Sustainability Metrics of Pavement Preservation Techniques

Tom Kazmierowski, P.Eng
Outline

- Past - What have we learned
- Present - Current practices and improvements
- Case Study - PaLATE
- Sustainable Future – Challenges
What is Pavement Preservation?

Coordinated approach to pavement maintenance/rehabilitation:

- Planned not reactive
- Treatments are performed before the appearance of significant distresses
- Extends the service life
Preservation treatments are designed to be proactive, applied while the pavement is still in good condition and maintains the pavement at a high level of service.

**Versus**

Worst-first & reactive types of major maintenance

- repairs made to existing distresses
- most common approach to pavement maintenance
Strategy Definitions

Preservation
- planned strategy to extend the life of the pavement
- preserves the system, retards deterioration, and maintains or improves the functional condition of the system (without increasing structural capacity)

Rehabilitation
- renews the life of the pavement
- work undertaken to restore serviceability and improve an existing pavement to a condition of structural or functional adequacy

Reconstruction
- removal and replacement of the existing pavement structure

Holding
- strategy that prolongs the life of an asset (for a planned period of time). Strategy employed to maintain acceptable levels of functionality or safety until full rehabilitation or reconstruction can be completed.
Pavement Treatment Strategies

- Preservation
- Rehabilitation
- Reconstruction

Time
“Mix of Fixes”

**Preservation**
- Microsurfacing
- Mill 50 mm, Pave 50 mm (Recycled Hot Mix, Warm Mix)
- Hot In-Place Recycling, chip seals, crack sealing, etc.

**Rehabilitation**
- Mill 50 mm, Pave 90 mm (Recycled Hot Mix)
- Cold In-Place Recycling and Pave 50 mm

**Reconstruction**
- Rubblize, granular grade raise, and thick HMA overlays
- Full depth reclamation (FDR) and HMA paving
- Full depth removal and replacement with new pavement structure

**Holding**
- Hot Mix Patching
- Thin Resurfacing
Holding Strategies

Pavement Condition

Time

Holding Strategies
Preservation Strategies – Rigid Pavements

- Dowel bar retrofit of cracks and joints,
- Cross-stitching of longitudinal cracks
- Joint and crack sealing / resealing
- Diamond grinding to address ride, friction or noise issues
- Partial depth repairs
- Pre-cast concrete pavement repairs
Dowel Bar Retrofit
Cross-sectional View

- 35°-45°
- See Note B
- Epoxy rebar into place
- Slab
- Subbase

1 in. min. thickness after drilling holes
Joint and Crack Sawing and Sealing
Partial Depth Repairs

Remove and Replace Deteriorated Surface Concrete
Precast Slab Repairs
Preservation Strategies – Flexible Pav’ts

- Thin Surfacing
  - Micro-surfacing
  - Slurry Seal
  - Chip Seal
  - Fibre modified Chip Seal
  - Ultra thin Bonded Friction Course
- Crack Sealing
- Hot In-place Recycling
- Warm Mix Asphalt
Crack Sealing

Typically used to prevent water and debris from entering cracks in the HMA pavement surface.
Thin Surfacings

Typically used to:
- seal cracks
- waterproof surface
- improve friction
- improve rideability
- rejuvenate surface

- Slurry seal
- Micro-surfacing
- Chip seal / Dynapatch
- Novachip
- FMCS
- Ultrathin (premium sand mix)
Slurry Seal

- **Description**
  - mixture of well-graded aggregate and slow setting asphalt emulsion

- **Purpose**
  - seal surface cracks
  - address raveling/oxidation
  - fill minor surface irregularities
  - restore friction
Micro-Surfacing

- a polymer-modified cold slurry paving system
- a mixture of dense-graded aggregate, asphalt emulsion, water and mineral fillers
- typically 12 mm thick
Chip Seals (Dynapatch)

Description

- Mechanical spray patching application of asphalt and single-sized aggregate chips rolled onto the pavement

Purpose

- seal pavement surface
- enrich hardened/oxidized asphalt
- improve surface friction
Ultrathin Bonded Friction Course (Nova Chip)

Description

- gap-graded, polymer-modified HMA placed on a heavy, emulsified asphalt tack coat

Purpose

- address surface distress
- increase surface friction
Fiber Modified Chip Seal (FiberMat)

