Performance of Cold In-place Recycling Technologies in Ontario

Becca Lane, P.Eng.
Manager, Materials Engineering and Research Office
Ministry of Transportation Ontario
Outline

Ministry of Transportation Ontario experience with:

- Cold in-place recycling (CIR)
- CIR with expanded asphalt (CIREAM)
- Challenges
- Performance
Implementation of Cold In-Place Pavement Recycling in Ontario

- Cold in-place recycling - 1989
- CIR with expanded (foamed) asphalt - 2003

Cold In-place Recycling (CIR) 6,848,943 m²
CIR with Expanded Asphalt (CIREAM) 3,241,653 m²

> 10,000,000 m²
Cold In-Place Recycling - CIR
Cold In-place Recycling

• 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 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

• Conserves aggregate
• Conserves asphalt cement
• Conserves energy
• Mitigates reflection cracking
• Increases structural adequacy
• Restores smooth ride
Historical Quantities for CIR

Summary of CIR Quantity (m²)

Note: No. of Projects shown in red

All Year Total: 6,948,943 m²
No. of Projects: 67
Cold In-Place Recycling with Expanded Asphalt (CIREAM)
Cold In-place Recycling with Expanded Asphalt (CIREAM)

- A new development in CIR technology is the use of expanded (foamed) asphalt, rather than emulsified asphalt.
- The expanded asphalt is then mixed with the reclaimed asphalt pavement.
CIREAM Trial, Hwy 7, Perth

• MTO’s first use of CIREAM was in 2003 on Highway 7, southwest of Ottawa.
CIR vs CIREAM

• A 5-km section of CIREAM was constructed adjacent to 8-km of conventional CIR mix.
• This gave the Ministry an excellent opportunity to compare the performance of the new technology to conventional CIR.
CIR with expanded asphalt
Conventional CIR
Conventional CIR mat

CIR with EA mat
Historical Quantities for CIREAM

Summary of CIREAM Quantity (m²)

Note: No. of Projects shown in red

All Year Total: 3,241,653 m²
No. of Project: 36
Challenges

• Constructability
  • Pavement widening
  • Width of screed
  • Shoulder treatment
  • Optimum moisture

• Acceptance testing
  • Moisture content & compaction
  • ITS
  • AC content
  • Corrective aggregate
Using a Milling Machine for Pavement Widening

Excavation for pavement widening performed with milling machine. Trench with mostly straight, vertical faces.

Pavement widening trench for CIR paving to extend under PPS.
Using milling machine for pavement widening

- using a small milling machine for the narrow excavation
- providing a straight, clean, vertical trench for the widening
- a much better result than a grader equipped with a boot

Hwy 6 (2011-3004) from Durham to Dornoch
No Screed at Paver Extension

- paver extensions without a proper screed at the extension portion
- potential for low density at the extension portion
- also causing break in cross-fall starting from the mid-lane

Hwy 4 (2011-3005) from Kippen to Clinton

Hwy 7/8 (2011-3020) Shakespeare to New Hamburg
Optimal moisture for field compaction

- Some labs recommend 75% OMC in the field.
- Mix design’s OMC = 5.8%. Field moisture should be 5.8% x 0.75 = 4.35%
- Some sublots fail in compaction

Hwy 3 (2011-3014) Dry Lake Road to Cayuga

Close-up of loose, coarse mat at centreline. Material was kicked up easily with boot.

Coarse, segregated areas noted in mat behind CIREAM paver.
Pulverizing PPS after CIR

- Conventional way: pulverizing PPS prior to CIR
- Hwy 17 - conducting CIR first and pulverize PPS at the final stage
- Did not see any instances where the newly placed CIR mat was affected by the process
**QA lab testing summary for CIR (2011)**

- All contracts pass in moisture.
- 2011-3005, one lot passes and one lot fails at 95.6% compaction.
- 2011-3005, 2011-3006 target density using mix design BRD.

<table>
<thead>
<tr>
<th>Contracts</th>
<th>Hwy</th>
<th>Moisture Avg. (%)</th>
<th>Moisture Sublot Acceptable</th>
<th>Moisture Lot Acceptable</th>
<th>Compaction Avg. (%)</th>
<th>Compaction Sublot Acceptable</th>
<th>Compaction Lot Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-3001</td>
<td>21</td>
<td>1.97</td>
<td>100%</td>
<td>100%</td>
<td>97.8</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2011-3005</td>
<td>4</td>
<td>1.30</td>
<td>100%</td>
<td>100%</td>
<td>96.9</td>
<td>70%</td>
<td>50%</td>
</tr>
<tr>
<td>2011-3006</td>
<td>3</td>
<td>1.63</td>
<td>100%</td>
<td>100%</td>
<td>98.1</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2011-4048</td>
<td>17</td>
<td>1.96</td>
<td>100%</td>
<td>100%</td>
<td>99.3</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
QA lab testing summary for CIREAM (2011)

- Poor QA results in NE Region (softer AC?)
- High failure rate for TSR in 2010 and 2011 (after changing of curing temp.?)
- Compaction results always good!

