Richland County “Oil Field” Road Problems, and Various Solutions 2006-2011

NDDOT/NDLTAP
Conference with Oil and Gas Producing Counties
Mandan ND
November 30, 2011

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Outline

• Richland Co Background Information
• Approach to Solution
• Pavement Designs and Alternatives Considered
• Preliminary Life Cycle Costs
• Thin BST ‘Pavements’
• Construction and Quality Assurance (Separate Presentation)
• Construction and Maintenance Strategies
• Concerns
• Conclusions
County 2008 Mission

• Ensure Public Safety on Road System
• Meet Public Expectations
• Address air quality and DEQ concerns
• Adhere to GRAVEL stewardship for the next generations
• Find surfacing alternatives with better cost/benefit
The Problem

- Heavy Truck Traffic on Weak Soil Roads
- Extensive Road Network
- Limited Budget
- Limited Rock Resources
Local Standard

- 5” Asphalt, 8” Base Gravel
- 4” Gravel (New construction)
- Spot Graveling

(Haul 90 to 110,000 cy / year)
Weak Soils (CBR = 3 or 4 typical)

5” Asphalt, + 6” Base (15 yrs old)  
3” Scoria, old gravel base (after 3 months)
Richland Co Road Network & Resource Impacts

- Oil Development, Wheat, Gravel Roads
- Missouri River
- Richland County Border
- Population Center, Beet Farms, Gravel
- 56 mi
- Montana
- North Dakota
- Yellowstone River
Road Network Miles & ADT

• Function Class Miles: 1132 (341 Bus Routes)
  Arterials: 86
  Major/Minor Coll: 232
  Local: 701
  Trails: 113

• CI Plan: Collectors (with) Bus Routes = 131.2 mi
  : Improve 20-25 mi. / year

• Truck Traffic
  – Ag Traffic: Beets (Sept & Oct), Cattle, & Grain hauling
  – Oil Field:
    • Well development: 1200 trucks over 3 months (each well)
    • Crude & Water Haul: 3 to 5 trucks/day for 25 years

Hot Mix: 40
Surface Treat: 10
Gravel: 968
Dirt: 235
Structural Thickness Design

Gravel Thicknesses are based on:
* Soil Strengths
* Truck Traffic
* AASHTO 93 Guide

For Example: Rd 127 had 71 Trucks per Day ~ Thickness required is 14

<table>
<thead>
<tr>
<th>Soil Strength</th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches of Gravel</td>
<td>4 7 9 12</td>
<td>7 9 12 16</td>
<td>9 12 16 20</td>
<td>12 16 20 24</td>
</tr>
</tbody>
</table>

| Trucks/Day→ | 50 100 150 200 |

<table>
<thead>
<tr>
<th>Risk</th>
<th>Factor, %</th>
<th>Route Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>60%</td>
<td>Feeders, detour route available</td>
</tr>
<tr>
<td>Moderate</td>
<td>80%</td>
<td>Collectors, detour route available</td>
</tr>
<tr>
<td>High</td>
<td>100%</td>
<td>Arterials, no detour, school bus routes</td>
</tr>
</tbody>
</table>
Weak Clay Subgrade Soils

Soil Strength by DCP: CBR of 1 to 6

Thin gravel layers mix with clay

Gravel with Fabric & Geogrid

Gravel with Fabric & Geogrid

Gravel $ Too High

Standard Paving Design

Fabric

Geogrid

Gravel

Crushed Gravel

Hot Mix
Approach to Solution

• Outside Assistance
  – Construction Management Contract (Century Companies)
  – Engineering Consultants (Interstate Engineering, Boesh, Monlux, Holman)

• Design structural sections based on subgrade strengths, truck traffic and available materials

• Consider all alternatives and materials available

• Build trial sections that have low initial cost
  – Test to estimate life and life cycle costs
  – Rebuild isolated areas that fail
Structural Design & Cost Info

• Subgrade
  – Predominant soil type – Lean Clay
  – Design Strengths ~ CBR of 3 to 6

• Truck Traffic
  – ADT – Variable, unpredictable, increase after improvements
  – Loads normally exceed legal limits
  – No load limit enforcement during winter/spring thaw

• Economics
  – Aggregate – very costly due to haul and shortages
  – Maintenance Costs – unknown for some alternatives
  – Funding – inadequate for scope of problem
# Truck Loading & Pavement Life

