LEADING EDGE TECHNOLOGIES
FOR LOW VOLUME ROADS

David Jones, PhD
University of California Pavement Research Center
Davis, California

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Edmonton, January 2014
Overview

- Introduction

- Unpaved road chemical treatment
  - Current practice
  - New guide
  - Web-based selection tool

- Full-depth reclamation
  - Practice review and needs identification
  - Current research
  - Interim findings

- Summary
Introduction

- Low-volume road problems
  - Unpaved
    - Fines loss (dust)
    - Wet weather passability
    - Safety and environment
  - Paved
    - Design life
    - Poor, unsafe ride quality
    - Expensive maintenance/reconstruction
Introduction

- Recommended approach
  - Unpaved
    - Focus on addressing key issues
    - Building the best possible road
    - Use chemical treatments (or seal) to keep a good road good
    - Monitor performance
    - Justify through extended life of road and reduced maintenance
  - Paved
    - Consider “unpaving” for low traffic
    - Consider full-depth reclamation with new surface for other roads
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- Summary
Unpaved Road Chemical Treatment

- Two main categories of additive
  - Surface stabilizers to control fines loss (dust control)
  - Full-depth stabilizers for improving passability, preserving material, and fines preservation (dust control)

- Additive selection
  - Currently based on:
    - Experience
    - US Forest Service (1999) and other guides
    - Marketing by suppliers
### Current Practice

- **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>
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<tr>
<td></td>
<td>Light &lt;100</td>
<td>Medium 100 to 250</td>
<td>Heavy &gt;250 (1)</td>
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<tr>
<td>Calcium Chloride</td>
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<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Magnesium Chloride</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Petroleum</td>
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<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>x ✓</td>
</tr>
<tr>
<td>Vegetable Oils</td>
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<td>x</td>
<td>x ✓</td>
</tr>
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<td>Electro-chemical</td>
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<td>✓ ✓</td>
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<tr>
<td>Synthetic Polymers</td>
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<td>✓ ✓</td>
<td>x ✓</td>
</tr>
<tr>
<td>Clay Additives (6)</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>x ✓</td>
</tr>
</tbody>
</table>

Note: ✓ indicates acceptable, X indicates unacceptable.
New Selection Guide

- 1999 US Forest Service Guide
- New developments since 1999
  - More products (±200 in USA)
  - More/refined categories
    - Dust control vs. stabilization
  - Additional experience
    - Documented field trials
  - Requests for more detailed guidance, preferably with ranking
2013 FHWA Guide

- Based on the concept of “Keep a good road good”
Keep a Good Road Good
Based on the concept of “Keep a good road good”

10-step process for selecting a treatment
- Manual or web-based tool
- Uses tables and simple formula to rank treatments
- Tables based on objective, traffic, climate, and material properties

Requires basic testing and engineering judgment
## Additive Selection Table

<table>
<thead>
<tr>
<th>Additive Category/Sub-Category</th>
<th>Traffic Average Daily Traffic</th>
<th>Climate Humidity/Storm Intensity</th>
<th>Plasticity Index</th>
<th>Wearing Course Material (%) Passing #200</th>
<th>Key to Colors and Explanation Notes in Selection Charts</th>
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<tbody>
<tr>
<td></td>
<td>&lt;100</td>
<td>100-250</td>
<td>&gt;250^</td>
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<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Water and Water plus Surfactant</td>
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<tr>
<td>Water</td>
<td>Not cost effective as a long-term fines preservation strategy</td>
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<tr>
<td>Water + surfactant</td>
<td>Not cost effective as a long-term fines preservation strategy</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Water absorbing</td>
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</tr>
<tr>
<td>Calcium chloride</td>
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<td>50^</td>
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<tr>
<td>Magnesium chloride</td>
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<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium chloride brine</td>
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<td>1</td>
<td>7</td>
<td></td>
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<td>50</td>
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</tr>
<tr>
<td>Tall oil pitch resin</td>
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<td>50</td>
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<tr>
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<td>Clay Additive</td>
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<tr>
<td>Bentonite</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key to Colors and Explanation Notes in Selection Charts:
- **Red**: Significant influence on performance
- **Orange**: Some influence on performance
- **Green**: No significant influence on performance

