>Passing sieve</th>
<th>Lower %</th>
<th>High %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1/2 inches</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>#6</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>#4</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>#2,5</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>#200</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 1: Driving Surface Aggregate Specifications

**Size:**

The required amounts and allowed ranges, determined by % weight, for various size particles are shown on page 1 of this certification.

**LA Abrasion:**

The acceptable limit as measured by weight loss is “less than 40% loss”. Los Angeles Abrasion test, AASHTO T-96 [ASTM C 131] shall be used to determine this property. Existing data obtained from tests made for and approved by PennDOT will be accepted.

**pH:**

Aggregate must be in the range of pH 6 to pH 12.45 as measured by EPA 9045C.

**Optimum Moisture:**

Material is to be delivered and placed at optimum moisture content as determined for that particular source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, procedure C, Standard.

**Transport:**

Tarps are to be used to cover 100% of the load’s exposed surface from the time of loading until immediately before dumping. This requirement includes standing time waiting to dump.
Plasticity Index

Forestry changed their DSA specification to include a Plasticity Index (PI) in mid 2012. DCNR made this change because of inconsistencies and difficulties they were having with DSA jobs around the state. Center staff began extensive testing of DSA parameters, including PI, in 2010. Based on these tests and PI parameters used by other entities, Forestry implemented a **maximum allowable PI value of 6** into their specification in 2012.

Lots more to come on this
Driving Surface Aggregate

DCNR ONLY
DSA Certification

Introduction

Driving Surface Aggregate Specifications
Dirt and Gravel Road Maintenance

Note that “Driving Surface Aggregate” is now approved.

Pursuant to Section 9.06 of the PA Vehicle Code, all Driving Surface Aggregate must be derived from natural stone formations. Stone is defined as rock that has been crushed, rock is defined as consolidated mineral matter. All components of the aggregate mixate to be derived from crushed rock material that meets program specifications for abrasion resistance, pH and freedom from contaminants.

Minus #200 fine composition:
The fines passing the #200 sieve must be rock material. No clay or silt soil may be added. Limestone material passing the #200 sieve may be used to make up a deficit in the distribution of sandstone. Any sandstone passing the #200 sieve must be derived from rock material. Other particulate such as coal dust and cement kiln dust may be added to the #200 sieve. The amount of particles passing the #200 sieve must be consistent with the amount specified in FTM No. 100.

LA Abrasion:
The acceptable limit as measured by weight loss is “less than 40% loss”. Los Angeles Abrasion test, AASHTO T-96 [ASTM C 131] shall be used to determine this property. Existing data obtained from tests made for and approved by PennDOT will be accepted.

pH:
Aggregate must be in the range of pH 6 to pH 12.45 as measured by EPA 9045C.

Optimum Moisture:
Material is to be delivered to the construction site at the moisture content determined for that particular source. The Optimum Moisture content can be determined using Proctor Test ASTM D698, procedure C. The moisture content should be within ±2% of the optimum moisture content.

Plasticity Index:
Material must not exceed Plasticity Index (PI) rating of 6. The laboratory test required for these results is the ASTM D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

Transport:
Tarps are to be used to cover 100% of the load's exposed surface from the time of loading until immediately before dumping. This requirement includes standing time waiting to dump.
Driving Surface Aggregate Update

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Three most common issues with DSA:

1. Out of spec (gradation)
   - If it is out of spec, it’s not DSA!

2. Optimum Moisture (usually to dry)
   - Dry DSA will segregate by size & will not compact.

3. Too much clay
   - Most difficult to control with current standards
   - Fines (-#200) must be crushed rock, not clay.
To much clay: retains moisture, rutting, dust
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So what can we do to control this problem?
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**What is PI:** Plasticity Index is the range of moistures at which a material behaves in a “plastic” state and is neither a solid or a liquid.
**What is PI:** While not a direct measurement, PI is the accepted methodology for quantifying CLAY in soil.

**PI for Dummies:**
High PI = Clayey Soil
Low PI = free of silt or clay
How is PI determined?:
PI is determined on portion of material passing a #40 sieve. That’s 40 holes per linear inch and 1600 holes per square inch.
How is PI determined?:

[Image of various equipment and materials used in determining PI, including a scale, testing apparatus, and samples of soil aggregate.]
Liquid Limit Device
Soil is soaked and allowed to dry to desired consistency. Soil is spread into brass cup and a ½” groove is cut. At the Liquid Limit, the 2 “sides” will come together at ~25 drops of the cup.
If it takes more than 25 blows/drops to bring sides together, material is too dry and water must be added. If it takes less than 25 blows, soil is too wet and must be allowed to dry further.
The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of about 1/8 inch. A soil is considered non-plastic if a thread cannot be rolled out down to 1/8” at any moisture.
The soil is then placed in a drying oven and reweighed to determine water content and percent moisture of original sample.
• The Plasticity Index (PI) is the difference between the Liquid Limit (LL) and the plastic limit (PL), so:
  • $PI = LL - PL$.
• Soils with a high PI tend to be clay.
• Soils with a low PI tend to be silt.
• Soils with a PI of zero or less are considered non-plastic and usually have little or no clay or silt.
**What is PI:** While not a direct measurement, PI is a reliable methodology for quantifying CLAY in soil.

