High Float Emulsions – Gravel Seals

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Outline

• Canadian road network
• Gravel seals
• High float emulsions
• Aggregates
• Gravel seal systems
• Placement operations
• Typical cycle
• Future Developments
Canadian Road Network

Hard surfaced roadways 415,600 km

Gravel roadways 626,700 km
Canadian Road Network

Km of Two-lane Roadway per 1000 Inhabitants per Province/Territory
Gravel Seals

- **Canadian version**
  - Gravel seals with high float emulsions were first placed on Manitoba/Saskatchewan roadways in the early 60’s

- **Scandinavian version**
  - Otta seals originate from the Otta Valley in Norway where it was first used in the early 60’s
Gravel Seals

- Gravel seals
  - Graded-aggregate
  - Low viscosity binders
  - Medium setting
  - Priming not always required
Gravel Seals

• **Gravel seals**
  - *Graded-aggregate*
  - *Low viscosity binders*
  - *Medium setting*
  - *Priming not always required*

• **Chip seal**
  - *Chippings*
  - *High viscosity binders*
  - *Rapid setting*
  - *Priming normally required*
Gravel Seals
High Float Emulsions

- **Components**
  - 100 to 200 PEN binder
  - Tall oil
  - Caustic soda
  - Solvent

- **Emulsion**
  - Anionic
  - + 62 or + 65 % residue
  - Solvent 1 to 15 % of vol. emulsion

- **Residue**
  - + 1200 sec. “Float Test”
  - Penetration 100 to 1000

Tall oil used to manufacture high float emulsions not only allowing emulsification of bitumen, it also “gels” bitumen residue.
High Float Emulsions
High Float Emulsions

HF emulsion residues have non-Newtonian flow characteristics.
High Float Emulsions

- “High Float” test
  - ASTM D 139-07, AASHTO T-50
  - Measures the resistance to flow at elevated temperatures
  - Use to determine if bitumen residue is gelled
High Float Emulsions

- Properties HF emulsions
  - Low viscosity/anionic
    - Ability to disperse
  - Lighter petroleum fraction
    - Ability to wet particles

- Properties of HF emulsion residues
  - Soft bitumen
    - Remains flexible and crack resistant
  - Hard binder
    - Resistant to bleeding, flushing & tracking
High Float Emulsions

<table>
<thead>
<tr>
<th>GRADE</th>
<th>HF-100S</th>
<th>HF-150S</th>
<th>HF-250S</th>
<th>HF-350S</th>
<th>HF-300M</th>
<th>HF-500M</th>
<th>HF-1000M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REQUIREMENTS</strong></td>
<td><strong>min.</strong></td>
<td><strong>max.</strong></td>
<td><strong>min.</strong></td>
<td><strong>max.</strong></td>
<td><strong>min.</strong></td>
<td><strong>max.</strong></td>
<td><strong>min.</strong></td>
</tr>
<tr>
<td>Residue by Distillation, % by mass</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>66</td>
<td>66</td>
<td>66</td>
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<tr>
<td>Oil Portion of Distillate, % by volume of emulsion</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Viscosity at 50°C, SF s</td>
<td>30</td>
<td>150</td>
<td>30</td>
<td>150</td>
<td>35</td>
<td>150</td>
<td>75</td>
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<tr>
<td>Shear Test, % retained on No. 100 sieve % by mass</td>
<td>—</td>
<td>0.10</td>
<td>—</td>
<td>0.10</td>
<td>—</td>
<td>0.10</td>
<td>—</td>
</tr>
<tr>
<td>Rolling Test (see Notes 4 &amp; 5)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Workability at -10°C</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Storage Stability Test, 24h % by mass</td>
<td>—</td>
<td>1.5</td>
<td>—</td>
<td>1.5</td>
<td>—</td>
<td>1.5</td>
<td>—</td>
</tr>
<tr>
<td>Demulsibility, 50 ml 5.55 g/l CaCl₂, % by mass</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
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<tr>
<td>Tests on Residue from Distillation:</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>a) Penetration at 25°C, 100 g, 5 s, divm</td>
<td>90</td>
<td>150</td>
<td>150</td>
<td>250</td>
<td>250</td>
<td>500</td>
<td>350</td>
</tr>
<tr>
<td>b) Apparent Viscosity at 50°C, Pa s</td>
<td>Requirements outlined on the chart beneath Figure 1</td>
<td>10</td>
<td>40</td>
<td>9</td>
<td>20</td>
<td>2</td>
<td>6</td>
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<tr>
<td>c) Roll Test at 50°C, s</td>
<td>1250</td>
<td>—</td>
<td>1250</td>
<td>—</td>
<td>1250</td>
<td>—</td>
<td>1250</td>
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<tr>
<td>d) Solubility in Toluene-carbon tetrachloride, % by mass</td>
<td>97.5</td>
<td>97.5</td>
<td>97.5</td>
<td>97.5</td>
<td>97.5</td>
<td>97.5</td>
<td>97.5</td>
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<tr>
<td>Delivery Temperature, °C</td>
<td>40</td>
<td>70</td>
<td>40</td>
<td>70</td>
<td>40</td>
<td>70</td>
<td>40</td>
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</tbody>
</table>

