DEVELOPMENTS IN NON-TRADITIONAL STABILIZERS

TRB Sponsored Webinar
August 1, 2012

MODERATOR
Roger W. Surdahl, P.E.
Technology Coordinator
FHWA – CFLHD
Special Acknowledgement and Thanks

Transportation Research Board
TRB Low Volume Roads Committee
10th International Conference on Low Volume Roads, July 2011
Evaluation of case studies and the sustainability of LVRs stabilized with non-traditional stabilizers
Towards the establishment of industry associations representing non-traditional road stabilizer suppliers
Evaluation of case studies and the sustainability of LVRs stabilized with non-traditional stabilizers

TRB Webinar 1 August 2012

Prof Alex Visser
University of Pretoria
alex.visser@up.ac.za
Scope of presentation

• Problem statement, what do we wish to achieve?
• Types of stabilisers
• Laboratory investigations
• Small scale evaluations
• Full scale experiments
• Sustainability evaluation system
• LVR stabilized with non-traditional stabilizers
• Evaluation of sustainability / outcomes
• Conclusions
Problem statement, what do we wish to achieve?

• SA > 500 000 km gravel roads

• Reduce material loss through stabilization
• Improve strength of substandard materials
• Reduce erosion of gravel roads by binding
• Reduce dust generation – quality of life
• Longevity – stabilizer to be durable

• Demonstrate sustainable practices
Types of dust palliatives

- Water / Wetting agents
- Lignosulphonate (natural polymer)
- Modified waxes
- Petroleum resins
- Hygroscopic salts
- Synthetic polymers
- Tar or bitumen

Types of stabilizers

- Synthetic polymers
- Enzymes or biological agents
- Tar or bitumen
- Sulfonated oils
- Cement or lime
Laboratory investigations

• In South Africa there is a standardized procedure for certifying non-traditional stabilizers. It is based on strength and erosion resistance on four standard materials.
Small scale investigations
DCP RESULTS: UNTREATED MATERIAL
DCP RESULTS: PRODUCT A
<table>
<thead>
<tr>
<th></th>
<th>DRY</th>
<th>SOAKED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>100 – 150 mm</td>
<td>19 – 95 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 – 50 mm</td>
</tr>
<tr>
<td>Product A</td>
<td>&gt;200 – 40 mm</td>
<td>43 – 200 mm</td>
</tr>
<tr>
<td></td>
<td>80 – 120 mm</td>
<td></td>
</tr>
<tr>
<td>Product B</td>
<td>130 – 65 mm</td>
<td>17 – 280 mm</td>
</tr>
<tr>
<td></td>
<td>29 – 120 mm</td>
<td></td>
</tr>
<tr>
<td>Product C</td>
<td>&gt;200 – 40 mm</td>
<td>100 – 150 mm</td>
</tr>
<tr>
<td></td>
<td>110 – 50 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 – 100 mm</td>
<td></td>
</tr>
<tr>
<td>Product D</td>
<td>45 – 140 mm</td>
<td>13 – 150 mm</td>
</tr>
</tbody>
</table>
Full scale investigations

- Paper presented at the 2011 LVR conference by Robbie Uys, Llewellyn Truter and Gerrie van Zyl “Various additives used as alternative to conventional road construction: Case study of Main Road 269” p.179 vol. 2 of TRR 2205
Background Information

- To be upgraded in 3 years, 10.5 km
- Traffic volume (355 AADT, 45 heavies)
- Limited budget (less than R1,5 million)
- Ideal opportunity to investigate different additives as a holding action
Background Information

• Situation
  – Rolling to mountainous
  – Annual rainfall: 450 – 500 mm (Weinert N : 2)
  – Traffic volumes: 2005; Light: 454; Heavies: 53
  – Geology: sandstone, mudstone, shale
  – Material properties:
    • GM: 1.3 – 2.1
    • PI: 3 – 6
    • LS: 2 - 4
EXPERIMENTAL DESIGN