## Truck ESAL Calculations *

<table>
<thead>
<tr>
<th>Gross Wgt, lbs</th>
<th>Number of Truck Axles</th>
<th>5</th>
<th>6</th>
<th>7</th>
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</thead>
<tbody>
<tr>
<td>40,000</td>
<td></td>
<td>0.40</td>
<td>0.38</td>
<td>0.36</td>
</tr>
<tr>
<td>80,000</td>
<td></td>
<td>3.37</td>
<td>2.30</td>
<td>1.22</td>
</tr>
<tr>
<td>100,000</td>
<td></td>
<td>6.2</td>
<td>4.2</td>
<td>2.1</td>
</tr>
<tr>
<td>120,000</td>
<td></td>
<td>13.9</td>
<td>8.7</td>
<td>3.6</td>
</tr>
<tr>
<td>140,000</td>
<td></td>
<td>26.6</td>
<td>16.6</td>
<td>6.5</td>
</tr>
<tr>
<td>160,000</td>
<td></td>
<td>51</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>180,000</td>
<td></td>
<td>91</td>
<td>55</td>
<td>19</td>
</tr>
<tr>
<td>200,000</td>
<td></td>
<td>147</td>
<td>89</td>
<td>32</td>
</tr>
</tbody>
</table>

*From AASHTO 93 Guide, with $p_t = 2.0$ and $SN = 4$
Winter/Spring Breakup Issues

• Frost depth prediction – thermal conductivity (Solid Rock > 3.5)
  – Hot Mix & Base Layer ≈ 1.7 to 2.1
  – Soil Cement and Soil ≈ 0.9 to 1.2

• Tools for predicting time of thaw and length of time for reduced load limits
Traffic Counting and Classification

- Traffic Counts
  Critical for route priority

- Classification (% Trucks)
  Critical for structural designs

Magnetic Sensor Traffic Counter (www.trafx.net)
~ works 14 months on 3 ‘C’ cell batteries

Traffic Counter Installation

Dig hole, bury in road shoulder
2006-2009 Designs

Traditional Pavement Design:
Rd 328 (2006)

Low Initial Cost Design ~
Thin BST on Base

- 9" Crushed Gravel Base
- Subgrade Soil

Double BST
- 4" Lift of Gravel Base stabilized with BASE 1,

Structural Layer

~ Subgrade Soil
Alternatives Considered ~ 2010 & 2011

• Improve Subgrade
  – Increased Subgrade Compaction → minor benefit
  – Stabilization
    • Portland Cement → Lab mix designs promising
    • Fly Ash → Billings & Sidney fly ash had low strengths
    • Lime → Cement preferred for low Plasticity soils
    • Bottom Ash, Sugar Beet Lime, Enzymes, etc → unsure, inconsistent benefits

• Base Rock
  – Fabric → prevents clay contamination
  – Geogrid → unsure benefits with high truck traffic
  – BASE 1, Enzymes, etc → unsure, inconsistent benefits

• Asphalt Surface
  – Hot Mix
  – BST
2010 Trial Sections

BST (1.5 miles)
- Chips with AC & MC over Fabric (0.25 mi)
- & Gravel with HF Emulsion (1.0 mi)

Treated Gravel (3.5 miles)
- Additives: 3% Bentonite & 1.5% Calcium Chloride

Structural Layer
- Soil Cement, 8” thick, 5, 6, 7 & 8% Cement)
USFS, Rainy Creek Road

2 inch rock loss in 17 years (ADT 100 to 300)

Loose aggregate along shoulders

Tight surface in wheel tracks
Chloride Salt Dust Control

Magnesium & Calcium Chloride Liquid

Dry Calcium Chloride Solid

28-32%

36-38%

94 Percent
Chloride Treatment Techniques

• Purpose
  – Reduce dust
  – Reduce rock resource depletion
  – Reduce costs (less blading & rock replacement)

• Annual Dust Treatments

• Heavy Stabilization Treatment
Dust Treatments vs Stabilization

• Gravel suitability
  – Run chloride retention prior to stabilization

• Annual dust treatment
  – Pro: More chloride at road surface
    Good for light traffic
  – Con: Greater long term cost

• Stabilization with light treatment every 3 to 5 yrs
  – Pro: Less dusting, raveling, wash boarding
    Good for heavy haul roads – saves money
    Less blading and rock replacement
    Greater public satisfaction
  – Con: High initial cost.
    Only suitable for good gravel gradations
Additives/Fillers for Clean Gravels

