South Dakota Gravel Study
A 2011 Success Story

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SD LTAP

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SDDOT/SDLTAP Gravel Road Experimental Project
Lessons Learned Thru 2017
SDDOT Gravel Road Test Project

- Three test sections were constructed in:
  - Hand County - northeast of Miller
  - Custer County - northwest of Custer
  - Brookings County - south of Volga
Location of Sections:
Substandard Gravel

SD Standard Specification

Modified Specification

Buffer Sections

Compacted and Uncompacted Sections

Compacted and Uncompacted Sections
Each section was built with three to four inches of new gravel after existing surface was prepared and shaped. Compaction/non compaction comparison as well.
One of the biggest challenges was finding gravel that meets the modified SDDOT Specification: "Shall have minimum plasticity index (PI) of seven". (Even higher minimum was considered in project planning)
Gravel Road Test Project

- Primary focus is on *effect of gravel quality* on life-cycle cost of gravel road maintenance

- Three types of gravel used in study:
  1. Substandard but commonly used - meets no spec except top size control - one inch minus.
  2. Barely meets SDDOT Gravel Surfacing Spec - percent passing #200 sieve is low and/or plasticity index (PI) at bottom of range at 4
  3. Modified SDDOT Spec - higher minimums of 10% passing #200 sieve and PI at 7.
What is Good Gravel?
<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>Subbase</th>
<th>Gravel Cushion</th>
<th>Aggregate Base Course</th>
<th>Limestone Ledge Rock</th>
<th>Gravel Surfacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIEVE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2&quot; (50 mm)</td>
<td>100</td>
<td></td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1&quot; (25.0 mm)</td>
<td>70-100</td>
<td>100</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3/4&quot; (19.0 mm)</td>
<td>100</td>
<td>80-100</td>
<td>80-100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>½&quot; (12.5 mm)</td>
<td></td>
<td>68-91</td>
<td></td>
<td>68-90</td>
<td></td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>30-70</td>
<td>50-75</td>
<td>46-70</td>
<td>42-70</td>
<td>50-78</td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td>22-62</td>
<td>38-64</td>
<td>34-58</td>
<td>29-53</td>
<td>37-67</td>
</tr>
<tr>
<td>No. 200 (75 μm)</td>
<td>0.0-15.0</td>
<td>3.0-12.0</td>
<td>3.0-12.0</td>
<td>3.0-12.0</td>
<td>4.0-15.0</td>
</tr>
<tr>
<td>Liquid Limit Max</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
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<tr>
<td>Plasticity Index</td>
<td>0-6</td>
<td>0-6</td>
<td>0-6</td>
<td>0-3</td>
<td>0-3</td>
</tr>
<tr>
<td>L.A. Abra. Loss, max.</td>
<td>50</td>
<td>40</td>
<td>40</td>
<td>40</td>
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<tr>
<td>Foot Notes</td>
<td>2</td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processing Required</td>
<td>crushed</td>
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<td>crushed</td>
<td>crushed</td>
</tr>
</tbody>
</table>
# Base – Surface Gravel Comparison

**Table 1. Example of Gradation Requirements and Plasticity for Two Types of Materials.**

<table>
<thead>
<tr>
<th>Requirement Sieve</th>
<th>Aggregate Base Course Percent Passing</th>
<th>Gravel Surfacing Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&quot;</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>80-100</td>
<td>100</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>68-91</td>
<td></td>
</tr>
<tr>
<td>No. 4</td>
<td>46-70</td>
<td>50-78</td>
</tr>
<tr>
<td>No. 8</td>
<td>34-54</td>
<td>37-67</td>
</tr>
<tr>
<td>No. 40</td>
<td>13-35</td>
<td>4-12</td>
</tr>
<tr>
<td>No. 200</td>
<td>3-12</td>
<td></td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>0-6</td>
<td>4-12</td>
</tr>
</tbody>
</table>

*Better when modified to 8 - 15*  

From South Dakota Standard Specifications. (16)
Sampling and testing is the only way to be sure.
Cost Of Good Gravel

