Technical Session on Road Dust Management

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Oxford English Dictionary

Dirt: any foul or filthy substance, as mud, grime, excrement.

From old Norse word drit
Introduction

- Unpaved roads
  - Function
  - Problems
  - Sustainability
  - Management

- Improvement options
  - Upgrade to sealed standard
  - Rehabilitation (regravel and reshape)
  - Fines preservation (dust control)
  - Surface stabilization
  - Understand the role of each

Guidelines
Guidelines

Guidelines?
Why Read Guidelines?

In the Next ± 90 Minutes

- Part 1
  - Unpaved road materials

- Part 2
  - Chemical treatments
Part 1: Understanding Unpaved Road Materials

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South African “Funky” Chart
Outline

- Introduction
- Road materials
  - Key material properties
  - Performance prediction
- Construction
  - Shape/drainage
  - Compaction
- Summary

Introduction

- Materials selected to optimize all weather performance
  - No dust when dry
  - Passable when wet
- Numerous specifications available worldwide
- Performance based are most useful
- Performance dependent on:
  - Particle size distribution
  - Plasticity (clay content)
  - Strength (bearing capacity)
  - Aggregate hardness
- Can be improved through chemical or mechanical modification
  - Chemical treatments best used for “keeping a good road good”
Outline

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Understanding Materials
Materials - Grading

Materials - Clay Content

Shrinkage
Materials - Clay Content

Liquid and Plastic Limit Tests = Plasticity Index

Test Results (±NZ $550)
### Guidelines & Specs - US

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Guidelines</th>
<th>FHWA Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FHWA</td>
<td>USFS</td>
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<tr>
<td></td>
<td>Haul</td>
<td>General Use</td>
</tr>
<tr>
<td>Sieve (mm)</td>
<td>25</td>
<td>100</td>
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<tr>
<td></td>
<td>19</td>
<td>90 – 100</td>
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<tr>
<td></td>
<td>4.75</td>
<td>50 – 78</td>
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<td></td>
<td>2.36</td>
<td>37 – 67</td>
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<td></td>
<td>0.425</td>
<td>13 – 35</td>
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<td></td>
<td>0.075</td>
<td>4 – 15</td>
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<tr>
<td>Plasticity Index</td>
<td>4 – 12</td>
<td>2 – 9 if 0.075 is &lt;12%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;2 if 0.075 is &gt;12%</td>
</tr>
</tbody>
</table>

1. Range for 0.075 mm sieve is 6.0 to 12.0% if the PI is greater than zero
### Using Test Results

<table>
<thead>
<tr>
<th>Sieve (mm)</th>
<th>NZ Type-1</th>
<th>NZ Type-2</th>
<th>Unpaved Road (FHWA)</th>
<th>Unpaved Road (USFS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5</td>
<td>--</td>
<td>100</td>
<td>100</td>
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</tr>
<tr>
<td>25</td>
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<tr>
<td>19</td>
<td>100</td>
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<td>65 - 100</td>
<td>84 - 100</td>
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<td>70 - 100</td>
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<td>4.7</td>
<td>25 - 35</td>
<td>37 - 67</td>
<td>40 - 62</td>
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<td>2.3</td>
<td>20 - 35</td>
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<td>13 - 35</td>
<td>22 - 36</td>
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<td>1.18</td>
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<td>0.425</td>
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<td>13 - 35</td>
<td>4 - 15</td>
<td>22 - 36</td>
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<tr>
<td>0.075</td>
<td>≤ 8</td>
<td>4 - 15</td>
<td>2 - 9</td>
<td>10 - 20</td>
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<tr>
<td>PI</td>
<td>≤ 6</td>
<td>≤ 6</td>
<td>4 - 12</td>
<td>2 - 9</td>
</tr>
</tbody>
</table>

### Key Grading & Plasticity Issues

- **No fines**
- **Good**
- **Too many fines**

Source: US Forest Service
Material Design

- **Grading coefficient**
  - Ratio between coarse, intermediate, and fine
  - \[ ((P_{25} - P_{2.36}) \times P_{4.75}) / 100 \]
  - Target somewhere between 15 and 35

- **Shrinkage product (clay factor)**
  - Linear shrinkage \( \times \) Po.425
  - Target somewhere between 100 and 365
  - Can use \( \frac{1}{2} \) PI if BLS is not tested
Material Design

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Particle size distribution factor ($G_c$)</td>
<td>15 - 35</td>
</tr>
<tr>
<td>Weighted clay factor ($S_p$)</td>
<td>100 - 365</td>
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<tr>
<td>Maximum size (mm)</td>
<td>40</td>
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<tr>
<td>Strength factor (CBR)</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Hardness factor (TIV)</td>
<td>20 - 65</td>
</tr>
</tbody>
</table>

** Calibrate for local use, conditions and test methods! Performance is always dependent on construction and maintenance quality!**

Outline

- Introduction
- Guidelines and specifications
- Road materials
  - Key material properties
  - Performance prediction
- Construction
  - Shape/drainage
  - Compaction
- Summary
Performance Prediction

