In-Place Pavement Recycling – The Payback of Green

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Ministry of Transportation Ontario
Outline

- Ontario road system overview
- Past - What have we learned
- Present - Current practices and improvements
- Sustainable Future - Challenges
Ontario Road System

- **Provincial System**
  - Funded through provincial taxes
  - 16,520 centre-line km, 3000 bridges
  - $1.7 B Capital Constr.

- **Municipal System:**
  - 152,000 centre-line km
  - 132,000 bridges
MTO Pavement Network Composition

- Provincial Road Network
  - freeway 8,900 lane-km
  - arterial 13,000 lane-km
  - collector 9,800 lane-km
  - local 7,500 lane-km

- 95% ==> Bituminous pavements
- 5%  ==> Concrete and other types of pavements
- 70% of Canada’s exports and $1.2 trillion in goods are carried on Ontario’s provincial highways
Hwy 17, Northern Ontario
Hwy 401, Toronto
Greening Pavement Initiatives

Environmentally friendly pavement design, preservation and rehabilitation strategies include:

• Reuse and recycling of materials
  - Pavement recycling
  - Roof shingles, rubber tires, glass and ceramics
  - Blast furnace slag, fly ash and silica fume

• Warm mix asphalt concrete

• Drainable/permeable pavements

• Reduced noise and perpetual pavements
Implementation of Pavement Recycling in Ontario

- Central plant recycling - late 70’s
- Milling, partial depth - early 80’s
- Full depth reclamation - mid 80’s
- Cold in-place recycling - 1989
- Hot in-place recycling - 1990
- FDR with EA (FA) - 2000
- CIR with EA (FA) - 2003
MTO In-situ Asphalt Recycling Quantities

Quantities (m²)

Years

Full Depth Reclamation - FDR

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Hot In-Place Recycling - HIR

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Cold In-Place Recycling - CIR

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FDR with Expanded Asphalt Stabilization

Ontario

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10 Year Summary of Quantities

- Full Depth Reclamation (FDR)  25,954,239 m²
- Hot In-place Recycling (HIR)  449,296 m²
- Cold In-place Recycling (CIR)  3,700,688 m²
- FDR with Expanded Asphalt  1,686,042 m²
- CIR with Expanded Asphalt  890,482 m²

Total Since 1998:  32,680,747 m²
Past Performance

• In-situ recycled pavements have performed well, often carrying significantly more traffic over their service life than anticipated.

• Designs built in the past have evolved from theory, road tests, and trial and error.

• Lessons have been learned from design problems/flaws, materials, and construction practices that have caused problems.
PCI Comparison – CIR vs. FDR

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IRI Comparison - CIR vs FDR

Age

<table>
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<th>IRI</th>
<th>Age</th>
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<tbody>
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<td>0.97</td>
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CIR

FDR
Recent improvements in design, materials and construction processes have significantly increased the benefits of in-situ recycling techniques.

Improvements in technology have provided cost effective designs and optimization of rehabilitation strategies.
Design Improvements

Pre-project Evaluation

• Pavement and subgrade condition & variability
• Review PMS records
• Adequate field testing
Design Improvements (cont.)

Pavement Investigation and Structural Design

- Detailed pavement condition survey – PCI & FWD
- Adequate asphalt, granular, & additive testing
- Mix design methods, “Cold Marshall” method
- Structural equivalency factors developed (GBE or $a_1$)
- Mechanistic-empirical design methodology
- Performance databases - PMS and AMS principles
- Economic assessment - Life Cycle Costing Analysis
Design Improvements (cont.)

Comprehensive Construction and Material Specifications

- OPSS 330, Full depth reclamation
- OPSS 334, Cold recycled mix
- OPSS 333, Cold in-place recycling
- OPSS 332, Hot in-place recycling
- OPSS 331, FDR with Expanded Asphalt Stabilization
- OPSS 335, CIR with Expanded Asphalt (pub.Nov/05)

Available online:

http://www.mto.gov.on.ca/english/transrd
Design Improvements (cont.)

Post Project Evaluation

- Review QC results/material quantities
- Assess performance – surveys, coring, NDT, lab testing
- Revise design procedures/parameters
Material Improvements

- Evolution of in-situ recycling products
  - Improved emulsions
  - CIR and FDR with expanded asphalt
  - Lime and cement slurry stabilization
  - Combination of additives

- Material and lab testing technology
- Benchmarking of material properties
- Improved surface courses – SuperPave Mixes
- QC and QA testing methods
Construction Improvements

• New in-place recycling equipment and processes
• Numerous qualified & innovative contractors
• Move from method specifications to ERS to performance related specifications
• Quality control and quality assurance methods
• Superior evaluation processes
  – FWD, GPR, $M_R$ testing, etc.
Towards a Sustainable Future

What is Sustainable Development?

“…. Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”
Towards a Sustainable Future

To achieve sustainability, every corporate decision should consider the impact of the triple-bottom-line.