• Purpose:
  – Reduce permeability
  – Improve chloride retention

• Bentonite Clay
  – Envirogel 12, Wyo-Ben
  – Similar to Cat Liter

• Bag House Fines (mineral filler)
  – By-product of asphalt mix manufacture
  – 70 to 80 % pass #200
  – Non Plastic

• Others
  – Crusher Reject
  – Roadside Soil, Pulverized
  – Fly Ash and Bottom Ash
  – Lime Kiln Dust
  – Etc, etc
Clay Binder

- Fills voids in gravel, forms road crust, sheds rain, retains chloride
- Chloride keeps clay from dusting

Gravel without Clay
- Rain penetration through gravel
- Subgrade soils weakened
- Blow Outs, Gravel Contaminated

Gravel with Clay
- Rain runs off surface
- Rain does not penetrate & leach Chlorides
- Fewer ‘Blowouts’, Longer Gravel Life
Mix Design Testing
(cheap insurance)

Duplicate field conditions in lab

Test to measure properties

Plot curves

- CBR Strength
- Tensile Strength
- Chloride Retention

% Bentonite

Rutting
Raveling

Dry at 140°F

Measure Re-blading Difficulty & Chloride Retention

Compact with Additives

Wet Strength

Soak 4 days

Soak in Water

Soil sample

Compacted Gravel Road Surface

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Lab Mix Design
Gravel, Bentonite & Calcium Chloride

Johnson Pit 2010 Clay-Chloride Mix Design

% Retained Calcium (Ret.)

- .61% Ret. for 1.5% CaCl₂
- .86% Ret. for No Additives
- .75% Ret. for 1.5% CaCl₂ & 3.5% Bentonite

Rutting Threshold for Heavy Truck Traffic
Performance Measurement (Strength Testing)
~ MDT Falling Weight Deflectometer (FWD) ~
FWD Operation Principles

Falling Weight

Buffers

Sensors

Strike Plate

Load Cell

Load Plate

Pavement

Load = 8,800 lbs

<table>
<thead>
<tr>
<th>Distance from Load</th>
<th>0”</th>
<th>8”</th>
<th>12”</th>
<th>18”</th>
<th>24”</th>
<th>36”</th>
<th>48”</th>
<th>60”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deflection, mils</td>
<td>23.1</td>
<td>16.1</td>
<td>13.3</td>
<td>9.9</td>
<td>7.9</td>
<td>4.7</td>
<td>3.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Subgrade $M_R$, Ksi</td>
<td>na</td>
<td>16.4</td>
<td>13.2</td>
<td>11.9</td>
<td>11.2</td>
<td>12.4</td>
<td>12.5</td>
<td>12.0</td>
</tr>
</tbody>
</table>

$M_R = 0.24 \times \text{Load}/(\text{deflection} \times \text{distance from load})$  Note $M_R$ of 12 = CBR of $\approx 8$

12/1/2011

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2010 & 2011 Soil Cement Designs

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Cement,</td>
<td>Soil Cement,</td>
<td></td>
</tr>
<tr>
<td>8” thick, 5%</td>
<td>10” thick, 8%</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>Cement</td>
<td></td>
</tr>
<tr>
<td>Compressive</td>
<td>225 psi</td>
<td>300 psi</td>
</tr>
<tr>
<td>Strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeze Thaw</td>
<td>Marginal</td>
<td>Good</td>
</tr>
<tr>
<td>Durability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexural Strength</td>
<td></td>
<td>56% Increase</td>
</tr>
</tbody>
</table>
Life Cycle Costs

- Primary Cost Inputs
  - Construction
  - Maintenance
  - Road User

- Life Prediction
  - Empirical thickness design methods
  - FWD back calculation

- Cumulative life cycle costs per mile
- Cost per ESAL/mile or Truck/mile

Early payback for high ADT roads

Ref: S Dak. Surfacing Selection Criteria
## Preliminary Cost Comparison

<table>
<thead>
<tr>
<th>Option</th>
<th>Life by FWD (80,000 GVW trucks)</th>
<th>Costs/Mile (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Support Structure</td>
<td></td>
</tr>
<tr>
<td>5” Hot Mix</td>
<td>9” Base on Fabric</td>
<td>600,000</td>
</tr>
</tbody>
</table>