**PI for Dummies:**
- High PI = Clayey Soil
- Low PI = free of silt or clay

Most DSA we’ve encountered has a PI of 0 to 12. Ideally, it should be no higher than 6.
2011 DSA Study:
• Done in 2011 by Quality Engineering Solutions for PennDOT under Low-Volume-Roads Program.
• Tested DSA with various fine contents (10%, 15%, 18%) and levels of plasticity (0, 4, 8)
• Results:
2011 DSA Study:
• Done in 2011 by Quality Engineering Solutions for PennDOT under Low-Volume-Roads Program.
• Tested DSA with various fine contents (10%, 15%, 18%) and levels of plasticity (0, 4, 8)
• Results:
  • Gradation: "the current DSA specification range for fine content (-#200) of 10-15% was reasonable”.
  • Plasticity: “the tolerance threshold for the PI limit (max) in DSA lies between 4 and 8.”
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## History and reason for PI testing

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-08</td>
<td>Forestry asks Center to investigate problems with DSA</td>
</tr>
<tr>
<td>2009</td>
<td>Center began testing samples of DSA to determine problem and solution. Discovered clay was the likely problem</td>
</tr>
<tr>
<td>2009</td>
<td>Material from several quarries began to be “rejected” due to high clay content.</td>
</tr>
<tr>
<td>2011</td>
<td>PennDOT DSA study completed.</td>
</tr>
<tr>
<td>2012</td>
<td>BOF incorporated PI into their DSA spec in 2012 (max 6)</td>
</tr>
<tr>
<td>2013</td>
<td>Center continued testing aggregate in order to determine if PI should be included in general DSA spec.</td>
</tr>
</tbody>
</table>
Plasticity Index: 28 samples

Plasticity Index (PI) Range: 0-11
PI Avg: 3.1
Fine Content: 26 samples
• 8/26 out of spec (3 low & 5 high)
• #200 Avg: 12.8
Driving Surface Aggregate

Results of Testing

**Maximum Dry Density:** 15 samples

- **Average:** 141 Lbs/Cuft

![Graph showing Maximum Dry Density](image-url)
Optimum Moisture: 15 samples

• Average: 6.7%
### Results:

- **Plasticity Index** is a cheap and reliable method to quantify clay content.
- Higher clay content = poor aggregate performance.
- **A DSA PI limit of <6**, as implemented by Forestry in 2012, will be recommended to the SCC for **next construction season**.
  - 6 is low enough to insure quality aggregate.
  - 6 is high enough to keep it “makeable”.
- **Will recommend to SCC that DSA testing (sieve and PI) be required on all jobs over 1,000 feet in length.**
- Many other states have PI limits in the surface aggregate specifications.
Results:

• Center aggregate testing is ongoing.

• Contact the Center before performing aggregate testing.
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Testing:
• Eliminate aggregate problems before delivery.
• Serve as a legally defensible backup if there are problems with the aggregate in the future.
• Allowable expense in the Program as part of the Project Costs (or district admin).
• The use of these tests is Strongly Encouraged (and will likely become required) on larger aggregate jobs (+1,000’ projects).

Start building these testing costs into the grant applications on DSA projects!!!
Gradation w/ Wash (sieve analysis): $100

- Will give you size analysis of aggregate
- Make sure you are getting DSA!!!
- 8 out of 26 the Center tested were out of spec!
Testing Overview

Testing:
- Gradation w/wash: $100
- **Std. Proctor** (Density & Opt. Moisture): **$145**
- Liquid Limit & Plasticity (PI): $100
- Field Technician (on site density): $200
  *varies with location, charged as hourly rate

TOTAL: $~550  *cost will vary

---

**Standard Proctor: $145**
- Will give you maximum density and optimum moisture.
- Required if you are going to do on-site density testing.
Testing Overview

Driving Surface Aggregate

Testing:
• Gradation w/wash: $100
• Std. Proctor (Density & Opt. Moisture)*: $145
• Liquid Limit & Plasticity (PI): $100
• Field Technician (on site density): $200
  *varies with location, charged as hourly rate
TOTAL: $~550 *cost will vary