• Control section
• Unsealed sections with additives
  – Enzymes
  – Natural polymer (Lignosulphonates)
  – Bitumen Emulsion
  – Synthetic polymer
  – Combination of synthetic polymer and bituminous binder
  – Traditional stabilizer (cement)
• Sealed sections
  – Cement stabilized
  – Combination of synthetic polymer and bituminous binder
  – Electro-chemical (ionic)
EXPERIMENTAL DESIGN

• Variations on unsealed sections
  – Enzymes (2 types; 2 application rates)
  – Natural polymer (2 application rates, combined with emulsion)
  – Bitumen Emulsion
  – Synthetic polymer (2 application rates)
  – Combination of polymer and bituminous binder (2 application rates)
  – Traditional stabilizer (cement)
CONSTRUCTION

- Same construction process
- 125 mm rip, mix-in and compact
- Basic equipment (app R40,000/km)
  - Motor grader
  - Water bowser
  - Vibratory roller
  - LDV
  - 2 operators, 2 flagmen

### Ease of Construction

<table>
<thead>
<tr>
<th>Product</th>
<th>Construct</th>
<th>Add Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control section</td>
<td>Easy</td>
<td>Slight</td>
</tr>
<tr>
<td>Enzyme</td>
<td>Easy</td>
<td>None</td>
</tr>
<tr>
<td>Natural Polymer</td>
<td>Moderate</td>
<td>Slight</td>
</tr>
<tr>
<td>Synthetic Polymer</td>
<td>Moderate</td>
<td>Slight</td>
</tr>
<tr>
<td>Synthetic Polymer/Bit Bind</td>
<td>Difficult</td>
<td>High</td>
</tr>
<tr>
<td>Cement</td>
<td>Moderate</td>
<td>Slight</td>
</tr>
</tbody>
</table>
Testing

<table>
<thead>
<tr>
<th>Section</th>
<th>Laboratory Testing</th>
<th>Construction Monitoring</th>
<th>Performance Monitoring</th>
<th>Financial Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rip and Recompact</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>2 Rip and Recompact</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>3 Base and Seal</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>4 Stabilize Cement</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>5 Stabilize Cement</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>6 Additive: Polymer</td>
<td>15.75</td>
<td>15.875</td>
<td>15.875</td>
<td>15.875</td>
</tr>
<tr>
<td>7 Additive: Polymer</td>
<td>16</td>
<td>16.1</td>
<td>16.1</td>
<td>16.1</td>
</tr>
<tr>
<td>8 Additive: Polymer</td>
<td>16.3</td>
<td>16.4</td>
<td>16.4</td>
<td>16.4</td>
</tr>
<tr>
<td>10 Additive: Lignosulphonate</td>
<td>17.05</td>
<td>17.15</td>
<td>17.15</td>
<td>17.15</td>
</tr>
<tr>
<td>11 Additive: Lignosulphonate</td>
<td>17.4</td>
<td>17.5</td>
<td>17.5</td>
<td>17.5</td>
</tr>
<tr>
<td>12 Additive: Lignosulphonate</td>
<td>17.9</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>13 Additive: Lignosulphonate</td>
<td>18.4</td>
<td>18.5</td>
<td>18.5</td>
<td>18.5</td>
</tr>
<tr>
<td>15 Additive: Enzyme</td>
<td>20.4</td>
<td>20.5</td>
<td>20.5</td>
<td>20.5</td>
</tr>
<tr>
<td>16 Additive: Enzyme</td>
<td>21.4</td>
<td>21.5</td>
<td>21.5</td>
<td>21.5</td>
</tr>
<tr>
<td>18 Additive: Enzyme</td>
<td>22.34</td>
<td>22.44</td>
<td>22.44</td>
<td>22.44</td>
</tr>
<tr>
<td>18 Electrochemical stabilisation and Seal</td>
<td>23</td>
<td>23.35</td>
<td>23.35</td>
<td>23.35</td>
</tr>
<tr>
<td>20 Additive: Polymer and Seal</td>
<td>23.35</td>
<td>23.7</td>
<td>23.7</td>
<td>23.7</td>
</tr>
</tbody>
</table>
PERFORMANCE MONITORING