**Construction** $900,000  Ann Mtc ?  Per Truck $1.50

(a) Based on Spring 2011 FWD back-calculation, better info available in 2012 (Note that 75 Trucks/day ≈ 20,000/yr)

(b) Costs are very project specific
## Preliminary Cost Comparison

<table>
<thead>
<tr>
<th>Option</th>
<th>Life by FWD (80,000 GVW trucks) (a)</th>
<th>Costs/Mile (b)</th>
<th>Construction</th>
<th>Ann Mtc</th>
<th>Per Truck</th>
</tr>
</thead>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>9” Base on Fabric</td>
<td>600,000</td>
<td>$900,000</td>
<td>?</td>
<td>$1.50</td>
</tr>
<tr>
<td>Double Chip BST</td>
<td>10” Base on Fabric</td>
<td>100,000</td>
<td>$400,000</td>
<td>?</td>
<td>$4.00(c)</td>
</tr>
</tbody>
</table>

(a) Based on Spring 2011 FWD back-calculation, better info available in 2012
(Note that 75 Trucks/day ≈ 20,000/yr)

(b) Costs are very project specific

(c) Base thickness inadequate – see next slide
# Preliminary Cost Comparison

<table>
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<tr>
<th>Option</th>
<th>Life by FWD</th>
<th>Costs/Mile (b)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(80,000</td>
<td>Construc</td>
<td>Ann Mtc</td>
<td>Per Truck</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GVW trucks)</td>
<td>tion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5” Hot Mix</td>
<td>600,000</td>
<td>$900,000</td>
<td>?</td>
<td>$1.50</td>
<td></td>
</tr>
<tr>
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<td>100,000</td>
<td>$400,000</td>
<td>?</td>
<td>$4.00(c)</td>
<td></td>
</tr>
<tr>
<td>on Fabric</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double Chip BST</td>
<td>1,000,000</td>
<td>$300,000</td>
<td>?</td>
<td>$0.30</td>
<td></td>
</tr>
<tr>
<td>on Fabric</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double Otta Seal BST</td>
<td>2,000,000</td>
<td>$400,000</td>
<td>? (d)</td>
<td>$0.20</td>
<td></td>
</tr>
<tr>
<td>Treated Gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Based on Spring 2011 FWD back-calculation, better info available in 2012  
(Note that 75 Trucks/day ≈ 20,000/yr)

(b) Costs are very project specific

(c) Base thickness inadequate – see next slide

(d) Gravel replacement & treatment costs are likely high, replacement frequency variable
### Structural Requirements for BST Pavements (WSDOT - LE)

<table>
<thead>
<tr>
<th>Max Traffic (80,000 GVW Trucks)</th>
<th>Subgrade Condition</th>
<th>Base Thickness, inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>50,000</td>
<td>Poor</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>12</td>
</tr>
<tr>
<td>125,000</td>
<td>Poor</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>12</td>
</tr>
<tr>
<td>250,000</td>
<td>Poor</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>13</td>
</tr>
</tbody>
</table>

#### WSDOT Flexible Pavement Layer Thicknesses Design Table for New or Reconstructed Pavements - LOW ESAL LEVELS

(English Version)

<table>
<thead>
<tr>
<th>Design Period ESALs</th>
<th>Subgrade Condition</th>
<th>Layer Thickness1 (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HMA Surfaced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reliability = 75%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HMA Surfaced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Courses</td>
</tr>
<tr>
<td>&lt; 100,000</td>
<td>Poor</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>0.25</td>
</tr>
<tr>
<td>100,000 to 250,000</td>
<td>Poor</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>0.30</td>
</tr>
<tr>
<td>250,000 to 500,000</td>
<td>Poor</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>0.55</td>
</tr>
</tbody>
</table>

1. Based on the 1998 WSDOT Guide for Design of Pavement Structures for flexible pavements with the following modulus:

- $E_{st} = 1.7 \times 10^6$ (MPa)
- Subgrade condition (effective modulus):
  - Poor: $E_g = 0.59 \times 10^6$ (MPa)
  - Average: $E_g = 0.88 \times 10^6$ (MPa)
  - Good: $E_g = 1.0 \times 10^6$ (MPa)

2. Gravel borrow may be substituted for a portion of crushed stone when the required thickness of the crushed stone is at least 245 mm. The minimum thickness of crushed stone is 125 mm when subgrade is 125 mm.