Plasticity: $100
• Will give you Plasticity Index (clay content).
• Proposing to implement PI limit of ≤6 next year.
• Insures you are don’t pay for DSA and getting 2RC!
### Testing Overview

**Driving Surface Aggregate**

<table>
<thead>
<tr>
<th>Testing</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation w/wash</td>
<td>$100</td>
</tr>
<tr>
<td>Std. Proctor (Density &amp; Opt. Moisture)</td>
<td>$145</td>
</tr>
<tr>
<td>Liquid Limit &amp; Plasticity (PI)</td>
<td>$100</td>
</tr>
<tr>
<td>Field Technician (on site density)</td>
<td>$200</td>
</tr>
</tbody>
</table>

*varies with location, charged as hourly rate

**TOTAL:** $~550  *cost will vary*

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**Field Technician: $200-500**

- Insures optimum moisture and maximum compaction during placement.
- Proctor test required beforehand.
- Billed hourly, so cost varies by location.
Sampling Protocol:

• Quarry visit should be scheduled to obtain aggregate sample (~75 lbs).

• Sample must be at the lab at least 2 week before placement.

• Center is creating a technical bulletin about proper sampling protocol for distribution next Spring.
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Garden Hollow Road (Bald Eagle SF)

- Live DSA placement this afternoon.
- Part of Center’s annual Demonstration Project with Bureau of Forestry.
- Material from Hanson, Salona Quarry.
- Results of material testing:

Refer to your Handout
### Sieve Analysis

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>DSA Spec</th>
<th>This Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5”</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>0.75”</td>
<td>65-95</td>
<td>88</td>
</tr>
<tr>
<td>#4</td>
<td>30-65</td>
<td>44</td>
</tr>
<tr>
<td>#16</td>
<td>15-30</td>
<td>21</td>
</tr>
<tr>
<td>#200</td>
<td>10-15</td>
<td>10.4</td>
</tr>
</tbody>
</table>
Plasticity

LIQUID / PLASTIC LIMITS OF SOIL - ASTM D 4318
Hanson - Salona

LIQUID LIMIT < 20
PLASTIC LIMIT non-plastic
PLASTICITY INDEX non-plastic

SUBMITTED BY: Ken McNulty, Laboratory Manager
DATE: 8/30/13
Driving Surface Aggregate

Garden Hollow DSA

AGGREGATES & SOILS TESTING CO.
PHYSICAL TESTING OF CRUSHED STONE AND SOILS
AASHTO ACCREDITED • INSLAB INSPECTED

817 Magaro Road • Enola, PA 17025 • 717-412-0998 • www.aggregatesandsoiltesting.com

Mr. Eric Nevel
Center for Dirt & Gravel Road Research
220 Transportation Research Building
University Park, PA 16802

AST# 15847-3
RECEIVED: August 28, 2013
TESTED: August 30, 2013
SUBMITTED BY CLIENT

STANDARD PROCTOR - ASTM D 698 (C)
Hanson - Salona

MOISTURE - DENSITY CURVE

Oversized Material Removed (+3/4") = 12.0%
Optimum Moisture Content (%) = 5.9
Maximum Dry Density (lb/cuft) = 143.5
Maximum Wet Density (lb/cuft) = 152.0

SUBMITTED BY: Ken McNulty, Laboratory Manager
DATE: 8/30/13

Proctor
In your Handout

MOISTURE CONTENT

DRY DENSITY (lb/cu ft)

145
144
143
142
141
139
138
137
136
135
134
133
132
131

3
4
5
6
7
8
9

5.9
143.5
What you will see this Afternoon:

• Base preparation including
  • Keys cut into existing road to support aggregate.
  • Proper crown in road base

• Live DSA placement through a track paver in single pass 6” loose lift.

• Compaction with 10 ton vibratory roller from 6” loose to 4” compacted lift.

• On site density and moisture testing with nuclear density gauge.
Trail Surface Aggregate (TSA):

- Developed by the Center in 2009 as a “ Downsized DSA” designed for trail surface.

- Over 24 miles of TSA have been placed on rail-trail projects since 2011.

- Brief stop at 17 mile Buffalo Valley Trail on tomorrow’s field trip.

Bottom Line:

• Would you buy a car without a test drive?

• If you are spending $20,000 (or much more) on DSA, isn't it worth $500 bucks to make sure it is right?
Driving Surface Aggregate Update

Look for more guidance as we move forward with these recommendations to the SCC for policy changes.

www.dirtandgravelroads.org