Description

- FMCS consists of a chip seal application incorporating chopped fiberglass strands in the polymer modified emulsion and a covering aggregate layer.
New Three-Stage Recycler
Three-Stage Hot Milling Process
The Pugmill Mixer

- Computerized additive controls & twin shaft pugmill
- Recycling agent and 20 to 30% new HMA
Warm Mix Asphalt

**Description**
- Reduction in the asphalt mixtures temperatures (~50 °C) while still achieving adequate compaction

**Purpose**
- Lower temperature
- Reduce fuel consumption
- Reduce GHG emissions
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Quantities (m2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro-surfacing</td>
<td>7,309,677</td>
</tr>
<tr>
<td>Slurry Seal</td>
<td>906,050</td>
</tr>
<tr>
<td>Chip Seal</td>
<td>849,178</td>
</tr>
<tr>
<td>FMCS</td>
<td>440,641</td>
</tr>
<tr>
<td>Ultra-thin</td>
<td>450,223</td>
</tr>
<tr>
<td>HIR</td>
<td>324,124</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10,279,893</strong></td>
</tr>
</tbody>
</table>
Coordinated Approach to Investment

Preservation or Holding + Rehabilitation = Optimized Asset Performance
Recent improvements in **design, materials** and **construction** processes have significantly increased the benefits of pavement preservation techniques. Improvements in technology have provided cost effective designs and optimization of preservation strategies.
Design Improvements

Comprehensive Construction and Material Specs:
- OPSS 341 and 369, Crack Sealing
- OPSS 303 and 304, Chip Seal and Surface Treatment
- OPSS 337, Slurry Seal
- OPSS 336, Micro-Surfacing
- OPSS 332, Hot in-place recycling
- OPSS 333, Cold in-place recycling
- OPSS 335, CIR with Expanded Asphalt

Available online: http://www.mto.gov.on.ca/english/transrd
Sustainability Concepts within Pavement Preservation
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”
Variation in Mean Surface Temp and CO2 Concentration
Sustainable Pavement Criteria

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

- Pavement preservation 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 Used per Lane-Kilometer of Material Placed

Adapted from ‘The Environmental Road of the Future, Life Cycle Analysis’
Case Study

Quantifying the Sustainable Benefits of Pavement Preservation Treatments versus Traditional Mill and Overlay
Impact Evaluation

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

Three pavement preservation treatments are compared to routine “Shave & Pave”:

- Mill 50 mm and overlay 50 mm WMA
- 50 mm HIR
- 12 mm Micro-surfacing

Versus

- Mill 50 mm and overlay 50 mm HMA
Using PaLATE model, the following emissions were calculated and compared for each treatment:

Based on typical 2-lane km section of hwy.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Energy (MJ)</th>
<th>CO2 (tonne)</th>
<th>NOx (kg)</th>
<th>SO2 (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill 50mm, Pave 50 mm</td>
<td>749,586</td>
<td>36</td>
<td>264</td>
<td>159</td>
</tr>
<tr>
<td>Mill 50 mm, Pave 50 mm WMA</td>
<td>700,015</td>
<td>35</td>
<td>236</td>
<td>148</td>
</tr>
<tr>
<td>50 mm HIR</td>
<td>627,646</td>
<td>28</td>
<td>202</td>
<td>127</td>
</tr>
<tr>
<td>12 mm Micro-surfacing</td>
<td>105,993</td>
<td>6</td>
<td>37</td>
<td>25</td>
</tr>
</tbody>
</table>
NOX Emissions

![Bar Chart]

- **Mill & Pave (HMA)**: Approximately 0.27 Tonne/2-lane km
- **Mill & Pave (WMA)**: Approximately 0.25 Tonne/2-lane km
- **HIR**: Approximately 0.20 Tonne/2-lane km
- **Microsurfacing**: Approximately 0.05 Tonne/2-lane km
SO2 Emissions

- Mill & Pave (HMA)
- Mill & Pave (WMA)
- HIR
- Microsurfacing

Tonne/2-lane km

SO2 Emissions
Environmental Benefits

- Per 2-lane km, micro-surfacing consumes only 8% of the energy, emits approximately 17% of the CO2, 14% of the NOX, and 16% of the SOX and costs 40-50% less when compared to a conventional mill and overlay treatment.