• DCP (initial, 3 months)
• Gravel loss (initial, 3 monthly intervals)
• Road roughness (2 – 5 times)
• Visual assessment (2 – 5 times)
Interesting Observations – bitumen emulsion

- Difficult to Control Mixing/Application
- Labour Intensive
- Difficult to pump into waterbowlser
- Messy
- Environmental Impact
- Slippery/
  Trees
- False Sense of
  Safety: Speeding
Interesting Observations

Effective initial dust control (Enzyme)

Transverse Erosion (Synthetic Polymer)

Pothole Development (Natural Polymer)

Potholes (Natural Polymer)
Interesting Observations

- Rut/Erosion
- Crocodile Cracks

- Block Cracks

- Rutting/Stoniness

- Transverse Cracks
Interesting Observations

• Maintainability ???
## Study Results

### CBR @ 95%

<table>
<thead>
<tr>
<th>Material Properties</th>
<th>Construction Monitoring</th>
<th>Gravel Loss</th>
<th>VCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated/Treated</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Sect | Action | From (km) | To (km) | GM | PI | OMC | MDD | CBR (95%) | UCS | Abrasion Resistance | Erosion Resistance | Moisture Sensitivity | Depth (mm) | Compaction | DCP (start) | DCP (3 months) | Gravel Loss (annual) | TRM20 (annual) | ARRB (annual) | Brazil (annual) | Period | Riding Quality (start) | VCI start | VCI end | Period | Construction | Rejuvenation | Life Cycle |
|------|--------|-----------|---------|----|----|-----|-----|-----------|-----|-------------|---------------|------------------|------------|------------|------------|---------------|-------------------|--------------|--------------|----------------|--------|---------------------|-----------|--------|--------|-------------|--------------|----------|-----------|
## Costs

<table>
<thead>
<tr>
<th>Product</th>
<th>Cost (R/M²) (2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzymes</td>
<td>R6.00 – R9.00</td>
</tr>
<tr>
<td>Emulsion</td>
<td>R11.00</td>
</tr>
<tr>
<td>Natural Polymer/Emulsion</td>
<td>R17.00</td>
</tr>
<tr>
<td>Natural Polymer</td>
<td>R9.00 – R12.00</td>
</tr>
<tr>
<td>Synthetic Polymer</td>
<td>R24.00 – R30.00</td>
</tr>
<tr>
<td>Polymer/ Bit Binder</td>
<td>R32.00 – R34.00</td>
</tr>
<tr>
<td>Cement</td>
<td>R10.00</td>
</tr>
<tr>
<td>Control Section (Rip &amp; Recompress)</td>
<td>R7.00</td>
</tr>
<tr>
<td>Seal/Cement</td>
<td>R25.00</td>
</tr>
<tr>
<td>Seal/Electro-chemical</td>
<td>R22.00</td>
</tr>
<tr>
<td>Seal/Polymer/Bit Binder</td>
<td>R37.00</td>
</tr>
</tbody>
</table>
Conclusions

• Treated materials perform better than untreated sections
• Performance of treated and sealed sections far superior to unsealed sections
• Each product may have a place in the market

• Consider
  – Rejuvenation frequency (life cycle cost)
  – Maintenance strategy (ease of blading)
  – Ease of construction
  – Traffic Volumes
  – Material Properties
Sustainability evaluation system

• Evaluate potential use of Greenroads™ to evaluate sustainability of LVRs stabilized with non-traditional stabilizers

• Accepted
  – Other methods of enhancing sustainability exist
  – Other rating systems exist
  – Conditions differ between countries

• Paper by Steyn and Visser, p.186 vol.2
Sustainability evaluation system

- Greenroads™
  - Sustainability performance metric
  - Points for sustainable practices
  - Materials should not be used in such a way that it can be depleted and that the waste caused by road building actions becomes a major problem to the environment
Greenroads™

