Eight-Year Review of the Full Depth Reclamation Process in the City of Edmonton

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Transportation Department

C-TEP/APWA Western Canada Pavement Workshop
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Presentation Outline

- Introduction:
- Budget Information/Market Issues:
- In-Place Recycling - Why we do it:
- Roadway Evaluation Techniques:
- FDR Volumes and Performance of the roads:
- FDR Materials Characterization:
- Questions
General Road Structures in Edmonton

- Deep Strength Asphalt or Oil Mix (10% of Network)
- Granular/Soil Cement (63% of Network)
- Composite Pavement (27% of Network)

- 150 - 300mm Hot Mix Asphalt or Oil Mix
- 50 - 250mm Hot Mix Asphalt
- 150 - 300mm Granular Base or Soil Cement Base
- 100-150 mm Hot Mix Asphalt
- 150-200mm Portland Cement Concrete
City of Edmonton Roadway 2007-2011 Construction Budget

2007 - 2011 CPP Funded Projects

Dollars (X 000,000)

Year

2007 2008 2009 2010 2011

Growth Art/Collector Rehabilitation Neighbourhood Rehabilitation (FDR)

Legend:
- Growth
- Art/Collector Rehabilitation
- Neighbourhood Rehabilitation (FDR)
95 Million tonnes of Aggregate both Sand and Gravel had actually been confirmed in 1978.

By the end of the 2009 construction season it has been estimated that we had used an additional 505 Million tonnes of sand and gravel in the Edmonton region.

By 2026 given current growth we estimate that we will have used an additional 400 to 550 Million tonnes of sand and gravel in the Edmonton region, taking us to almost 1 Billion tonnes.

1978 - 2026 Cumulative Aggregate Usage - Predicted

- **Gravel & Asphalt**
- **Combined**
- **Concrete**
- **Sand**
Aggregate Supply Issues

- Current Local Aggregate Sources:
  - Are of poorer quality;
  - Have smaller rock fraction maximum size;
  - More costly to process;
  - Secondary processing to remove deleterious materials;
  - Further aggregate haul distances
Pavement Distresses Treated

- Cracking, in the form of:
  - Age;
  - Fatigue;
  - Block;
  - Longitudinal;
  - Reflective;
  - Discontinuity

- Loss of bond between pavement layers

- Loss of surface integrity due to raveling, potholes, and bleeding

- Inadequate structural capacity
Pavement Distresses
Key Factors For Selection and Design

The outcome is contingent on:

- Proper analysis of the existing pavement structure including visual and structural assessments, investigations and materials sampling;
- Use of an appropriate Mix Design process;
- Use of an appropriate Pavement Design process.
Preliminary Assessments, Investigations and Materials Sampling

- Test Pitting
- Coring
- Subgrade Evaluation (Dynamic Cone Penetrometer - DCP & Backcalculation)
- Ground Penetrating Radar (GPR)
- Deflection Testing
- Visual distress survey
Field Investigations - Test Pitting, DCP Testing & Coring
Road Radar - GPR Unit (2004 - Current)
Ground Penetrating Radar

Asphalt on Soil Cement Base

Asphalt on Concrete on Granular Base

Asphalt on Soil Cement Base

Annotation Legend
- Patch Start, End
- Detour Start, End
- Manhole
- Watermain
- Fire Hydrant
- Pavement Change

Layer Legend
- ACP Overlay
- ACP/Base Interface
- Base Interface

Layer interfaces are dotted, dashed, or solid, corresponding to the reflected signal amplitude.

Survey Date: 2006-08-09

EBA Engineering Consultants Ltd.

PROJECT: 86 Street

CLIENT: City of Edmonton

TITLE: 118 Avenue to 112 Avenue
Southbound Outside Lane, Center Wheel Path
Continuous Profile Data

DATE: 2006-08-30
FILE NO.: 9500128
FIGURE: D4.5
PAGE: 1 of 1
Core #9: 100mm AC 250mm+ Granular

Core #6: 92mm AC 258mm+ Granular

Core #50: 70mm AC 230+ Granular
GPR Layer Thickness

Legend:
- 0 - 25 mm
- 26 - 50 mm
- 50 - 100 mm
- 101 - 150 mm
- 151 - 200 mm
- 201 - 250 mm
- 251 - 300 mm

Fulton Place Neighbourhood 2010 Project
Deflection Testing Pre & Post Construction

Dynaflect

Falling Weight Deflectometer
Ellerslie Road Deflection Profile - 142 to 156 Street
Ebound

Station

Deflection (mils)

Existing Roadway Prior to Construction
Pavement Design

- City of Edmonton's asphalt overlay design is based on deflection models.
- For new construction our designs are based on the AASHTO 1993 Pavement Design Guide;
Mix Design

- Mix Design as per latest version of the Wirtgen “Cold Recycling Manual”
- Mix design as per Appendix 2
- "Mix Design Procedures of Stabilized Materials"
- Samples obtained utilizing WR2500
Mix Design Laboratory Testing