<table>
<thead>
<tr>
<th>Contract</th>
<th>Hw y</th>
<th>Dry Tensile Strength</th>
<th>Wet Tensile Strength</th>
<th>TSR</th>
<th>Compaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Avg. (kPa)</td>
<td>Sublot Accept-able</td>
<td>Lots Acceptable</td>
<td>Avg. (kPa)</td>
</tr>
<tr>
<td>2010-5133</td>
<td>11</td>
<td>268</td>
<td>96.6%</td>
<td>85.7%</td>
<td>126</td>
</tr>
<tr>
<td>2010-5142</td>
<td>11</td>
<td>245</td>
<td>69.8%</td>
<td>66.7%</td>
<td>100</td>
</tr>
<tr>
<td>2011-3004</td>
<td>6</td>
<td>294</td>
<td>100.0%</td>
<td>100.0%</td>
<td>232</td>
</tr>
<tr>
<td>2011-3013</td>
<td>8</td>
<td>319</td>
<td>100.0%</td>
<td>100.0%</td>
<td>183</td>
</tr>
<tr>
<td>2011-3014</td>
<td>3</td>
<td>318</td>
<td>100.0%</td>
<td>100.0%</td>
<td>164</td>
</tr>
<tr>
<td>2011-3020</td>
<td>7/8</td>
<td>305</td>
<td>100.0%</td>
<td>100.0%</td>
<td>224</td>
</tr>
<tr>
<td>2011-4033</td>
<td>17</td>
<td>319</td>
<td>100.0%</td>
<td>100.0%</td>
<td>193</td>
</tr>
</tbody>
</table>
Effectiveness of Adding Corrective Aggregates

- showing improvement in mix design only
- very poor QA results in terms of ITS

Hwy 11 – Hearst (2010-5142)

Original Mix Design (no corrective agg.)
- $\text{ITS}_\text{dry} = 176.8$ KPa
- $\text{ITS}_\text{wet} = 101.7$ KPa
- AC added = 1.0%

Improved Mix Design (with corrective agg.)
- $\text{ITS}_\text{dry} = 268$ KPa
- $\text{ITS}_\text{wet} = 182$ KPa
- AC added = 1.3%
- Add 10% screening

$\text{ITS}_\text{dry}$
- Range: 147 to 354 KPa
- Average: 245 KPa
- Lots fail: 3 out of 9
- Sublots fail: 18 out of 43

$\text{ITS}_\text{wet}$
- Range: 57 to 183 KPa
- Average: 100 KPa
- Lots fail: 5 out of 9
- Sublots fail: 12 out of 43

TSR
- Sublots fail: 38 out of 43
Min AC (1%) vs. optimal AC

- Current spec. – design % AC that passes dry/wet tensile strength, and min. AC of 1%
- Optimal AC when dry/wet tensile strength reach the maximum

Hwy 7/8 - Shakespeare to New Hamburg (2011-3020)
Incorporating shoulder granular into CIR / CIREAM

- Permit a narrow strip of shoulder gravel to be processed as part of the CIR / CIREAM mix (addition of 3% granular)
- Eliminate the 0.1m wide excavation for pavement widening.

Hwy 8 – Stratford (2011-3013)

**Original Mix Design (without 3% granular)**
- $\text{ITS}_{\text{dry}} = 327 \text{ KPa}$
- $\text{ITS}_{\text{wet}} = 181 \text{ KPa}$
- % fines = 5.2%
- % AC added = 1.2%

**Revised Mix Design (with 3% granular)**
- $\text{ITS}_{\text{dry}} = 405 \text{ KPa}$
- $\text{ITS}_{\text{wet}} = 220 \text{ KPa}$
- % fines = 5.37%
- % AC added = 1.2%
LWD testing of CIR & CIREAM

- Testing in two CIR sites and two CIREAM sites
- 5 sub-sections for each site (10 to 25 m apart)
- Continually testing for 17 days.

Typical Testing Sub-section

Edge of Pavement to Centre Line: Approx 3.75m
LWD testing of CIR & CIREAM

- See a general trend of reduction in deflection.
- Results sensitive to temperature and moisture.
- Spatial-specific results (must be tested at the same location).
- Need correlation if intending to use as QA tools.
Monitoring

- To monitor short and long term performance, MTO carries out annual field reviews of the in-place recycling projects:
  - Roughness (IRI) and rutting surveys using the ARAN
  - Visual distress data collection
Full Depth Reclamation

• Compare the performance of in place recycling technologies to full depth reclamation treatments
  • Full depth reclamation involves in-place full depth processing of the existing Hot Mix Asphalt (HMA) and underlying granular base, then shaping and compacting the processed materials as granular base.
  • Typically place 2 lift hot mix overlay (90 mm).
IRI Performance of Full Depth Reclamation Contracts

Age

IRI

0.95 0.97 1.02 1.06 1.16 1.26 1.32 1.39 1.41 1.49

0.00 0.50 1.00 1.50 2.00
Performance of CIR vs FDR

IRI Trend of 100 FDR Contracts

<table>
<thead>
<tr>
<th>IRI Trend of 100 FDR Contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.95 0.99 0.97 1.06 1.02 1.06 1.13 1.19 1.25 1.29 1.32 1.39</td>
</tr>
<tr>
<td>Age 1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

MTO Pavements and Foundations Section
IRI Comparison CIR vs. CIREAM

Avg IRI CIR  Avg IRI CIREAM

Years

IRI

2003  2004  2005  2006  2007  2008  2009  2010

MTO Pavements and Foundations Section

Ontario

Ministry of Transportation
Highway 7 Perth – 2002-4040
Conclusions

• Cold In Place Recycling technologies are performing very well in Ontario.
• Performance monitoring indicates very similar performance characteristics between the conventional CIR and the CIREAM.
• There are still challenges with contract administration.
• Use of recycling technologies is cost effective, conserves natural resources, saves on transportation, energy and GHG emissions, and results in similar performance to conventional techniques.
Thank you!

Becca Lane, P. Eng.
Materials Engineering and Research Office
Tel: 416-235-3512
email: Becca.Lane@ontario.ca