- Seven components evaluated
  - ecology
  - equity
  - economy
  - extent
  - expectations
  - experience
  - exposure
Greenroads™

- Project Requirements (PR)
- Voluntary Credits (VC)
- Achievement or certification
  - Greenroads, Silver, Gold and Evergreen
- Assist in rating the most sustainable option
# Greenroads™ components

<table>
<thead>
<tr>
<th>METRIC</th>
<th>EXAMPLE OF DETAILS</th>
<th>AVAILABLE CREDITS</th>
</tr>
</thead>
</table>
| Project Requirements (PR) | - Environmental review process  
                          - Lifecycle cost analysis  
                          - Lifecycle inventory  
                          - Quality control plan  
                          - Noise mitigation plan  
                          - Waste management plan  
                          - Pollution prevention plan  
                          - Low-impact development  
                          - Pavement management system  
                          - Site maintenance plan  
                          - Educational outreach    | 11                |

• Same for all options evaluated
Greenroads™ components

- **Bold metrics** - may be directly affected by the use of non-traditional stabilizers for unpaved roads

<table>
<thead>
<tr>
<th>METRIC</th>
<th>EXAMPLE OF DETAILS</th>
<th>AVAILABLE CREDITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment and water (EW)</td>
<td>Environmental management system, Runoff flow control, <strong>Runoff quality</strong>, Stormwater cost analysis, Site vegetation, Habitat restoration, Ecological connectivity, Light pollution</td>
<td>21</td>
</tr>
<tr>
<td>Access and Equity (AE)</td>
<td>Safety audit, Intelligent transportation systems, <strong>Context sensitive solutions</strong>, <strong>Traffic emissions reduction</strong>, Pedestrian access, Bicycle access, Transit and HOV access, Scenic views, Cultural outreach</td>
<td>30</td>
</tr>
<tr>
<td>Construction Activities (CA)</td>
<td>Quality management system, Environmental training, Site recycling plan, <strong>Fossil fuel reduction</strong>, <strong>Equipment emission reduction</strong>, Paving emission reduction, <strong>Water use tracking</strong>, Contractor warranty</td>
<td>14</td>
</tr>
<tr>
<td>Materials and Resources (MR)</td>
<td>Lifecycle assessment, <strong>Pavement reuse</strong>, <strong>Earthwork balance</strong>, <strong>Recycled materials</strong>, <strong>Regional materials</strong>, Energy efficiency</td>
<td>23</td>
</tr>
<tr>
<td>Pavement Technologies (PT)</td>
<td>Long-life pavement, Permeable pavement, Warm mix asphalt, Cool pavement, Quiet pavement, Pavement performance tracking</td>
<td>20</td>
</tr>
<tr>
<td>Custom Credits (CC)</td>
<td><strong>Custom designed credits</strong></td>
<td>10</td>
</tr>
<tr>
<td>Greenroads total</td>
<td></td>
<td>118</td>
</tr>
</tbody>
</table>
Greenroads™ components

• Process
  – components that will not differ between different types of stabilization efforts - ignored
  – focus on components where different stabilizers will potentially cause a difference in the outcome
Greenroads™ components

- Runoff quality
- Context sensitive solutions
- Traffic emissions reduction
- Fossil fuel reduction
- Equipment emission reduction
- Water use tracking
- Pavement reuse
- Earthwork balance
- Recycled materials
- Regional materials
- Custom designed credits (mainly labor)
Application

