GRAVEL ROAD DUST ABATEMENT – STATE OF THE PRACTICE

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Overview

DUST KILLS!
Keep your distance
Overview

- Introduction
- Additive categories
- Project investigation
- Additive selection
- Conclusions
- Way forward
Introduction

- Gravel road problems
  - Fines loss
  - Wet weather passability
- Recommended approach
  - Use chemicals to keep a good road good
  - Justify through extended life of road and reduced maintenance
  - Base decision on guidelines and experience
Introduction

- Timeline for road additive development
  - Chlorides since 1907
  - Lignin sulfonates since 1913
  - Others since the 1930's
  - Research and implementation
  - Where are we after 100 years?

- Which additive?

- Two main categories
  - Surface stabilizers to control fines loss (dust control)
  - Full-depth stabilizers for improving passability
Overview

- Introduction
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What's in a Name?

Roadbond  Soilglue  Roadfix

Soilfix  Dustacide  ISS 2500  Durazyme

Dustbond  CBR+Pennzs suppressing

Roadpacker  Roadtreat  Dustex

Permazyme  Soil sement

Dustplus  RRP235

Reverseal  Calmag

Roadoil  Dustdown

Sandfix
Additive Categories

- Fines retention/surface stabilization
  - Water absorbing
    - Magnesium or calcium chloride
  - Organic non-petroleum or natural polymers
    - Lignosulfonate, tree resins
  - Organic petroleum and petroleum resins
    - Asphalt emulsions and asphalt modified additives
  - Synthetic/mineral oils
  - Synthetic polymer emulsions
    - Latex, acrylates, polyvinyl acetates
Water Absorbing
Organic Non-Petroleum
Organic Petroleum
Synthetic/Mineral Oils/Fluids
Synthetic Polymer Emulsions
Additive Categories

- Full-depth stabilization
  - Organic petroleum and petroleum resins
  - Synthetic polymer emulsions
  - Electrochemical/sulfonated oils
  - Enzymes
Overview

- Introduction
- Additive categories
- Project investigation
  - Economic analysis
  - Road information
  - Material properties
- Additive selection
- Conclusions
- Way forward
Materials

- Material properties must optimize all weather performance
- Optimize materials by processing depth/adding new material
- Numerous specifications available worldwide, performance based are most useful
- Performance dependent on:
  - Particle size distribution
  - Plasticity (clay content)
  - Strength (bearing capacity)
  - Aggregate hardness
## Guidelines

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Base (FHWA)</th>
<th>Wearing Course (FHWA)</th>
<th>Wearing Course Example County</th>
</tr>
</thead>
<tbody>
<tr>
<td>1½</td>
<td>100</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>90 - 100</td>
<td>100</td>
<td>75 - 100</td>
</tr>
<tr>
<td>¾</td>
<td>--</td>
<td>90 - 100</td>
<td>50 - 100</td>
</tr>
<tr>
<td>½</td>
<td>60 - 85</td>
<td>65 - 85</td>
<td>35 - 85</td>
</tr>
<tr>
<td>#4</td>
<td>45 - 65</td>
<td>50 - 78</td>
<td>25 - 70</td>
</tr>
<tr>
<td>#8</td>
<td>33 - 53</td>
<td>37 - 67</td>
<td>13 - 50</td>
</tr>
<tr>
<td>#30</td>
<td>--</td>
<td>13 - 35</td>
<td>13 - 50</td>
</tr>
<tr>
<td>#200</td>
<td>3 - 12</td>
<td>4 - 15</td>
<td>5 - 30</td>
</tr>
<tr>
<td>PI</td>
<td>0 - 4</td>
<td>4 - 12</td>
<td>4 - 20</td>
</tr>
</tbody>
</table>
## Guidelines

<table>
<thead>
<tr>
<th>Agency</th>
<th>Passing #200</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Utah LTAP</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>USDA Forest Service - Montana</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Australia</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>New Zealand</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Pennsylvania Center for Dirt and Gravel Road Studies</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>New York State DOT</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Louisiana DOTD</td>
<td>3</td>
<td>15</td>
</tr>
</tbody>
</table>

Source: George Huntington, Wyoming LTAP
Material Performance

- Three steps to understand material performance
  - Basic calculations using simple test results
  - Interpret results in terms of expected performance
  - Decide on an appropriate management strategy
Guidelines

Stabilization and Rehabilitation Measures for Low-Volume Forest Roads
Corrugations and Ravelling
Slipperiness
Overview

- Introduction
- Additive categories
- Project investigation
- Additive selection
- Conclusions
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Additive Selection

- Four part process
  - Preliminary selection (additive category) based on traffic, geometry, climate and soil chemistry
  - Refine selection (specific additives) based on AADT, PI, P#200, and weather
  - Check material compatibility & predict likely performance
  - Mix design and performance check of treated materials

- See FHWA Handbook
## Preliminary Selection

<table>
<thead>
<tr>
<th>Additive Category</th>
<th>Traffic Limitations</th>
<th>Road Geometry Limitation</th>
<th>Climate Limitations</th>
<th>Soil Chemistry Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cars</td>
<td>Trucks</td>
<td>Steep Grades</td>
<td>Sharp Curves/Super-elevation</td>
</tr>
<tr>
<td>Water absorbing</td>
<td>A</td>
<td>A&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>B&lt;sup&gt;3&lt;/sup&gt;</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Organic non-petroleum</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>B&lt;sup&gt;4&lt;/sup&gt;</td>
<td>C&lt;sup&gt;1,2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Organic petroleum</td>
<td>A</td>
<td>A&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Synthetic polymer</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Synthetic oils</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Electrochemical</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Enzyme</td>
<td>A</td>
<td>B&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

