A Summary of Performance Data: 25 Years of Recycled Pavements in Ontario, Canada

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Overview

• MTO has a long history of in-place pavement recycling - *since the mid 1980’s!*

• Recycled asphalt pavement is one of the most sustainable pavement design options
  • Reuses existing materials
  • Reduces energy consumption
  • Reduces greenhouse gas emissions
  • Reduces transportation
  • Conserves natural resources

• The performance of in-place recycled asphalt pavement is comparable to more expensive traditional pavement rehabilitation methods.
Four Most Common In-place Recycling Processes in Ontario

**Full Depth Reclamation**
1. Full Depth Reclamation (FDR) – OPSS 330
2. Full Depth Reclamation with Expanded Asphalt (FDR with EA) – OPSS 331

**Cold In-Place Recycling**
3. Cold In-place Recycling (CIR) – OPSS 333
4. Cold In-place Recycling with Expanded Asphalt (CIREAM) – OPSS 335
MTO Recycling History

Implementation Timeline

- 1980: FDR
- 1990: CIR
- 2000: FDR with EA
- 2010: CIREAM
Full Depth Reclamation - FDR
What is Full Depth Reclamation (FDR)?

FDR is a pavement rehabilitation technique in which the full asphalt pavement section and a pre-determined portion of the underlying materials are uniformly crushed, pulverized or blended.
Full Depth Reclamation

• The pulverized layer varies from 150 to 300 mm
• Approx. 50:50 blend of RAP and existing granular
• Particle size - 100% passing 50 mm sieve and 95% passing 37.5 mm sieve
• Typically overlay with one to two lifts of hot mix asphalt
Full Depth Reclamation (FDR)

Summary of FDR Quantity

Note: No. of Projects shown in red
Qty. expressed in 2-Lane Km, 7.5 m width

All Year Total: 7,244 Km
No. of Project: 450
FDR with Expanded Asphalt (Foamed Asphalt)
FDR Stabilization with Expanded Asphalt

- ~2% to 3% by mass of asphalt cement at elevated temperature (~160°C)
- injected with a small amount of cold water (~3%) inside an expansion chamber
- causing expansion or foaming of the asphalt cement.
- PG58-28 commonly used for foaming
Advantages of FDR with EA

• Recycling roadway, re-using in-place materials (aggregates, AC).
• Reducing transportation costs for hauling virgin materials to the site or waste off the site.
• Increasing the structural strength of the FDR by adding a stabilizing agent.
• Saving a lift of hot mix and shouldering materials.
Expanded Asphalt Stabilization (EAS or FDR with EA)

Summary of EAS Quantity

Note: No. of Projects shown in red
Qty. expressed in 2-Lane Km, 7.5 m width

All Year Total: 466 Km
No. of Project: 27
Cold In-Place Recycling - CIR
Cold In-place Recycling (CIR)

- CIR is a pavement rehabilitation method that mills up an existing asphalt pavement, sizes it, mixes in additional asphalt cement, and lays it back down without off-site hauling and processing.
- The added asphalt cement is typically an **asphalt emulsion**, a blend of asphalt cement and water droplets.
CIR using Emulsion

- Emulsion is a blend of asphalt cement
- Typical Composition
  - 60-65% residual asphalt cement
  - 35-40% water, emulsifiers & chemicals
- Need to allow for:
  - break (evaporation of water and asphalt droplets coalesce)
  - cure (return of residual asphalt properties)
- MTO requires a curing period – min. 14 days
Cold In-place Recycling (CIR)

Summary of CIR Quantity

Note: No. of Projects shown in red
Qty. expressed in 2-Lane Km, 7.5 m width

All Year Total: 1,124 Km
No. of Project: 80
Cold In-Place Recycling with Expanded Asphalt (CIREAM)
Cold In-place with Expanded Asphalt (CIREAM)

• A new development in CIR technology is the use of expanded (foamed) asphalt, rather than emulsified asphalt.
• In this new process, 1% cold water is added to hot asphalt cement causing it to rapidly expand (foam).
• The expanded asphalt is then mixed with the reclaimed asphalt pavement.
Cold In-place Recycling with Expanded Asphalt Mix (CIREAM)

Summary of CIREAM Quantity

<table>
<thead>
<tr>
<th>Year</th>
<th>2-Lane Km</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>2005</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>2006</td>
<td>6</td>
<td>1</td>
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<tr>
<td>2007</td>
<td>10</td>
<td>1</td>
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<tr>
<td>2008</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>2009</td>
<td>106</td>
<td>10</td>
</tr>
<tr>
<td>2010</td>
<td>165</td>
<td>13</td>
</tr>
<tr>
<td>2011</td>
<td>107</td>
<td>7</td>
</tr>
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<td>2012</td>
<td>69</td>
<td>4</td>
</tr>
<tr>
<td>2013</td>
<td>73</td>
<td>6</td>
</tr>
<tr>
<td>2014</td>
<td>78</td>
<td>8</td>
</tr>
<tr>
<td>2015</td>
<td>178</td>
<td>10</td>
</tr>
</tbody>
</table>

All Year Total: 829 Km
No. of Projects: 62

Note: No. of Projects shown in red
Qty. expressed in 2-Lane Km, 7.5 m width
CIR / CIREAM Design Considerations

- Suitable for a wide range of pavement deterioration including:
  - Thermal, fatigue and reflection cracking
  - Rutting due to mix instability
  - Ravelling / coarse aggregate loss
  - Loss of bond between layers
- Requires minimum existing pavement thickness of 100 mm
- Typical treatment depth 75 – 125 mm
- Warm, dry weather and curing period required
Advantages of CIR & CIREAM