- Evaluation of various sections from existing studies
- All different types of material and stabilizers
- Base evaluation on existing information
<table>
<thead>
<tr>
<th>SECTION NUMBER</th>
<th>SECTION IDENTIFICATION &amp; MATERIAL DESCRIPTION</th>
<th>TYPE OF STABILIZER</th>
<th>STRENGTH RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>P Ferricrete; Grading modulus – 2.01; CBR at 95% mod AASHTO – 7.6; PI – 10; AASHTO A-2-4</td>
<td>Synthetic Polymer Emulsion A (SPEA)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Synthetic Polymer Emulsion B (SPEB)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enzyme (E)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulphonated Oil (SO)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>1 (best)</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Synthetic Polymer Emulsion A (SPEA)</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>D Windblown sand; Grading modulus – 0.85; CBR at 95% mod AASHTO – 20; PI – 4; AASHTO A-4</td>
<td>Synthetic Polymer Emulsion B (SPEB)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enzyme (E)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulphonated Oil (SO)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>1 (best)</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Synthetic Polymer Emulsion A (SPEA)</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>B Weathered Dolerite; Grading modulus – 1.65; CBR at 95% mod AASHTO – 10; PI – 11; AASHTO A-2-6</td>
<td>Synthetic Polymer Emulsion B (SPEB)</td>
<td>1 (best)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enzyme (E)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulphonated Oil (SO)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Synthetic Polymer Emulsion A (SPEA)</td>
<td>1 (best)</td>
</tr>
<tr>
<td>17</td>
<td>Q Gravel; Grading modulus – 1.95; CBR at 95% mod AASHTO – 24; PI – 12; AASHTO A-2-6</td>
<td>Synthetic Polymer Emulsion B (SPEB)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enzyme (E)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulphonated Oil (SO)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>Cement (C)</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>Enzyme (E)</td>
<td>10</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>Cement catalyst (CC)</td>
<td>1 (best)</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>Organic non-petroleum (ONP)</td>
<td>8</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>Organic non-petroleum (ONP)</td>
<td>6</td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>Sulphonated Oil (SO)</td>
<td>11</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>Enzyme (E)</td>
<td>9</td>
</tr>
<tr>
<td>28</td>
<td></td>
<td>Polymer (P)</td>
<td>5</td>
</tr>
<tr>
<td>29</td>
<td></td>
<td>Cement (C)</td>
<td>3</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>Organic petroleum (OP)</td>
<td>4</td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>Control</td>
<td>7</td>
</tr>
</tbody>
</table>
Evaluation of sustainability

• Same stabilizer not providing highest potential sustainability for all materials
  – all stabilizers do not perform equally well on all materials

• Best strength rating not necessarily best sustainability rating
  – sustainability evaluation incorporate Runoff quality, Fossil fuel reduction and Custom designed credits
Evaluation of sustainability

• Some cases (i.e. material P)
  – Greenroads™ rating indicate control section as highest potential sustainability
  – control section also provided highest strength
  – cases where stabilization of in situ material may not necessarily be optimum solution
Evaluation of sustainability

• Sustainability evaluation should not stand alone in evaluation of stabilization evaluation of potential road projects

• Common sense and standard engineering evaluation important
Evaluation of sustainability / outcomes

<table>
<thead>
<tr>
<th>SECTION NUMBER</th>
<th>SECTION IDENTIFICATION &amp; MATERIAL DESCRIPTION</th>
<th>TYPE OF STABILIZER</th>
<th>STRENGTH RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P Ferricrete; Grading modulus – 2.01; CBR at 95% mod AASHTO – 7.6; PI – 10; AASHTO A-2-4</td>
<td>Synthetic Polymer Emulsion A (SPEA)</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Synthetic Polymer Emulsion B (SPEB)</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Enzyme (E)</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Sulphonated Oil (SO)</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Control</td>
<td>1 (best)</td>
</tr>
</tbody>
</table>
## Evaluation of sustainability / outcomes