- Increasing plasticity
- Shrinkage product

Grading coefficient:
- Increasing coarseness / increasing gap

- Erodible
- Good
- Ravels

- Slippery and dusty

- Corrugates and ravels

Calibrate for local use!
Calibrate for Local Use

Calibrate for Local Use
Performance Prediction

- **Erosion**
- **Slippery and dusty**
- **Good**
- **Ravels**

Grading coefficient

- **Corrugates and ravel**

Shrinkage product

- 0
- 100
- 365

Erosion

- Image of a dirt road with侵蚀 marks.
Performance Prediction

- Shrinkage product
- Slippery and dusty
- Erodible
- Good
- Ravels
- Corrugates and ravels

Corrugation and Raveling

- Grading coefficient
- Corrugation and Raveling

Image of a road with corrugation and raveling.
Performance Prediction

- Slippery and dusty
- Erodible
- Good
- Ravels

Grading coefficient

Corrugation and Raveling
Corrugation and Raveling

Performance Prediction

- Shrinkage product
- Slippery and dusty
- Erodible
- Good
- Ravels
- Corrugates and ravel s
- Grading coefficient
Dry Passability

Performance Prediction

Shrinkage product

Slippery and dusty

Erodible

Good

Corrugates and ravels

Grading coefficient

Ravels

UCPRC
Raveling

Performance Prediction

- Erodible
- Good
- Ravels
- Corrugates and ravelas

Grading coefficient

Shrinkage product

Slippery and dusty
Slipperiness

Dusty
Performance Prediction

- Slippery and dusty
- Good, but dusty
- Erodible
- Corrugates and ravels
- Ravels

Grading coefficient:
- Good
- Good, but dusty
- Erodible
- Slippery and dusty

Shrinkage product:
- 0
- 100
- 365

Good Gravel Road
Good Gravel Road

Performance Prediction

- Slippery and dusty
- Good, but dusty
- Good
- Erodible
- Corrugates and ravels
- Ravels

Shrinkage product

Grading coefficient
Good, but Dusty

Photo courtesy of Jeb Tingle
Exercise

<table>
<thead>
<tr>
<th>Sieve (mm)</th>
<th>NZ Type-1</th>
<th>NZ Type-2</th>
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<td>19</td>
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<td>74</td>
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<td>4.75</td>
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<td>25 - 40</td>
<td>30</td>
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<td>20 - 35</td>
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<td>0.075</td>
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<td>8</td>
</tr>
<tr>
<td>PI</td>
<td>≤ 6</td>
<td>≤ 6</td>
<td>4</td>
</tr>
</tbody>
</table>

Exercise

- GC = 32
  - (100 - 34) x 46
  - 3,220 / 100
  - 32

- SP = 6

Not rocket science, just rock and a little science!
Deformation - Potholes

Deformation - Rutting
# Hardness

![Image of a road surface with cracks and debris]

## Guidelines - US

<table>
<thead>
<tr>
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<tr>
<td><strong>Grading Coefficient: (15 – 35)</strong></td>
<td>32</td>
<td>32</td>
<td>37</td>
<td>37</td>
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<tr>
<td>Low range</td>
<td>31</td>
<td>34</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Mid range</td>
<td>26</td>
<td>36</td>
<td>38</td>
<td>38</td>
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<tr>
<td>High range</td>
<td>49</td>
<td>41</td>
<td>45</td>
<td>45</td>
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<tr>
<td><strong>Worst case</strong></td>
<td>32</td>
<td>32</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td><strong>Shrinkage Product: (100 – 365)</strong></td>
<td>26</td>
<td>30</td>
<td>38</td>
<td>38</td>
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<tr>
<td>Low range</td>
<td>192</td>
<td>105</td>
<td>126</td>
<td>126</td>
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<tr>
<td>Mid range</td>
<td>420</td>
<td>207/23</td>
<td>243/27</td>
<td>243/27</td>
</tr>
<tr>
<td>High range</td>
<td>420</td>
<td>23</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td><strong>Worst case</strong></td>
<td>420</td>
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</tbody>
</table>

### Performance Prediction

- **Slippery and dusty**
- **Erodible**
- **Good but dusty**
- **Really good**
- **Corrugates and ravelers**

- **Grading coefficient**
- **Increasing coarseness / increasing gap**
- **Increasing plasticity**
- **Shrinkage product**
Discussion

- Materials that meet US guidance and specifications may still perform badly
  - Only two of the 14 potential materials are likely to perform well
  - Most materials likely to washboard and ravel
  - Some materials likely to be slippery/impassable when wet

- Problematic for inexperienced engineers
- Aggregate suppliers and contractors still meet spec
- Importance of using PI (weighted) and grading together is clear
Outline

- Introduction
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  - Key material properties
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Shape and Drainage
**Why Compact?**
- ± 2,000 tonnes to place 75mm of gravel on a 1.5km x 7m road
- 25mm lost within 3 months if not compacted

**Maintenance Compaction**
Outline

- Introduction
- Guidelines and specifications
- Road materials
  - Key material properties
  - Performance prediction
  - Material blending
- Construction
  - Shape/drainage
  - Compaction
- Summary

Summary

- Materials should be selected to optimize all weather performance
  - No dust when dry
  - Passable when wet
- Use any specification, but understand performance
  - Select the best possible material
  - Blend if necessary
  - Change maintenance programs to suit
  - Improve with chemicals
- Testing is not expensive and will save $$
Time for a Break?