### Notes and Explanations:
- **1**: Cars and trucks at higher speeds may break surface crust and accelerate washboarding and raveling, if so more frequent rejuvenation will be required.
- **2**: More than 20 days with less than 40% relative humidity.
- **3**: High intensity storms.
- **4**: Likely to leach out and/or down into lower layers during storm events.
- **5**: Soaked California Bearing Ratio (CBR) and abrasion resistance must be checked / increased with increasing number of trucks to ensure all-weather passability.
- **6**: Materials have little or no effective binder content and are prone to washboarding and raveling. Treatments may leach down to road surface.
- **7**: May become slippery when wet.
- **8**: High fines content may require higher application rates to be effective.
- **9**: Requires a minimum humidity level to perform effectively.
- **10**: May leach down into layer, but dry back of the material plus a light water spray / rejuvenation will return it to surface.
- **11**: Generally not suitable as a spray-on application. A “skin” can form on the surface which is damaged by traffic.
- **12**: Requires frequent rejuvenation.
- **13**: Relatively high initial product cost price, but life-cycle cost could be lower than other treatments.
## Traffic and Climate

<table>
<thead>
<tr>
<th>Additive Category/Sub-Category</th>
<th>Traffic Average Daily Traffic</th>
<th>Climate Humidity/Storm Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;100</td>
<td>100-250&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Water and Water plus Surfactant</strong></td>
<td></td>
<td></td>
</tr>
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<tr>
<td><strong>Water absorbing</strong></td>
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<td></td>
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<tr>
<td>Calcium chloride</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Magnesium chloride</td>
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</tr>
<tr>
<td>Sodium chloride brine</td>
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<tr>
<td><strong>Organic Non-Petroleum</strong></td>
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<td></td>
</tr>
<tr>
<td>Glycerin based</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lignosulfonate</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Molasses/sugar</td>
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<td>50</td>
</tr>
<tr>
<td>Plant oil</td>
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<td>7</td>
</tr>
<tr>
<td>Tall oil pitch resin</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td><strong>Organic Petroleum</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphalt emulsion</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Base oil</td>
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<td>1</td>
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<td>Petroleum resin</td>
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<td>Synthetic fluid</td>
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<td>1</td>
</tr>
<tr>
<td>Synthetic fluid + binder</td>
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<tr>
<td><strong>Synthetic Polymer Emulsion</strong></td>
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<tr>
<td>Synthetic polymer</td>
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<tr>
<td>Concentrated Liquid Stabilizer</td>
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<tr>
<td>Clay Additive</td>
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</tr>
<tr>
<td>Bentonite</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
2013 FHWA Guide

- www.ucprc.ucdavis.edu/dustcontrol
- www.roaddustinstitute.org
Overview

- Introduction
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- Full-depth reclamation
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  - Current research
  - Interim findings
- Summary
Introduction

- FDR-FA introduced to California in 2000
- Pilot project in 2001
- International research focus
- California research focus
  - Thick AC "evolved roads"
  - Closure limitations
  - Mix & structural design
  - Construction factors
Introduction

- Asphalt concrete (50mm)
- “Oil”
- Subgrade/Base (Old gravel road)
Introduction
UCPRC Research Focus

- Recycling/sustainability strategic initiative
- Phase 1: FDR-NS and FDR-FA study
  - Literature review
  - Mechanistic sensitivity analysis
  - Pilot project assessment
  - Accelerated pavement testing
  - Laboratory study
  - Preliminary guidelines
- Phase 2a: FDR-PC and FDR-EE
- Phase 2b: PDR-FA and PDR-EE
  - As for Phase 1
  - ME performance models
  - Comprehensive guidelines for CA
Pilot Project Assessment

- Key findings on Project Selection
  - Drainage/land use
Pilot Project Assessment

Rice field

Distance (m)

$E_{FA}$ (MPa)

Jun-06

May-07

Nov-06

Nov-07
Field Testing: LTPP

- Key findings on construction
  - Pre-pulverization
  - Equipment problems
  - Training / supervision
Field Testing: LTPP

- Key findings on construction
  - Pre-pulverization
  - Equipment problems
  - Training / supervision
  - Temperatures
Field Testing: LTPP