| CREDIT (maximum points) | SECTION IDENTIFICATION | RATING PER GREENROADS GUIDELINES  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Section number for Highest to Lowest ranking, values in brackets are equal</td>
</tr>
<tr>
<td>Runoff quality (3)</td>
<td>P</td>
<td>2, 1, 5, 3, 4</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>10, 8, 9, 7, 6</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>(12, 14), 11, 15, 13</td>
</tr>
<tr>
<td></td>
<td>Q</td>
<td>18, 16, 19, 20, 17</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>22, 26, (23, 30), 31, 21, 27, 29, 28, (24, 25)</td>
</tr>
<tr>
<td>Context sensitive solutions (5)</td>
<td>P</td>
<td>5, 4, 3, 2, 1</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>9, 7, (6, 8), 10</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>14, 13, 11, 15, 12</td>
</tr>
<tr>
<td></td>
<td>Q</td>
<td>17, 18, (16, 20), 19</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>22, 24, 27, 29, 28, (23, 25, 30), 26, 31, 21</td>
</tr>
</tbody>
</table>
## Evaluation of sustainability / outcomes

<table>
<thead>
<tr>
<th>SECTION NUMBER</th>
<th>SECTION DESIGNATION</th>
<th>TYPE OF STABILIZER</th>
<th>STRENGTH RATING</th>
<th>GREENROADS RATING</th>
<th>GREENROADS CERTIFICATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>SPEA</td>
<td>2</td>
<td>6.8</td>
<td>Silver</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>SPEB</td>
<td>2</td>
<td>8.3</td>
<td>Gold</td>
</tr>
<tr>
<td>3</td>
<td>P AASHTO A-2-4</td>
<td>Enzyme (E)</td>
<td>3</td>
<td>6.8</td>
<td>Silver</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Sulphonated Oil (SO)</td>
<td>3</td>
<td>6.8</td>
<td>Silver</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Control</td>
<td>1 (best)</td>
<td><strong>9.0</strong></td>
<td>Gold</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>SPEA</td>
<td>2</td>
<td>5.6</td>
<td>Silver</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>SPEB</td>
<td>3</td>
<td>7.5</td>
<td>Gold</td>
</tr>
<tr>
<td>8</td>
<td>D AASHTO A-4</td>
<td>Enzyme (E)</td>
<td>3</td>
<td>7.9</td>
<td>Gold</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Sulphonated Oil (SO)</td>
<td>4</td>
<td><strong>9.0</strong></td>
<td>Gold</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Control</td>
<td>1 (best)</td>
<td>7.5</td>
<td>Gold</td>
</tr>
</tbody>
</table>
Conclusions

• Greenroads™ metric can be used to evaluate potential sustainability of unpaved low volume roads stabilized using non-traditional stabilizers

• Metric provides insight into potential effect of various parameters on sustainability of various stabilization options
Recommendations

• Proposed adaptations to Greenroads™ metric evaluated further for application in unpaved roads with stabilized layers

• Analysis of paving road as option as interesting further dimension to analysis

• Development of specific version for use on unpaved roads may be considered
  – majority of roads in developing countries unpaved
Dankie
Contact details

- Department of Civil Engineering
- University of Pretoria
- Pretoria
- 0002 South Africa

- Email: alex.visser@up.ac.za
Towards the establishment of industry associations representing non-traditional road stabilizer suppliers

David Jones, PhD
University of California Pavement Research Center
djjones@ucdavis.edu

Based on a presentation at the 10th International Conference on Low-Volume Roads, Florida, July, 2011
DUST KILLS!
Keep your distance
Summary

- Introduction
- Background
  + Unsealed roads
  + Chemical stabilizers
  + Challenges to stabilizer use
  + The chemical stabilizer industry
- Industry associations
- Road manager responsibilities
- Conclusions
Introduction

- Unsealed roads
  - Function
  - Problems
  - Sustainability
  - Management
  - Ownership

- Improvement options
  - Upgrading
  - Dust control
  - Surface stabilization
Main Road Categories in South Africa

- Forestry
- Agriculture
- Mining
- Tourism
- Railway / canal / powerline service
- Military
- Border patrol
- etc
Summary

- **Introduction**
- **Background**
  - Unsealed roads
  - Chemical stabilizers
  - Challenges to stabilizer use
  - The chemical stabilizer industry
- **Industry associations**
- **Road manager responsibilities**
- **Conclusions**
Background - Unsealed Roads

