Stabilizing Sand Roads Using Wood Fiber Materials and Byproducts
The Issue

Sandy regions without ready gravel.

Legend
- Unstable Sand
- National Forest Boundaries

- NORTHERN GREAT LAKES REGION
- CENTRAL OREGON
- SAND HILLS NEBRASKA
- FLORIDA
The Issue

Low volume roads in unstable “sugar sands”

- Poor traction
- Difficult maintenance
- Gravel tends to sink in and “disappear”

Scope of the issue on National Forests

- 6.2 million acres of unstable sand area on NFs
- 22,247 miles of forest roads through sand areas
- Remote, very low volume roads
STABILIZING SAND ROADS

The Issue
Northern Great Lakes Region
The Issue
Southeast - Florida
The Issue

Poorly graded sands and generally rounded grains result in unstable ground – (like marbles)

Wisconsin
Various minerals, subangular - subrounded

Florida
quartz, subangular - subrounded

Oregon
Volcanic, pumice, subrounded
Alternatives

How do you stabilize your low volume road when gravel is not available or economical?

Raw Wood Materials
- Natural organic material on hand (leaf litter, etc.)
- Wood products (chunkwood, wood chips, etc.)
- Wood wastes (bark and sawdust)

Pulp/Paper Mill Byproducts
- Lignosulfonates
- Sludge
- Boiler ash
- Others ....
Alternatives

Wood materials are often plentiful

Legend
Green – pulp mills
Blue – plywood mills
Black – saw mills
Grey – other mills

More than 400 paper mills in the U.S. + timber mills, pulp mills, and others
Alternatives

Woodchips

Wood chipper

Wood chip road fill, 30 years old
Alternatives

Chunkwood

Chunker with stockpile

Chunker blade
Alternatives

Wood Shreds and Wood Straw

Wood shreds

Wood Straw™
Alternatives

Bark and Sawdust

Bark

Sawdust
Alternatives

Pulp/Paper Mill Liquid Wastes/Byproducts

- Sludge on agricultural field
- Lignosulfonate sprayed on road
Alternatives

Pulp/Paper Mill Boiler Ash

Bottom ash

Flyash
Alternatives

Other Pulp/Paper Mill Solid Wastes/Byproducts

- Slaker Grit
- Paper Mill Waste Lime
- Causticizing residuals
- “Knots”
Alternatives

Grain Size Comparison

- Boiler Ash (Wisconsin)
- Native Sands (Wisconsin)
- Wood Chips
- Chunkwood (Wisconsin)
Alternatives
Comparison of Compaction Characteristics

- SAND WITH SLUDGE (WISCONSIN)
- BOILER ASH (WISCONSIN)
- CHUNKWOOD (WISCONSIN)

Dry Density (pcf)

Moisture Content (%)
Alternatives

Comparison of California Bearing Ratio
Alternatives

Field Investigation of Past Projects - Chunkwood

Wisconsin road 30 years old

Oregon road 20 years old
Alternatives

Field Investigation of Past Projects - Sludge

Wisconsin road 30 years old

Florida road 25 years old
Alternatives

Interim Conclusions for Wood Materials

- North Great Lakes region - Prefers any amendment to no treatment. - Road crews use local leaf litter when necessary.
- North Great Lakes region – chunkwood & sludge treated roads had good performance after 25-30 years. Colder climate with short growing season.
- Southeast region - chunkwood & sludge treated roads showed poor performance. Warmer climate with long growing season …faster breakdown (rot, biodegradation).
- Boiler ash looks promising.
Boiler Ash Alternative

Pulp/Paper Mill Boiler Ash Advantages

- Wood waste from energy production
- Obtained free from mill
- An inert sand/gravel like material
- Improves sand stability by better gradation
- Some cementitious (hardening) properties
Boiler Ash Alternative

Environmental Issues

- It is mostly WOOD ASH – natural in forest “Closed loop” concept – return material to forest where it originated
- It is NOT coal flyash like concrete additive
- Ash is part of energy production NOT part of paper manufacturing process
- Meets federal chemical standards
- Meets tighter Wisconsin DNR standards
- Agencies encourage “Beneficial Reuse of Industrial Byproducts”
- Use on roads avoids landfill disposal
- Our demonstration projects were specifically approved by Wisconsin DNR
Boiler Ash Alternative

Boiler Ash Comes from Generating Power

Paper mill power plant

Process, material recovery
Boiler Ash Alternative

Boiler Ash Comes from Wood Fuel (mostly)