A = No significant influence of performance  
B = Some influence on performance  
C = Significant influence on performance

1 Empty trucks and trailers at high speed may break crust and accelerate washboarding and raveling
2 CBR must be increased with increasing number of trucks to ensure all-weather passability
3 May be slippery when wet
4 Likely to leach out with heavy rainfall
5 May leach down into layer, but dry-back plus light rejuvenation will return it to surface
6 Can react with some elements if abundant in soil to form non-hygroscopic compounds (e.g., iron chloride in soils with very high iron content)
7 Choice of anionic or cationic emulsion may influence performance on certain soils
8 Requires specific clay minerals for satisfactory reaction
## Preliminary Selection

<table>
<thead>
<tr>
<th>Additive Category</th>
<th>Soil Chemistry Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water absorbing</td>
<td>B⁶</td>
</tr>
<tr>
<td>Organic non-petroleum</td>
<td>A</td>
</tr>
<tr>
<td>Organic petroleum</td>
<td>B⁷</td>
</tr>
<tr>
<td>Synthetic polymer</td>
<td>A</td>
</tr>
<tr>
<td>Synthetic oils</td>
<td>A</td>
</tr>
<tr>
<td>Electrochemical</td>
<td>C⁸</td>
</tr>
<tr>
<td>Enzyme</td>
<td>C⁸</td>
</tr>
</tbody>
</table>

A = No significant influence        B = Some influence        C = Significant influence
## Refined Selection

<table>
<thead>
<tr>
<th>Dust Palliative</th>
<th>Traffic Vehicles per Day</th>
<th>Plasticity Index/Shrinkage Product</th>
<th>Surface Material Fines (Passing 75 μm, No.200, Sieve)</th>
<th>Climate During Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;100</td>
<td>100-250</td>
<td>&gt;250&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;50</td>
<td>50-365</td>
<td>&gt;365</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;5</td>
<td>5-15</td>
<td>&gt;15</td>
<td></td>
</tr>
<tr>
<td>Water absorbing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Mag Chloride</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Organic petroleum</td>
<td>B</td>
<td>B&lt;sup&gt;6&lt;/sup&gt;</td>
<td>B&lt;sup&gt;6&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Asphalt emulsion</td>
<td></td>
<td>B</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Petroleum resin</td>
<td></td>
<td>B</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Organic non-petroleum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lignin</td>
<td>A</td>
<td>A</td>
<td>B&lt;sup&gt;5&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Tall oil</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Bio-Fluids</td>
<td>A</td>
<td>A</td>
<td>B&lt;sup&gt;3&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Synthetic polymer emulsion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic polymer&lt;sup&gt;5&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic/Mineral Oils</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Synthetic Fluid (EPA Definition)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Electrochemical/Enzyme</td>
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<td></td>
</tr>
<tr>
<td>Electro-Chemical&lt;sup&gt;6,7&lt;/sup&gt;</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enzyme&lt;sup&gt;5,7&lt;/sup&gt;</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Other (mechanical)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay Additives&lt;sup&gt;5&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> Higher application rates/more frequent rejuvenation required for high truck traffic

<sup>2</sup> 20 days with less than 40% relative humidity

<sup>3</sup> May become slippery in wet weather if shrinkage product >250

<sup>4</sup> May leach out in heavy rain

<sup>5</sup> Mix-in treatment usually required

<sup>6</sup> SS-1 or CSS-1 with only clean, open-graded aggregate

<sup>7</sup> Requires reactive (usually expansive) clay minerals to react with

A = Good  B = Fair  C = Poor
Water Absorbing

Grading coefficient

Increasing coarseness / increasing gap

Shrinkage product

Increasing plasticity

Erodible

Good but dusty

Slippery and dusty

Corrugates and ravels

Ravels

Good

Good but dusty

Erodible

Good

Fair with maintenance

Good
Water Absorbing
Organic and Synthetics

Grading coefficient

Increasing coarseness / increasing gap

Increasing plasticity

Shrinkage product

Corrugates and ravels

Erodible

Slippery and dusty

Good

Fair with maintenance
Electrochemical and Enzymes

- **Grading coefficient**

- **Shrinkage product**

- **Increasing coarseness / increasing gap**

- **Good, may be dusty**

- **Erodible**

- **Ravels**

- **Slippery and dusty**

- **Corrugates and ravels**

- **Good**

- **Fair with maintenance**

- **Increasing plasticity**
# Material Compatibility

<table>
<thead>
<tr>
<th>Maximum size (mm)</th>
<th>40 - 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness factor (TIV)</td>
<td>20 - 65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>After treatment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Strength factor (CBR)</td>
<td>&gt;15³</td>
</tr>
<tr>
<td>- Abrasion resistance</td>
<td>&lt; 10% loss</td>
</tr>
<tr>
<td>- Erosion resistance</td>
<td>&lt; 8% loss</td>
</tr>
<tr>
<td>- Density</td>
<td>&gt;100%</td>
</tr>
</tbody>
</table>

** Calibrate for local use, conditions and test methods!**

Performance is always dependent on construction and maintenance quality!**
Overview

- Introduction
- Additive categories
- Project investigation
- Additive selection
- Conclusions
- Way forward
Conclusions

- Huge selection of additives
- There are no wonder products or "silver bullet"
- Decision based on
  - Problem
  - Materials
  - Cost-benefit
  - Vendor credibility
- Understand performance
- Investigation and testing is inexpensive, and will save $$ by optimizing selection
Way Forward

- FHWA studies
  - Road dust management handbook
  - Category specifications
- USGS studies
  - Environmental testing
- USFS studies
  - Additive selection
  - Gravel road management
- Road Dust Institute
  - Information clearing house
  - Fit-for-purpose certification
- Industry association