- Safety hazard
- Health hazard
- Air and water pollution
- Vehicle operating costs
- Reduced agricultural yields
- Loss of fines
  + Increased rate of gravel loss
  + Increased maintenance frequency
Background - Unsealed Roads

- **Dust generation in South Africa**
  - 3.4 mt/yr
    - ~ 215,000 trucks
  - 1.1 mt/yr lost
    - ~ 70,000 trucks

- **Erosion**
  - 38.1 mt/yr
    - ~ 2,380,000 trucks
Background - Chemical Additives

- Before 1900
- 1907
  + Chlorides
- 1913
  + Lignosulfonate
- 1913 - 1960's
  + No major developments
- After 1970
**Background - Chemical Additives**

- **Dust palliatives**
  - Water/wetting agents
  - Water absorbing
  - Organic, non-petroleum
  - Organic, petroleum
  - Synthetic polymer emulsions
  - Synthetic/mineral oils
  - Blends
  - Other

- **Surface Stabilizers**
  - Organic, petroleum
  - Synthetic polymer emulsions
  - Synthetic/mineral oils
  - Electrochemical/enzymes
  - Blends
  - Other
Background - Chemical Additives

- Research
  + Process
  + Documentation
    • Reports, guidelines, etc
  + Publications
    • Papers
  + Specifications
  + Fit-for-purpose certification
Background - Additive Industry

- Good and bad suppliers
  - Research vs. marketing
  - Documentation
- Fragmented industry
  - Chloride & Lignin Institutes
  - Other industries
    - Lime association
    - Chip seal association
    - AustStab
    - Sabita, etc
- Proprietary vs. specification
- Skepticism in road agencies
Summary

- Introduction
- Background
  - Unsealed roads
  - Chemical stabilizers
  - Challenges to stabilizer use
  - The chemical stabilizer industry
- Industry associations
- Road manager responsibilities
- Conclusions
Industry Association(s)

- Suggested roles
  + Work towards and help develop:
    - An "owner" for unsealed road specs
    - Dedicated funding streams
    - Category specifications
    - Research protocols
    - Environmental assessment protocols
    - Frameworks for guidelines and specifications
    - Standardized MSDS formats/content
    - Fit-for-purpose certification
  + Provide education and training
  + Enforce codes of conduct
  + Establish guidelines for marketing
The Way Forward

- Road Dust Institute
  - Montana State University, UC Davis, University of Alaska, Fairbanks, & University of Nevada, Reno
  - FHWA support
  - www.roaddustinstitute.org
Summary

- Introduction
- Background
  - Unsealed roads
  - Chemical stabilizers
  - The chemical stabilizer industry
- Industry associations
- Road manager responsibilities
- Conclusions
Road Manager Responsibilities

- Do a literature review!
- Understand your road materials, traffic, and climate
- Use additives to keep good roads good, don't waste them on bad roads
- Justify a chemical treatment program based on savings in maintenance, regravelling, and road safety
- Select an appropriate additive based on materials, traffic, and climate
# Additive 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</td>
<td>B^3</td>
<td>B^{1,2}</td>
</tr>
<tr>
<td>Organic non-petroleum</td>
<td>A</td>
<td>B^{1,2}</td>
<td>B^3</td>
<td>C^{1,2}</td>
</tr>
<tr>
<td>Organic petroleum</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B^{1,2}</td>
</tr>
<tr>
<td>Synthetic polymer</td>
<td>A</td>
<td>B^{1,2}</td>
<td>A</td>
<td>B^{1,2}</td>
</tr>
<tr>
<td>Synthetic oils</td>
<td>A</td>
<td>B^{1,2}</td>
<td>A</td>
<td>B^{1,2}</td>
</tr>
<tr>
<td>Electrochemical</td>
<td>A</td>
<td>B^{1,2}</td>
<td>A</td>
<td>B^{1,2}</td>
</tr>
<tr>
<td>Enzyme</td>
<td>A</td>
<td>B^{1,2}</td>
<td>A</td>
<td>B^{1,2}</td>
</tr>
</tbody>
</table>