Non-merchantable timber

Bark and branches

Coal (10%) for better combustion
Boiler Ash Alternative

Simple Construction Equipment & Techniques

1. Deliver ash
2. Spread and shape
3. Blend
4. Compact
Boiler Ash Alternative

Boiler Ash Spread on Prepared Road
Boiler Ash Alternative

Before vs. After

Before ash treatment

Immediately following ash treatment

One year following ash treatment
Boiler Ash Alternative
Engineering Field Testing

FWD testing  DCP testing  Compaction testing
Boiler Ash Alternative

Engineering Lab Testing

Boiler ash adds binder and tends to flatten the curve – more stable because more well-graded
Boiler Ash Alternative
Compaction Characteristics

Addition of boiler ash shifts the curve down (lighter) and to the right (wetter)

Note: For all ash, no sand
Max density = 83 pcf
Opt moisture = 28%

Dry Density (pcf)

Moisture Content (%)
Addition of boiler ash clearly improves traffic bearing characteristics.

<table>
<thead>
<tr>
<th>CBR Value</th>
<th>Without Ash</th>
<th>With Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR685</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>West third</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR685</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Middle third</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR685</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>East third</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR1155</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>South third</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR1155</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Middle third</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR1155</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>North third</td>
<td></td>
<td></td>
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</tbody>
</table>
Boiler Ash Alternative

Unconfined Compressive Strength

Compressive strength indicates cementitious properties of boiler ash.

<table>
<thead>
<tr>
<th></th>
<th>Strength at 1 day</th>
<th>Strength at 14 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR685 (50% ash - 50% soil)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR1155 (50% ash - 50% soil)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flambeau Mills ash (100% ash; 60-40 flyash-bottom ash)</td>
<td></td>
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</tbody>
</table>
Boiler Ash Alternative

Dynamic Cone Penetration (DCP) Testing

Forest Service DCP Readings, FR 685, MP 0.50 Right Track (South)

Penetration Rate (mm/blow)

Depth below ground surface (mm)

Before Ash
After Ash
1 Year After Ash

DCP results show mixed results. Why? Likely a function of moisture.
Boiler Ash Alternative

Falling Weight Deflectometer (FWD) Testing

FWD results tend to suggest ash treatment made roads softer rather than stiffer. Why? Likely a function of moisture.
# Boiler Ash Alternative

## Costs

<table>
<thead>
<tr>
<th>Item</th>
<th>FR1155 Boiler Ash</th>
<th>FR1155 Gravel Surfacing</th>
<th>FR685 Boiler Ash</th>
<th>FR685 Gravel Surfacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase material</td>
<td>$0</td>
<td>$15,000</td>
<td>$0</td>
<td>$15,000</td>
</tr>
<tr>
<td>Haul/deliver to site</td>
<td>$15,000</td>
<td>$8,000</td>
<td>$9,720</td>
<td>$23,000</td>
</tr>
<tr>
<td>Shape and prep road bed</td>
<td>$6,100</td>
<td>$6,100</td>
<td>$6,100</td>
<td>$6,100</td>
</tr>
<tr>
<td>Spread and compact material (includes blending for boiler ash)</td>
<td>$12,100</td>
<td>$7,500</td>
<td>$12,100</td>
<td>$7,500</td>
</tr>
<tr>
<td>Total Cost Per Lane Mile</td>
<td>$33,200</td>
<td>$36,600</td>
<td>$27,920</td>
<td>$51,600</td>
</tr>
<tr>
<td>Cost Per Lane Mile Less Haul Costs</td>
<td>$18,200</td>
<td>$28,600</td>
<td>$18,200</td>
<td>$28,600</td>
</tr>
<tr>
<td>Ash-Gravel Cost Difference</td>
<td>57%</td>
<td>57%</td>
<td>57%</td>
<td>57%</td>
</tr>
</tbody>
</table>
Wood Materials For Stabilizing Low Volume Sand Roads

Conclusions

- Alternate stabilization materials are needed in areas of “sugar sand.”

- Raw wood products and byproducts can be viable road-stabilizing materials where they are abundant and cheap.

- Some byproducts from paper/pulp mills can be viable road-stabilizing materials where they are abundant and cheap.

- Paper mill boiler ash is an especially promising alternate road-stabilizing material.

- Wood-related materials are generally environmentally sound and re-use is encouraged by most states to divert waste from landfills.
Stabilizing Sand Roads Using Wood Fiber Materials and Byproducts

For more information:
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