- Key findings on construction
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  - Equipment problems
  - Training / supervision
  - Temperatures
  - Compaction
Pilot Project Assessment

- Key findings on construction
  - Pre-pulverization
  - Equipment problems
  - Training / supervision
  - Temperatures
  - Compaction moisture
  - Compaction
Pilot Project Assessment

- Key findings on construction
  - Pre-pulverization
  - Equipment problems
  - Training / supervision
  - Temperatures
  - Compaction moisture
  - Compaction
  - Quality control
Field Testing: LTPP
Field Testing: LTPP
Research Implementation: Phase 1

- Final report documenting entire study
- Guideline for California
  - Project investigation
  - Mix design
  - Structural design
  - Construction
- FDR and FDR-FA chapters in Highway Design Manual and Standard Specifications
- Tech transfer on projects
  - Implementation decision at District and county level
Phase 2 FDR Study

- Extend Phase 1 study to include:
  - Additional work on FDR-NS
  - FDR-PC
  - FDR-EE
  - PDR-FA (Control)
- Prepare single guideline on FDR (specific to California)
- Develop input parameters for ME design for rehabilitation using FDR
Phase 2 FDR Study

- **Status**
  - Field sections identified and monitoring started (visual and FWD)
  - APT test track constructed
  - APT started
  - Laboratory testing started
    - AMPT included in testing program
Phase 2 FDR Study Test Track
Phase 2 FDR Study Test Track
Phase 2 Interim Results

- FDR-NS satisfactory for low-volume roads
- Excellent performance on FDR-FA and FDR-PC
- Poor performance on FDR-EE
  - Construction and curing issues

<table>
<thead>
<tr>
<th>Phase</th>
<th>Half Axle Wheel Load (kN)</th>
<th>Number of Repetitions</th>
<th>Rut Depth (mm)</th>
<th>Cracking (m/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FDR-NS</td>
<td>FDR-FA</td>
<td>FDR-NS</td>
</tr>
<tr>
<td>1</td>
<td>40</td>
<td>300,000</td>
<td>300,000</td>
<td>12.2</td>
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<td>2</td>
<td>60</td>
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<td>16.9</td>
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<td>3</td>
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<td>250,000</td>
<td>22.0</td>
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<tr>
<td>4</td>
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<tr>
<td>Total</td>
<td></td>
<td>665,000</td>
<td>1,000,000</td>
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</tr>
</tbody>
</table>

ESALs¹: 4,430,591, 492,155
ESALs to failure: 4,430,591, 17,772,552

Equivalent Standard Axle Loads, calculated by (axle load/18,000)⁴.²
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Summary: Chemical Treatment

- Huge selection of additives
- There are no “wonder” products
- Select treatments based on:
  - Problem/objective
  - Traffic, climate and materials
  - Cost-benefit
  - Vendor credibility
- Understand performance
- Apply and maintain appropriately
- Testing is not expensive, and will save money
Summary: FDR

- FDR is a very appropriate rehabilitation technology (state, county and city)
- Use continues to grow in the US while specifications are refined
- Long-term performance is acceptable
- Good design, construction and training is essential
Thank you!

djjones@ucdavis.edu     www.ucprc.ucdavis.edu
(djones.consult@gmail.com)
Chemical Treatment Selection

- Step 1: Review local experience
- Step 2: Understand materials
- Step 3: Set objective for treatment
- Step 4: Select traffic and climate categories
- Step 5: Select plasticity index and fines content
- Step 6: Consider road geometry
- Step 7: Calculate performance / rank for selection
## Selection Based on Performance

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Traffic</th>
<th>Climate</th>
<th>PI</th>
<th>Fines</th>
<th>Perf</th>
<th>Rank</th>
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<tr>
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<td>Damp</td>
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<td>4</td>
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<td>59</td>
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## Selection Based on Performance

<table>
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<tr>
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<td>8</td>
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<td>NS</td>
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Chemical Treatment Selection

- Step 1: Review local experience
- Step 2: Understand materials
- Step 3: Set objective for treatment
- Step 4: Select traffic and climate categories
- Step 5: Select plasticity index and fines content
- Step 6: Consider road geometry
- Step 7: Calculate performance / rank for selection
- Step 8: Understand environmental impacts
- Step 9: Understand other limitations
- Step 10: Do performance testing