3. The assumed elastic modulus for BST (1,000 MPa (100,000 psi))

4. The assumed thickness for all BST layers is 30 mm (1.2 inches).

5. Crushed stone thickness increased to a total pavement structure of approximately 305 mm (12 inches) based on modulus and subgrade conditions.
Gravel Base or Soil Cement?

**BST over 10” Gravel Base**

- $400,000/mile, $4/Truck (*)
- Water infiltration to Clay Subgrade is close to structural support area
- Edge cracking & break off mtc. problems

**BST over 10” Soil Cement**

- $250,000/mile, $0.30/Truck (*)
- Harder support from soil cement reduces damage from large rock punctures, turning movements, etc
- Flatter wider shoulder is less of a hazard
- Wide impermeable shoulder keeps surface water further away from critical structure support area.

(*) Maintenance Cost ??
Thin vs. Thick Asphalt Layers

• Thin BST/Otta Seals (3/4” thick)
  – Lower costs for construction, maintenance, recycling & replacement
  – Suited for low traffic & cold climates ~
    more flexible & less cracking
  – Good wear surface, no structural strength
  – Quick failure from overloads during thaw

• Thick Asphalt Pavements (>3” thick)
  – Stronger ~ supports greater loads
  – Poor option directly on top soil cement

• Warning – Both thick & thin options must have good structural support and drainage
Rock Used for Double BST

5/8” & 3/8” Clean Chips

Cost/Mile ≈ $75,000 (Double Shot with Fabric)
AC (PG-58-28): 0.85 gal/SY
MC-3000: 0.40 gal/SY:
Total Chip #/SY: 45#/SY & 27 #/SY

5/8” Gravel – Otta Seal

Cost/Mile ≈ $60,000 (Double Shot)
Total HF 125S: 0.82 gal/SY
Total Gravel: 70 #/SY
Double BST Options

Clean Chip BST

Otta Seal BST with Gravel
2011 Work ~ BST on Soil Cement

- **Structural Layer**
  - Soil Cement (8%, 10 inch)
  - Clay Subgrade

- **Double BST Otta Seal**
  - (HFE 125S with 5/8” Gravel)
  - 21 miles

- **Double BST With Chips on Fabric**
  - PG 58-28 Tack for Fabric
  - PG 58-28 with 5/8” Chips
  - MC 3000 with 3/8” Chips
  - 4 miles
# Otta Seal Materials Specs

## High Float Emulsion Spec (5-4-2011)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>HF125S (Note A)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tests on Emulsion</strong></td>
<td></td>
</tr>
<tr>
<td>Viscosity, Saybolt Furol, Seconds at 50°C</td>
<td>35</td>
</tr>
<tr>
<td>Residue by Distillation, % by Mass</td>
<td>85</td>
</tr>
<tr>
<td>Demulsibility, % 50 ml 0.1 N CaCl₂</td>
<td>75</td>
</tr>
<tr>
<td>Oil Portion of Distillate, volume/Mass, %</td>
<td>1.0</td>
</tr>
<tr>
<td>Sieve Test, % by Mass</td>
<td>0.1</td>
</tr>
<tr>
<td>Storage Stability Test, 24 hr, % by Mass</td>
<td>1</td>
</tr>
<tr>
<td>Coating Test</td>
<td>Note B</td>
</tr>
<tr>
<td>Coating ability &amp; water resistance ASTM D244:</td>
<td></td>
</tr>
<tr>
<td>Coating, dry aggregate</td>
<td>good</td>
</tr>
<tr>
<td>Coating, after spraying</td>
<td>fair</td>
</tr>
<tr>
<td>Coating, wet aggregate</td>
<td>fair</td>
</tr>
<tr>
<td>Coating, after spraying</td>
<td>fair</td>
</tr>
<tr>
<td>Adhesion Agent, % by Weight of Residue</td>
<td>Note C</td>
</tr>
<tr>
<td><strong>Tests on Distillation Residue</strong></td>
<td></td>
</tr>
<tr>
<td>Penetration at 25°C, 5s, 100g</td>
<td>125</td>
</tr>
<tr>
<td>Solubility Trichloroethylene % by Mass</td>
<td>97.5</td>
</tr>
<tr>
<td>Float Test at 60°C, s</td>
<td>1200</td>
</tr>
<tr>
<td>Apparent Specific Gravity at 60°C, Pa.s</td>
<td></td>
</tr>
<tr>
<td>Ductility, 25°C, 5cm/min, cm</td>
<td>40</td>
</tr>
</tbody>
</table>

Note A: Certificate of Compliance and test reports are required.