A = No significant influence  
B = Some influence  
C = Significant influence

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
# Additive Selection

<table>
<thead>
<tr>
<th>Dust Palliative</th>
<th>Traffic Vehicles per Day</th>
<th>Plasticity Index</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>3-10</td>
<td>&gt;10</td>
<td>Wet</td>
</tr>
<tr>
<td></td>
<td>100-250</td>
<td></td>
<td></td>
<td>Damp to Dry</td>
</tr>
<tr>
<td></td>
<td>&gt;250</td>
<td></td>
<td></td>
<td>Dry</td>
</tr>
<tr>
<td>Water absorbing</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mag chloride</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic petroleum</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphalt emulsion</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petroleum resin</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic non-petroleum</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lignin</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tall oil</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bio-Fluids</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic polymer emulsion</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic polymer</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic/Mineral Oils</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic Fluid (EPA Definition)</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrochemical/Enzyme</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electro-Chemical</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enzyme</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (mechanical)</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay Additives</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

1. Higher application rates/more frequent rejuvenation required for high truck traffic.
2. May become slippery in wet weather.
3. Mix-in treatment usually required.
4. Requires reactive (usually expansive) clay minerals to react with.
5. >20 days with less than 40% relative humidity.
6. May leach out in heavy rain.
7. SS-1 or CSS-1 with only clean, open-graded aggregate.
Performance Prediction

Calibrate for local use!

- Erodible
- Really good
- Slippery and dusty
- Ravels

Increasing coarseness / increasing gap

Grading coefficient

Shrinkage product

Increasing plasticity
Water Absorbing

- Increasing coarseness / increasing gap
- Increasing plasticity
- Erodible
- Good but dusty
- Slippery and dusty
- Good
- Fair with maintenance
- Corrugates and ravels

Grading coefficient

Shrinkage product

Increasing plasticity
Organic and Synthetics

Grading coefficient

Increasing coarseness / increasing gap

Shrinkage product

Increasing plasticity

Slippery and dusty

Good

Erodible

Fair with maintenance

Ravels

Corrugates and ravel
Electrochemical & Enzymes

- Grading coefficient
- Shrinkage product
- Increasing coarseness / increasing gap
- Good, may be dusty
- Erodible
- Fair with maintenance
- Good
- Increasing plasticity
- Corrugates and ravels
- Slippery and dusty

Increasing coarseness / increasing gap
Road Manager Responsibilities

- Do a background check on the additive by assessing:
  - Expertise of supplier / technical support
  - Background documentation and guidelines
    - Research, environmental testing, economics, etc
  - MSDS
  - Specifications / fit-for-purpose certification
  - Use by others

- Prepare the road accordingly
  - Materials, shape, drainage
  - Keep a good road good!
Road Evaluation
Road Evaluation
Road Manager Responsibilities

- Apply additives according to guidelines
  - Topical - blade, water, multiple applications, compact, etc.
  - Mix in - regravel, moisture content, shape, compact, etc.
- Do thorough quality control
- Rejuvenate at appropriate intervals
- Monitor performance and costs and use these to justify continuation/expansion of the program
Application
Application
Application
Summary

- Introduction
- Background
  - Unsealed roads
  - Chemical stabilizers
  - The chemical stabilizer industry
- Industry associations
- Road manager responsibilities
- Conclusions
Conclusions

- Looking back
  - Poorly organized industry
  - Very little use of additives
  - Unsealed roads are not sustainable

- Looking forward
  - Industry association(s)
  - Road manager responsibilities
  - Research protocols
  - Performance and life-cycle based decisions
  - Additive category specifications

- Road Dust Institute formed to drive change in the USA, and hopefully rest of the world as well
Thank you!

David Jones
dj.jones@ucdavis.edu
www.ucprc.ucdavis.edu

It's decision time!