- SIEVE ANALYSES;
- PLASTICITY;
- MOISTURE DENSITY RELATIONSHIP;
- BITUMEN FOAMING CHARACTERISTICS;
- PREPARATION OF SAMPLES;
- MIX WITH STABILIZING AGENTS;
- CURING OF SAMPLES;
- INDIRECT TENSILE STRENGTH TESTING
**FOAM MIX DESIGN REPORT**

<table>
<thead>
<tr>
<th>Client:</th>
<th>City of Edmonton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project:</td>
<td>Ellerslie Road</td>
</tr>
<tr>
<td>Sample Number:</td>
<td>1</td>
</tr>
<tr>
<td>Material to be foamed</td>
<td></td>
</tr>
<tr>
<td>Location:</td>
<td>Insitu/Camron0/50 blend</td>
</tr>
<tr>
<td>Asphalt content:</td>
<td></td>
</tr>
<tr>
<td>Optimum moisture content:</td>
<td>5.5</td>
</tr>
<tr>
<td>Maximum dry density:</td>
<td></td>
</tr>
<tr>
<td>Asphalt cement used for foaming</td>
<td></td>
</tr>
<tr>
<td>Supplier:</td>
<td>Husky Energy</td>
</tr>
<tr>
<td>Type:</td>
<td>150-200 pen</td>
</tr>
<tr>
<td>Temperature of asphalt cement:</td>
<td>160 C</td>
</tr>
<tr>
<td>Percentage &quot;foaming&quot; water:</td>
<td>1% cement</td>
</tr>
<tr>
<td>Additive and percentage:</td>
<td></td>
</tr>
</tbody>
</table>

### Foamed asphalt treated material characteristics

| Foamed asphalt added: | 2.0 | 2.5 | 3.0 | 3.5 |
| Actual foamed asphalt added: | 2.00 | 2.50 | 3.00 | 3.50 |
| Diameter of specimen (mm): | 101.0 | 101.0 | 101.0 | 101.0 |
| Height of specimen (mm): | 64.0 | 64.7 | 65.2 | 64.7 |
| Mass of specimen (g): | 1086.5 | 1105.0 | 1105.5 | 1104.5 |
| Bulk density (kg/m³): | 2118 | 2132 | 2117 | 2131 |
| Relative density (kg/m³): |       |       |       |       |
| ITS dry (kPa): | 427 | 355 | 358 | 325 |
| ITS soaked (kPa): | 262 | 327 | 280 | 291 |
| Retained ITS (%): | 61 | 92 | 78 | 90 |
| Resilient ITS (Mpa): |       |       |       |       |

![Graphs showing indirect tensile strength (ITS) vs foamed asphalt content and bulk relative density.](image)
Equipment Used - WR2500 or WR2500S
The Recycling Train

Urban Application - WR2500 S

Asphalt Tanker
Wirtgen 2500 S
Water Truck
Residential/Collector Roadway Reconstruction Process Asphalt & Granular/Soil Cement

Place 100 mm New Hot Mix 50 - 100mm
Hot Mix Asphalt

150 - 300mm
Place 300mm 3-20 or 3-25 Granular Base or Soil Cement Base

Stabilize Subgrade 150mm Depth with 10Kg/m2 Cement
Residential/Collector Roadway Foam Process
Asphalt & Granular/Soil Cement

Place 50-100 mm
New Hot Mix
Asphalt

50 - 100mm
Hot Mix Asphalt

Prepulverize
125-250mm
Foam and Mix
Existing Hot Mix Asphalt &
Granular/Soil Cement
Prepulverized Materials
Materials

Soil Cement Base

50-75mm Remaining
Granular materials
## Cost Comparison Example 2009$

### Project 20,000 M² Residential Reconstruction/FDR with Foamed Asphalt

**Existing Structure - 50mm AC over 175mm SC**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>unit</th>
<th>Unit Cost</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.032</td>
<td>Remove Asphalt Course (50mm)</td>
<td>m²cm</td>
<td>$0.97</td>
<td>1000</td>
<td>$970.00</td>
</tr>
<tr>
<td>11.034</td>
<td>Remove Soil Cement Course</td>
<td>m²cm</td>
<td>$0.90</td>
<td>3500</td>
<td>$3,150.00</td>
</tr>
<tr>
<td>16.021</td>
<td>Gravel 3-20 Base</td>
<td>tonne</td>
<td>$71.76</td>
<td>13200</td>
<td>$947,232.00</td>
</tr>
<tr>
<td>31.010</td>
<td>150 Cement Stabilized Subgrade</td>
<td>m²</td>
<td>$7.28</td>
<td>20000</td>
<td>$145,600.00</td>
</tr>
<tr>
<td>31.030</td>
<td>Cement for Stabilizing Subgrade</td>
<td>10Kg</td>
<td>$2.14</td>
<td>20000</td>
<td>$42,800.00</td>
</tr>
<tr>
<td>40.421</td>
<td>Asphalt Overlay (ACR) Mass</td>
<td>tonne</td>
<td>$114.00</td>
<td>5082</td>
<td>$579,348.00</td>
</tr>
</tbody>
</table>