• Process, size and mix in additional bitumen stabilizing agent, and lay it back down without off-site hauling and processing (100% recycling)
• pavement rehabilitation method without the addition of heat (fuel savings)
• open to traffic within hours
• mitigate reflective cracks
• save one layer of HMA overlay
## In-place Recycling History

<table>
<thead>
<tr>
<th>Process</th>
<th>Start Year</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Depth Reclamation (FDR)</td>
<td>Since 1985</td>
<td>30 years</td>
</tr>
<tr>
<td>Cold In-place Recycling (CIR)</td>
<td>Since 1989</td>
<td>26 years</td>
</tr>
<tr>
<td>FDR with Expanded Asphalt Stabilization (EAS)</td>
<td>Since 2001</td>
<td>14 years</td>
</tr>
<tr>
<td>CIR with Expanded Asphalt Mix (CIREAM)</td>
<td>Since 2003</td>
<td>12 years</td>
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</tbody>
</table>
## In-place Recycling Pavement Quantities

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of Projects</th>
<th>Quantity (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDR</td>
<td>450</td>
<td>7,244</td>
</tr>
<tr>
<td>CIR</td>
<td>80</td>
<td>1,124</td>
</tr>
<tr>
<td>EAS</td>
<td>27</td>
<td>466</td>
</tr>
<tr>
<td>CIREAM</td>
<td>62</td>
<td>829</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td><strong>619</strong></td>
<td><strong>9,663 km</strong></td>
</tr>
</tbody>
</table>
Performance History

• Over the years MTO has monitored the performance of the in-place recycled pavements.
• The performance comparisons are based on the treatment types:
  • FDR and EAS are base reconstruction treatments
  • CIR and CIREAM are binder course rehabilitation treatments
• The following performance charts summarize the performance of in-place recycled pavement compared to conventional treatments.
IRI Performance Trend for FDR vs. EAS

IRI

EAS  FDR  Reconstruction (O 3)

0.85  0.99  1.03
0.94  0.98  1.07
1.03  1.06  1.08
1.06  1.07  1.15
1.07  1.17  1.20
1.17  1.25  1.28
1.25  1.32  1.34
1.32  1.37  1.42

Age
IRI Performance Trend for CIR vs. CIREAM

- CIR
- CIREAM
- M&O 2

Age: 0 1 2 3 4 5 6 7 8 9

IRI: 0.81 0.96 1.03 1.08 1.15 1.28 1.33 1.37 1.40 1.45 1.55
PERFORMANCE CASE STUDIES

ARAN Monitoring

• To monitor pavement performance, MTO carried out annual ARAN testing:
  • Roughness (IRI) and rutting surveys
IRI Comparison of Expanded Asphalt Various Mixes
Three Different Mix Designs, Hwy 17, Wawa

IRI

Average IRI Entire Hwy
Average IRI Mix 1
Average IRI Mix 2
Average IRI Mix 3

Year

2002 2003 2004 2005 2006 2007 2008 2009 2010

IRI Comparison of Expanded Asphalt Various Mixes
Three Different Mix Designs, Hwy 17, Wawa

IRI

Average IRI Entire Hwy
Average IRI Mix 1
Average IRI Mix 2
Average IRI Mix 3

Year

2002 2003 2004 2005 2006 2007 2008 2009 2010
IRI Comparison of Expanded Asphalt Various Mixes versus Control Section, Hwy 17, Wawa
Summary of Long Term Performance (Hwy 17, Wawa)

• Results of ARAN surveys carried out in the years following construction found that the pavement has remained smooth (IRI<1) and in excellent condition (PCI>85) after 10 years in service.
• The three different mix designs, two with corrective aggregate and one without, performed similarly over the 10 year period.
• A control section of FDR with 80 mm HMA overlay started off with similar performance but deteriorated at a much faster rate.
Ten Year Performance
International Roughness Index (IRI) Comparison of 3 Treatments on Hwy 17 near Wawa, Ontario
PERFORMANCE CASE STUDIES

Highway 7 East of Perth – CIR and CIREAM
CIR/CIREAM project
Hwy. 7, east of Perth in 2003

• A 5-km section of CIREAM was constructed adjacent to 7-km of conventional CIR mix.
• Both pavements were uniform in appearance and performed well under traffic.
Performance Evaluation - ARAN

• After construction, the roughness and rut depth of the CIR and CIREAM sections were measured using the Ministry’s Automatic Road Analyser (ARAN) on an annual basis.

• After 10 years, the CIR and CIREAM sections are performing very well, with an average IRI of 1.1 and an average rut depth of 3 mm.
10 Years Performance of CIR and CIREAM on Highway 7
(Average IRI)

- Avg IRI CIR
- Avg IRI CIREAM

Years

IRI

0.0
0.5
1.0
1.5
2.0
2.5
3.0

10 Years Performance of CIR and CIREAM on Highway 7
(Average Rut Depth in mm)

- Avg Rut CIR
- Avg Rut CIREAM

Rut (mm)

Year
Condition of pavement, Year 10
Performance of Adjacent Conventional Pavement Treatment

• Of interest is the performance of the adjacent section to the west on Highway 7, Perth to Wemyss, where a more conventional treatment (milling, full depth crack repair, and two lift overlay) was carried out.

• This type of rehabilitation is more expensive, more time consuming, and more of an inconvenience to the travelling public due to construction delays.
Comparing CIR/CIREAM to Conventional Treatment

CIR / CIREAM vs. Crack Repair and Overlay on Highway 7, Perth

- Avg IRI CIR
- Avg IRI CIREAM
- Hwy 7, Perth to Wemyss
Conclusions

• MTO has over 25 years of experience in recycled asphalt pavements
• Excellent performance has been achieved through continuous refinements to the specifications and construction processes
• MTO will continue to promote pavement recycling and is committed to providing a safe, sustainable and economical transportation system in Ontario.
Thank you!

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