- As is the cost of everything good, gravel is not an exception !!!!
- Analyzing cost of the gravel's life cycle is very important
- Is slightly more expensive gravel that requires 10 less blading's per year really more expensive?
- Giving the public a safe road at a reasonable cost is very important!
How Do We Obtain Good Gravel

- Contractor
- Pit Selection
- Managing the Source
- Testing
- Managing the Stockpile
Pit Selection

- Availability of Good Material
- Option To Bring In Material To Meet Spec
- Cost of Material
- Location of Pit (Reduced Haul Costs)
Contractor

- Is the Contractor Familiar With the Area
- Willing To Meet Spec
- Willing To Test or Be Tested
- Process In A Suitable Time Frame
Testing

- Taking Tests
- Timely Testing
- Who Pays For the Test
- Does It Meet Spec
- What if It Is Out of Spec?
- Cost of Test
Control quality at the time of production.
One way to meet modified spec - blend different material from separate sources

This was done on one section in Brookings Co and one section in Custer Co
More blending or “manufacturing” in the future?
Processing material from a natural clay source
Road mixing to get a high quality surface gravel
Some sections showed contrast in performance quickly due to gravel quality

Custer County Test Sections
Brookings County Test Sections

Substandard Section

Modified Section

Only one month after construction
Current Status of Project

- SDLTAP has accumulated photo documentation on all sections over the past two years.
- Measurement and documentation has been done on these distress types in 2012:
  1. Accumulation of loose aggregate (float)
  2. Changes in top width from time of construction
  3. Presence of corrugation (washboard) on surface
  4. Change in roadway crown
The float test
Simply remove loose aggregate from a 10 inch cross section, weigh it and convert that to a one-mile section.
Change is top-width is measured on traveled way - grass line to grass line

XX ft.
Corrugation (washboard): Hard to quantify in extent, fairly easy to measure severity.
Crown: measured with a laser level
Summary of Loose Aggregate

- Brookings Section - measured 10-10-12:
  - Substandard Compacted: 383 tons per mile
  - Substandard Uncompacted: 405 tons per mile
  - Standard Spec Uncompacted: 211 tons per mile
  - Standard Spec Compacted: 203 tons per mile
  - Modified Spec Compacted: 71 tons per mile
Summary of Loose Aggregate (Con’t)

• Hand Co Section - measured 9-11-12
  – Substandard Compacted: 430 tons per mile
  – Substandard Uncompacted: 402 tons per mile
  – Standard Compacted: 266 tons per mile
  – Standard Uncompacted: 287 tons per mile
  – **Modified Spec Compacted: 277 tons per mile

** Testing showed gradation and plasticity varied little from Standard
Hand Section - Loose Aggregate

Volume of Loose Aggregate in Tons per Mile

Modified gravel

Note:
"C" means compacted
"UC" means uncompacted

Matinmaas Matinmaas Oakley UC* Oakley C* Bonebright C*
C* UC*
Summary of Loose Aggregate (cont.)

- Custer Co Section - measured 10-16-12
  - Substandard Compacted: 134 tons per mile
  - Substandard Uncompacted: 134 tons per mile
  - Modified Compacted: 92 tons per mile
Custer Section - Loose Aggregate


- Substandard Compacted
- Substandard Uncompacted
- Modified Spec
Deviation in Roadway Width*

- **Brookings Section:**
  - Modified section: 21 ft, 6 in
  - Substandard section: 24 ft, 7 in

- **Hand Section:**
  - Modified section: 24 ft, 6 in
  - Substandard section: 26 ft, 10 in

- **Custer Section:** No measurement due to uneven cross section

*Width deviation measured after harvest 2012.*
Corrugation (Washboard)

• No corrugation observed on any sections meeting at least minimum standard specification.

• However, Brookings substandard section had corrugation on 100% of center wheel path at last observation.

• Custer substandard did not have corrugation.
Concluding Points

- Meeting basic SDDOT standard surface gravel specification reduces loose aggregate by 1/3 to 1/2.
- Widest differential was in Brookings County near end of corn harvest with 405 tons of loose aggregate on substandard section to only 71 tons on modified section.
- Most interesting fact thus far: Brookings has done blade maintenance up to four times on substandard section to only once on modified!
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QUESTIONS?
THANK YOU FOR YOUR TIME