- Since the implementation of micro-surfacing contracts, assuming a 7 year life for micro-surfacing and a 10 year life for conventional mill and overlay, GHG emissions have been reduced by:
  - 28,600 t of CO2
  - 220 t of NOx
  - 130 t of SO2

  And saved 659,000 tonnes of aggregates.
Economic Benefits

- Over the past 10 years, MTO has constructed 7.3 million m² of micro-surfacing. If a traditional mill and overlay were performed instead of micro-surfacing over the past 10 years, $59.1 million more would have been spent based on initial construction costs.

- From a life cycle costing perspective, the 10 year annualized cost associated with using mill and overlay would be $37.2 million more than the cost of micro-surfacing.
Municipal and provincial agencies currently use numerous innovative pavement preservation technologies that conserve aggregates, reduce GHG emissions, and minimize energy consumption.

A key sustainability strategy is to implement these technologies on a larger scale and encourage their use Canada wide.

These technologies support a “zero waste” approach and will assist in meeting our GHG 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
- Several sustainability rating systems are available to quantify and encourage pavement sustainability
- We are 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.
Green Rating Systems

What are they?

- Typically, points based rating system designed to assess the “greenness” of pavements/infrastructure.

Goal:

- To provide an assessment of the sustainability of pavement/infrastructure designs and construction for the purpose of promoting greener practices.
Existing Green Rating Systems

- LEED® for Buildings
- University of Washington Green Roads
- NYSDOT GreenLITES Project Design Certification Program
- MTO GreenPave
- Golder GoldSET
# GreenPave Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Goal</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement Design Technologies</td>
<td>To optimize sustainable designs. These include long life pavements, permeable pavements, noise mitigating pavements, and pavements that minimize the heat island effect.</td>
<td>9</td>
</tr>
<tr>
<td>Materials &amp; Resources</td>
<td>To optimize the use/reuse of recycled materials and to minimize material transportation distances.</td>
<td>11</td>
</tr>
<tr>
<td>Energy &amp; Atmosphere</td>
<td>To minimize energy consumption and GHG emissions.</td>
<td>8</td>
</tr>
<tr>
<td>Innovation &amp; Design Process</td>
<td>To recognize innovation and exemplary efforts made to foster sustainable pavement designs.</td>
<td>4</td>
</tr>
<tr>
<td><strong>Maximum Total:</strong></td>
<td></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>
GreenPave Overview

Category

Pavement Technologies
9 Points
- Long-Life Pavements
  3 Points
- Permeable Pavements
  2 Points
- Noise Mitigation
  2 Points
- Cool Pavements
  2 Points

Materials & Resources
11 Points
- Recycled Content
  5 Points
- Undisturbed Pavement Structure
  2 Points
- Local Materials
  2 Points
- Construction Quality
  2 Points

Energy & Atmosphere
8 Points
- Reduce Energy Consumption
  3 Points
- GHG Emissions Reduction
  3 Points
- Pavement Smoothness
  1 Point
- Pollution Reduction
  1 Point

Innovation & Design Process
4 Points
- Innovation in Design
  2 Points
- Exemplary Process
  2 Points

Sub-Category

Blue font designates sections applicable only to constructed pavements
Proposed Rating Levels

GreenPave certified

- **BRONZE**: 10 to <15 Points
- **SILVER**: 15 to <20 Points
- **GOLD**: > 20 Points
- **TRILLIUM**: For Future Development Stages

Golder Associates
Additional GreenPave Resources

Reference Guide

Computer Spreadsheet
Summary

We will better achieve our sustainable pavement goals through:

- Building on current industry/ministry partnerships in the development of improved specifications and design/construction procedures
- Encouraging continued innovation by our pavement preservation contractors
- Supporting dedicated research programs to advance the technology
- Increasing technology transfer to accelerate adoption of pavement preservation concepts
Pavement preservation solutions satisfy the definition of sustainable pavements:

- Pavement preservation programs begin with the concept that the treatments are proactive and they are applied when the pavement is still in relatively good condition.
- Thinner, faster, less disruptive, less contract administration, less GHG emissions and less energy consumption.
- With coordinated pavement preservation/rehabilitation programs the value of the road network will increase.
Conclusions

- There is an increased focus on sustainable asset preservation, both at the provincial and municipal levels.
- Pavement preservation and rehabilitation treatments applied at the right time 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?

Tom Kazmierowski, P. Eng.
Senior Consultant
Golder Associates Ltd.
Tel: 905-567-4444
Email: tom_kazmierowski@golder.com