“What are the Social, Economic, and Environmental (SEE) Impacts of the decision”
GHG Emissions and Global Warming

Variation in Mean Surface Temp and CO₂ Concentration

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Kyoto Protocol

- Adopted in 1997 to address global warming by reducing greenhouse gas (GHG) emissions
- Came into effect on Feb 16, 2005 with 141 countries signing on
- In-situ recycling technology and construction practices are well positioned to assist in achieving this challenging goal
Sustainable Pavement Criteria

“...safe, efficient, environmentally friendly pavements meeting the needs of present-day users without compromising those of future generations”

• In-situ recycling technologies address the main criteria for a sustainable pavement:
  • Optimizing the use of natural resources
  • Reducing energy consumption
  • Reducing greenhouse gas emissions
  • Limiting pollution
  • Improving health, safety and risk prevention
  • Ensuring a high level of user comfort and safety
Energy Use Per Tonne Of Material Laid Down

Source: The Environmental Road of the Future, Life Cycle Analysis by Chappat, M. and Julian Bilal. Colas Group, 2003, p.34
Sustainable Pavements

• The report concludes that recycling technologies are the most promising tool to assist in the selection of environmentally friendly flexible pavements.

• MTO’s primary pavement design/rehabilitation goal is to provide safe durable roads that maximize the use of recycled materials.
Ontario Case Study

Environmental Benefits of In-place Recycling (CIR + CIREAM) vs. Mill and Overlay
Impact Evaluation

• PaLATE software - 
  Pavement Life-cycle Assessment Tool for Environmental and Economic Effects
• Created by Dr. Horvath of the University of California at Berkley
• Assists decision-makers in evaluating the use of recycled materials in highway construction (both LCC and Environmental Impacts).
Study Assumptions

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<th>CIR</th>
<th>CIREAM</th>
<th>M&amp;O</th>
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<tr>
<td>Existing HMA Depth</td>
<td>150mm</td>
<td>150mm</td>
<td>150mm</td>
</tr>
<tr>
<td>New HMA</td>
<td>50mm</td>
<td>50mm</td>
<td>130mm</td>
</tr>
<tr>
<td>% AC</td>
<td>5%</td>
<td>1.0% &amp; 5%</td>
<td>5%</td>
</tr>
<tr>
<td>% Emulsion</td>
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Using PaLATE model, the following emissions were calculated and compared:
CO₂ Emissions

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<th>Treatment</th>
<th>Tonne</th>
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<td>Mill &amp; HMA</td>
<td>200</td>
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<tr>
<td>CIR</td>
<td>100</td>
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<tr>
<td>CIREAM</td>
<td>100</td>
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Carbon Dioxide Emissions

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NO\textsubscript{X} Emissions

![Bar chart showing NO\textsubscript{X} emissions for Mill & HMA, CIR, and CIREAM treatments. The bar for Mill & HMA is significantly higher than the others.]
SO$_2$ Emissions

![Bar chart showing sulfur dioxide emissions for different treatments. The chart indicates that Mill & HMA has the highest emissions, followed by CIR and CIREAM.]
Environmental Benefits

- Per 2-lane km, CIR/CIREAM emits approximately 50% less GHG, consumes 62% less aggregates, and costs 40-50% less when compared to a conventional mill and overlay treatments.
- Since the implementation of CIR/CIREAM contracts, MTO has reduced GHG emissions by:
  - 104,112 t of CO₂
  - 848 t of NOₓ
  - 18,123 t of SO₂

And saved 1,426,720 tonnes of aggregates.
Technology Transfer

• CIR/CIREAM are two of the most environmental friendly flexible pavement rehabilitation techniques available; they reduce Life Cycle Costs, reuse existing non-renewable material, minimize new materials and reduce on site transportation.

• MTO actively promotes CIR/CIREAM through technical papers, presentations and by example
Sustainable Pavements in Ontario

- MTO currently uses numerous innovative in-situ recycling technologies that conserve aggregates, reduce GHG emissions, and minimize energy consumption.
- A key MTO sustainability strategy is to implement these technologies on a larger scale and encourage their use province wide.
- These technologies support a “zero waste” approach and will assist in meeting our emission reduction commitments while addressing the triple-bottom-line (SEE).
What's next?

- Current Life Cycle Costing (LCC) includes:
  - Initial, and discounted main/rehab costs and remaining life costs
  - User costs
- We now have the tools to calculate GHG emissions and energy savings – PaLATE software
- Moving towards including an environmental component into LCC (Environmental benefits/credits).
- Insures that the best treatment is selected to benefit economic, social and environmental needs
  - a Sustainable Approach.
Summary

MTO will better achieve its sustainable pavement goals through:

- Building on current industry/ministry partnerships in the development of improved in-situ recycling specifications and design/construction procedures
- Encouraging continued innovation by the province's in-situ recycling contractors
- Supporting dedicated research programs to advance the technology
- Increasing technology transfer to accelerate adoption of in-situ recycling concepts
Conclusions

• There is an increased focus on sustainable asset preservation in Ontario, both at the provincial and municipal levels.

• Pavement preservation and rehabilitation incorporating timely insitu recycling treatments can significantly extend pavement life and result in improved network performance over time.

• Implementation of sustainable AM principles and performance measures are critical to addressing infrastructure investment requirements and environmental stewardship over the long-term.
Thank you!

Questions?

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