(1) Test methods are as outlined in CGSB CAN1-16.5-M84
(2) Upper limit on % residue is governed by the viscosity limits.
(3) CGSB 8-GP-2M, Sieves Testing, Woven Wire, Metric
(4) Follow ASTM D244, except that the mixture of limestone and emulsified asphalt shall be capable of being mixed vigorously for 5 min., 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 then be not be less than 90% coated.
(5) Follow ASTM D244, except that the mixture of lime and emulsified asphalt shall be mixed vigorously for 5 min., then allowed to stand for 3h, after which the mixture shall be capable of being mixed an additional 5 min. The mixture shall then be mixed twice with approximately its own volume of tap water, without allowing appreciable loss of liminous film. After the second mixing the aggregate shall be at least 90% coated.
# Gravel Seal Systems

<table>
<thead>
<tr>
<th>Systems</th>
<th>Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chip Seals</td>
</tr>
<tr>
<td>Single layer</td>
<td>Single</td>
</tr>
<tr>
<td>Multiple layer</td>
<td>Racked-in Double Sandwich Cape seal Triple Sandwich /double Inverted (double)</td>
</tr>
<tr>
<td>Options</td>
<td>Priming of base Fibre-reinforced (FiberMat) Pavement fabric reinforcement Flush, scrub and fog seals</td>
</tr>
</tbody>
</table>
Gravel Seal Systems
Gravel Seal Systems

- Factors influencing selection/design
  - Roadway
  - Existing pavement
  - Traffic
  - Environment

- Preparatory work
- Systems with options
- Binder/Aggregate
- Spray and spread rate
Gravel Seal Systems

- Preparatory work requirements
  - Create a sound base/substrate
Gravel Seal Systems

- Preparatory work requirements
  - Create a sound base/substrate
- Selection of system with options
  - Fibres, flush seal, single/double
Gravel Seal Systems

- Preparatory work requirements
  - Create a sound base/substrate
- Systems with options selection
  - Fibres, single/double, flush seal
- Binder/aggregate selection
  - HF-100S, -150S, -250S, -350S, PMB
  - Aggregate grading, size
  - Compatibility testing
Gravel Seal Systems

- Preparatory work requirements
  - Create a sound base/substrate
- Systems with options selection
  - Fibres, single/double, flush seal
- Binder/aggregate selection
  - HF-100S, -150S, -250S, -350S, PMB
  - Aggregate grading, size
  - Compatibility testing
- Spray and spread rate determination
  - Empirical method
Placement Operations

1. Sweeping the pavement
2. Spraying the emulsion coat
3. Spreading the chipping layer
4. Tyre rolling

Traffic allowed at reduced speed

Alternating traffic

40
Placement Operations

• Classic operation
• Usage of steel roller
• Flush seal (sand seal)
• Sweeping (localized practice)
Placement Operations

- Fibre option “FiberMat”
Placement Operations

- Fibre option “FiberMat”
Typical Life Cycle

- **Year 0**
  - *Pulverization*
  - *Granular material*
  - *Double gravel seal*

- **Year 1**
  - *Reseal*

- **Year 8 to 12**
  - *Levelling*
  - *Reseal*

- **Year 15 to 20**
  - *End of cycle*

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### Life Cycle Cost Analysis ($/km)

<table>
<thead>
<tr>
<th>Year</th>
<th>Treatment</th>
<th>Capital</th>
<th>Discounted to year 0</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>Initial</td>
<td>$62,000.00</td>
<td>$62,000.00</td>
</tr>
<tr>
<td>1</td>
<td>Reseal</td>
<td>$16,500.00</td>
<td>$15,865.38</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Levelling +Reseal</td>
<td>$33,500.00</td>
<td>$24,478.12</td>
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<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>15</td>
<td>New Cycle</td>
<td>$62,000.00</td>
<td>$34,426.40</td>
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<tr>
<td>16</td>
<td>Reseal</td>
<td>$16,500.00</td>
<td>$8,809.48</td>
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<tr>
<td>...</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Residual value at year 20</td>
<td>$53,119.05</td>
<td>$24,242.84</td>
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<tr>
<td></td>
<td>Total present worth</td>
<td></td>
<td>$121,336.55</td>
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</tbody>
</table>
Future Developments

- Usage of bio-solvents
- Fibre-reinforcement
- Rational design method
- Breaking agents
- Wetting agents
STE. JULIENNE, QC (2010)
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