Note B: Follow ASTM D244, except that the mixture of limestone and emulsified asphalt shall be capable of being mixed vigorously for 5 minutes, at the end of which period the stone shall be thoroughly and uniformly coated. The mixture shall then be completely immersed in tap water and the water poured off. The stone shall not be less than 90% coated.

Note C: The emulsion must include an adhesion agent and suppliers should cover costs for such in their bids. The actual amount of adhesion agent must be determined by ASTM D 244 with aggregate from the planned source after contract award.

## Proposed Gradation Limits (5-4-2011)

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Richland Co Spec</th>
<th>MN Otto Seal Spec</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>5/8&quot;</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>94</td>
<td>100</td>
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<tr>
<td>3/8&quot;</td>
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<td>7</td>
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<tr>
<td>#200</td>
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</table>
Soil Cement Construction Spec

- Made from PCA, DOT, FHWA specs
- Reviewed by five stabilization contractors
- Sections
  - Materials
  - Equipment
  - Quality Control & Assurance
  - Construction (12 subsections)
  - Measurement & Payment
2011 & 2012 Projects

2011 Work

Future Construction (tentative)

BST over Soil Cement 25 miles (2011)
Soil Cement Construction

- Test Strip
- Road Preparation
- Reinforcement of Weak Subgrade
- Cement Spreading
- Mixing Cement & Water
- Compaction
- Final Shaping & Compaction
- Curing
- Traffic Control
Soil Cement Quality Assurance

- Cement application rate
- Pulverization
- Depth of mixing
- Moisture content during mixing
- Compaction
- Surface Finish
- Curing
BST Quality Assurance

• Application Rate Design
• Road Surface Prep
• Sampling asphalt and aggregate
• Distributor & Spreader Uniformity Tests
• Yield Tests
• Adjustment of Application Rates
• Brooming
Construction & Maintenance Strategies

• Construction
  – All Roads:
    • Remove all secondary ditches and roadside vegetation
    • Modify soft spots with cement
  – Arterials
    • Rebuild to proper geometric standards
    • Stabilize soil with cement and BST

• Maintenance & Repair: Arterials
  – Surface wear: Seal coat
  – Structural problems
    • Grind up failed areas
    • Mix in new cement, asphalt emulsion, gravel, or ?
    • Build new BST surface
BST over Base ~ Rehab Strategy

- Rip and disc or grind up failed BST pavements
- If BST was rutting, add more base (or cement)
- Rebuild BST
Suggestions for Soil Cement/BST Construction

- Rebuild arterials to proper geometric standards
- Indicate ride will not be as good as hot mix – ride depends on blade operator skills
- Utilize detailed spec
- Mandatory prebid meeting
- Project foreman must attend prework meeting
- Plan to spend 5% on QA
- Build and maintain “As Built” plans
Concerns/Unknowns

• Structural Designs
  – No ability to predict truck traffic volumes
  – No control of heavy loads
  – No control during winter/spring breakup

• Soil Cement
  – Long term freeze/thaw durability and cracking
  – Repair and reconstruction costs/techniques

• BST: Maintenance seal frequency

• Funding: May not keep pace with network destruction
Conclusions

• Costs
  – Although there are unknowns with soil cement, it appears to be a promising cost effective alternative
  – Consider soil stabilization if rock costs are high
  – Gravel stabilized with clay & chloride can be cost effective
  – Estimated life cycle costs are useful
  – BST and Otta seal cost less to build and maintain than hot mix if structural support and drainage are adequate

• Technical assistance on soil cement
  – Don’t rely on PCA, Consultants, Contractors
  – Locate qualified independent personnel
  – Utilize TRB publications
Conclusions

• Testing
  – FWD testing of soil cement strength and durability for life prediction is critical
  – Amount of QA/QC needs depend on contractor, site conditions, weather, etc

• Design
  – BST over soil cement is better option than hot mix due to cracking
  – Fabric under chip seal reduces cracking & increases life

• Document performance and share information
Richland County Task Force

- Russ Huotari - Richland Co
- Josh Johnson - Interstate Engineering
- John Twedt, Troy Kelsey - Century Companies
- Steve Monlux – LVR Consultants
Questions/Comments