**Total Cost Reconstruction**

$85.96/m²  
$1,719,100

### Foamed Asphalt Option - Prepulverize & Foam 150mm Depth with 75mm ACR Surface

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>unit</th>
<th>Unit Cost</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.047</td>
<td>Pre-pulverized Road Base</td>
<td>m²</td>
<td>$3.91</td>
<td>20000</td>
<td>$78,200.00</td>
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<tr>
<td>31.048</td>
<td>Add/Delete 0.2% Oil</td>
<td>m²</td>
<td>$0.46</td>
<td>20000</td>
<td>$9,200.00</td>
</tr>
<tr>
<td>31.049</td>
<td>Add/Delete 0.5% Cement</td>
<td>m²</td>
<td>$0.66</td>
<td>20000</td>
<td>$13,200.00</td>
</tr>
<tr>
<td>31.051</td>
<td>150mm FDR using Foamed Asphalt</td>
<td>m²</td>
<td>$13.49</td>
<td>20000</td>
<td>$269,800.00</td>
</tr>
<tr>
<td>40.421</td>
<td>Asphalt Overlay (ACR) Mass</td>
<td>tonne</td>
<td>$114.00</td>
<td>3811</td>
<td>$434,454.00</td>
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</table>

**Total Cost Foamed Asphalt**

$40.24/m² (47% Less)  
$804,854.00
## Contract Totals Tendered by the City of Edmonton 2001-2009

<table>
<thead>
<tr>
<th>Year</th>
<th>Contracts</th>
<th>Locations</th>
<th>Total Per year (m²)</th>
<th>Combined Total (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>One Contract</td>
<td>3 locations</td>
<td>45,000</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>One Contract</td>
<td>14 locations</td>
<td>120,000</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>Two Contracts</td>
<td>13 locations</td>
<td>160,000</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Three Contracts</td>
<td>2 neighbourhoods &amp; 5 locations</td>
<td>124,000</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>Six Contracts</td>
<td>4 neighbourhoods &amp; 3 locations</td>
<td>369,000</td>
<td>1,929,000</td>
</tr>
<tr>
<td>2006</td>
<td>Five Contracts</td>
<td>2 neighbourhoods &amp; 7 locations</td>
<td>259,000</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>Six Contracts</td>
<td>3 neighbourhoods &amp; 7 locations</td>
<td>288,000</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Seven Contracts</td>
<td>3 neighbourhoods &amp; 6 locations</td>
<td>166,000</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Ten Contracts</td>
<td>4 neighbourhoods &amp; 9 locations</td>
<td>398,000</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Nine Contracts</td>
<td>3 neighbourhoods &amp; ~15 locations</td>
<td>Total not yet available</td>
<td>Does not include 2010 locations</td>
</tr>
</tbody>
</table>
156 Street, 137 to St. Albert Trail - Rural Granular Cross-Section

Pre-Construction 2002  Post-Construction 2002  May, 2009
150 Avenue, 94 to 88 Street - Urban Soil Cement Cross-Section

Pre-Construction 2001  Post-Construction 2001  May, 2009
Some Cracking
93 Avenue, 146 to 149 Street

Location Under Evaluation
Wet-Dry Testing

Wet-Dry Testing (Density vs. % Loss)

\[ y = -43.909 \ln(x) + 2168.2 \]

\[ R^2 = 0.7616 \]

Maximum Allowable loss 11%
Freeze-Thaw Testing

Freeze Thaw Testing (Density vs. % Loss)

\[ y = -127.24 \ln(x) + 2237.4 \]

\[ R^2 = 0.7112 \]

Maximum Allowable loss 11%
Wet/Dry - Freeze/Thaw
Resilliency Modulus FWD Backcalculation

Foamed Stabilized Materials Resilient Modulus
(Backcalculated)

Resiliency Modulus (MPa)

Construction Year

2000 2001 2002 2003 2004 2005 2006
Benefits Of Cold Recycling

- Reuse of the material in the existing pavement generally better quality materials than are currently available.
- Derive maximum benefit of existing pavement structure as a stabilized base course material
- Simultaneous addition of “make-up (granular)” material and/or stabilizing agent(s)
- Speed of construction - one or two pass operation vs. a multi-pass operation
- Accommodation of traffic - roadway is never closed to traffic
- Economics ($) 30 to 50% saving
Conclusions

- Cold Recycling utilizing Foamed Bitumen is a viable technology for use on many different types of roadways;
- The structural capacity of Foamed Bitumen treated materials approaches 85% of hot laid asphalt mixes Granular Base Equivalency of between 1.6 and 1.8;
- The full depth pulverization completely eliminates any possibility of reflective cracking;
- There is no requirement for lengthy curing periods prior to overlay of Foamed bitumen treated materials;
- Pre-engineering work by the owner is critical;
- Imported granular material is definitely an option to cover any material gradation problem.
Questions?