Managing Fugitive Dust On Alaska’s Roads and Airports

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Road Map

• Understanding fugitive dust
• Methods to manage dust
• Field Research
• Laboratory Research
• Applying Palliatives in Rural Alaska
Unpaved Roads in the US

- 1.3 million miles of unpaved road in US
- 97% located in rural areas
- Source of 10.5 million tons particulate matter <10μm (PM10)
Consider: 2-mile stretch of unpaved road, 20 vehicles/day, average speed = 30 mph.

Result: 10,920 lbs of dust (PM10) per month

(Roberts et al., 1975)
Impact of Loss of Particulate Matter from Unpaved Roads

- Degradation of road surface
- Driver safety
- Health and Quality of life
Health Issues

- Impacts children, elderly, and those with respiratory ailments the most
- Mortality rates increase 4.3% to 10% per 10 \( \mu \text{g m}^{-3} \) PM10
- PM2.5 may penetrate into the alveoli reducing transfer of oxygen
- 1 micron may enter the bloodstream
How Small are These Particles We Are Working With?

- **Heavy Dust**
- **Settling Dust**
- **Suspended Atmospheric Dust**
- **PM 10**
- **PM 2.5**

Particle Size (μm):
- 0.0001
- 0.001
- 0.01
- 0.1
- 1
- 10
- 100
- 1000
Really Small!

HUMAN HAIR
50-70 μm (microns) in diameter

PM$_{2.5}$
Combustion particles, organic compounds, metals, etc.
< 2.5 μm (microns) in diameter

PM$_{10}$
Dust, pollen, mold, etc.
< 10 μm (microns) in diameter

90 μm (microns) in diameter
FINE BEACH SAND

Image courtesy of the U.S. EPA
What Causes This?
We Need a Source of Dust
Next We Need a Mechanical Means of Lofting Particles into The Air
Moving Dust

- Advective Transport
- Turbulent Diffusion
- Settling
- Mechanical and Convective Lofting
Dust Settling
Settling time from a 2m loft

- 0.1 mm: ~3 sec
- 0.05 mm: ~11 sec
- 0.01 mm (PM10): ~4 minutes
- 0.0025 mm (PM2.5): ~1 hour
- 0.001 mm: 5.9 hours
Optical Haze
Methods to Manage Dust
Good Dust Management Starts with a Good Road
Using the Right Building Material is Critical
Too few fines causes washboarding
Too Many Fines Causes Muddy Roads
<table>
<thead>
<tr>
<th>Aggregate With No Fines</th>
<th>Aggregate With Sufficient Fines For Maximum Density</th>
<th>Aggregate With Great Amount Of Fines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grain-to-grain contact</strong></td>
<td>Grain-to-grain contact with increased resistance against deformation</td>
<td>Grain-to-grain contact destroyed, aggregate “floating” in soil</td>
</tr>
<tr>
<td><strong>Variable density</strong></td>
<td>Increased to maximum density</td>
<td>Decreased density</td>
</tr>
<tr>
<td><strong>Pervious</strong></td>
<td>Low permeability</td>
<td>Low permeability</td>
</tr>
<tr>
<td><strong>Non-frost susceptible</strong></td>
<td>Frost susceptible</td>
<td>Frost susceptible</td>
</tr>
<tr>
<td><strong>High stability if confined, low if unconfined</strong></td>
<td>Relatively high stability in confined or unconfined conditions</td>
<td>Low stability and low strength</td>
</tr>
<tr>
<td><strong>Not affected by adverse water conditions</strong></td>
<td>Not greatly affected by adverse water conditions</td>
<td>Greatly affected by adverse water conditions</td>
</tr>
<tr>
<td><strong>Difficult to compact</strong></td>
<td>Moderately difficult to compact</td>
<td>Not difficult to compact</td>
</tr>
<tr>
<td><strong>Ravels easily</strong></td>
<td>Good road performance</td>
<td>Dusts easily</td>
</tr>
</tbody>
</table>
A Good Crown is Critical

• Too Flat Causes ponding
A Good Crown is Critical

• Too Steep Causes Erosion
A Good Crown is Critical

• Should be between 4% and 5%
Gap under blade indicates crown.

Blade rolled forward to feather material.

Material feathered to eliminate water ponding.
Limiting Fugitive Dust by Limiting Speed

15 MPH

30 MPH
Types of Palliatives

• Water
• Water Absorbing Products (deliquescent/hydroscopic)
  o calcium chloride, magnesium chloride, brine
• Organic Nonpetroleum Products
  o vegetable oils
  o animal fats
  o lignosulfonate
  o tall oil emulsions
• Electrochemical Products
  • enzymes
  • ionic products
  • sulfonated oils
### 1999 US Forest Service Guide

<table>
<thead>
<tr>
<th>Dust Palliative</th>
<th>Traffic Volumes, Average Daily Traffic</th>
<th>Surface Material</th>
<th>Climate During Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Light &lt;100</td>
<td>Medium 100 to 250</td>
<td>Heavy &gt;250 (1)</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Magnesium Chloride</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Petroleum</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Lignin</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Tall Oil</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Vegetable Oils</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Electro-chemical</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Synthetic Polymers</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Clay Additives (6)</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
</tbody>
</table>
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• Water

• Water Absorbing Products (deliquescent/hydroscopic)
  - calcium chloride, magnesium chloride, brine

• Organic Nonpetroleum Products
  - vegetable oils
  - animal fats
  - lignosulfonate
  - tall oil emulsions

• Electrochemical Products
  • enzymes
  • ionic products
  • sulfonated oils
CaCl₂ Characteristics

- Most commonly used
- Requires high fines (10 - 14%)
- Ineffective when RH falls below 35%
- Can be slippery during and after a rainfall
- Has a bitter taste
- A mucus irritant
- Can impact water quality
Types of Palliatives

- Synthetic Polymer Products
  - polyvinyl acetate
  - vinyl acrylic
- Organic Petroleum Products
  - asphalt emulsions
  - dust oils
- Synthetic Fluids
  - With or without “binders”
  - Clay Additives
Synthetic Fluids

- Petroleum Products with all aromatics removed
- Meet all EPA/DEC toxicity requirements
- Naturally clear liquid but may have additives
- Non-corrosive
- Considerably more expensive than CaCl$_2$
- Liquid below -40 F
What we Have Learned so Far About Synthetic Fluid Performance

Average PM10 Concentration (mg/m³)

Fines Content (% Passing #200 Sieve)

- Summit
- Deering
- Buckland
- Kotzebue
- St Michael
- Kobuk
- White Mountain

0 0.04 0.08 0.12 0.16 0.2
4 6 8 10 12 14 16
Impact of Gradation
Synthetic Fluid Effectiveness Longevity

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**Less Than One Month After Application**

**Approximately One Years After Application**

**Approximately Two Years After Application**
Applying Palliative in the Village
It has to be done right

- Application must be uniform
It has to be done right

- Application must be uniform
It has to be done right

• Application must be uniform
It has to be done right

- Good Equipment is Not Expensive
The system is versatile
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Questions?

Image courtesy of Subaru of America, Inc.