Sustainable Pavements – Environmental, Economic and Social Benefits of In-situ Pavement Recycling

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ABSTRACT

The Ministry of Transportation of Ontario is committed to using technologies to help build a more sustainable transportation system that supports today's needs while protecting the environment for future generations.

Cold in-place recycling (CIR) is an established pavement rehabilitation technology that processes 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 emulsified asphalt. A recent development in CIR technology is the use of expanded (foamed) asphalt, rather than emulsified asphalt to bind the mix. This combination of CIR and expanded asphalt technologies is termed Cold In-Place Recycled Expanded Asphalt Mix (CIREAM).

Both CIR and CIREAM technologies support the philosophy of a sustainable transportation system. More specifically, CIR and CIREAM meet the criteria for a sustainable pavement: safe, efficient, economic, environmentally-friendly pavement meeting the needs of present-day users without compromising those of future generations.

1.0 OBJECTIVES OF PAVEMENT RECYCLING

The Ontario Ministry of Transportation (MTO) has implemented an innovative in-situ pavement recycling program to provide a sustainable rehabilitation option that is safe, efficient, environmentally friendly and cost-effective, that meets the needs of present-day users without compromising those of future generations. This paper outlines how MTO is achieving sustainable pavements through an innovative in-situ pavement recycling program.

2.0 PROJECT DESCRIPTION

With the increasing cost of fuel and environmental awareness, pavement recycling has become a popular design alternative when selecting rehabilitation strategies for Ontario's highways and is frequently replacing traditional paving techniques. The MTO has an active pavement recycling program that is strongly promoted and monitored for performance and cost-effectiveness. Over the past 18 years, MTO has successfully in-situ recycled approximately 5,730,000 m^2 of hot mix asphalt (HMA) pavement.

One of the most successful recycling techniques used by MTO is Cold In-place Recycling (CIR), an innovative pavement rehabilitation method that typically processes up to 125 mm of an existing HMA pavement, sizes it, mixes in additional asphalt emulsion, and lays it back down without off-site hauling and processing.

A recent innovation in CIR technology is the use of expanded (foamed) asphalt, rather than emulsified asphalt to bind the mix. In this new process, hot asphalt cement is pumped through an expansion chamber on the cold recycling unit, where a small amount (1%) of cold water is injected and immediately vaporizes. This creates thousands of tiny bubbles within the hot asphalt cement causing it to rapidly expand (foam). The expanded asphalt is then mixed with the reclaimed asphalt pavement (RAP). As with conventional CIR, the material is then profiled and compacted to form a binder course layer. This combination of CIR and expanded asphalt technologies is termed Cold In-place Recycled Expanded Asphalt Mix (CIREAM) *(1)*.

3.0 BACKGROUND

To date, MTO has completed 45 CIR and 4 CIREAM contracts that equate to over 5,730,000 m^2 or approximately 770 lane-km of pavement recycling.

In an attempt to quantify the environmental, social and economic benefits of recycling, this paper compares the aggregate consumption, greenhouse gas emissions, per-lane kilometer cost, long term performance, mobility and safety of CIR/CIREAM to a conventional pavement rehabilitation technique.

The placement of CIR and CIREAM consists of milling the existing pavement surface to a depth of 100 mm, processing the material through an in-situ screening/crushing machine and either infusing the reclaimed asphalt pavement with asphalt emulsion (CIR) or expanded asphalt cement (CIREAM). The material is placed to the desired profile with a hot mix paver, compacted to the desired density, and overlaid with a single lift of HMA.

The traditional rehabilitation technique that is being compared to CIR/CIREAM consists of milling the existing asphalt surface to a depth of 100 mm, paving 130 mm of HMA in three lifts and compacting to the desired density.

4.0 SUSTAINABLE PAVEMENTS

The Kyoto Protocol was adopted by Canada in late 1997 to address the problem of global warming by reducing the world's greenhouse gas emissions (GHG). As part of this, Canada committed to reducing its greenhouse gas (GHG) emissions by six percent below 1990 levels by the time its first commitment period ends in 2012 *(2)*. In-situ pavement recycling technologies such as CIR and CIREAM are well positioned to assist in achieving these goals.

These recycled pavements are sometimes referred to as sustainable pavements. A sustainable pavement can be defined as a safe, efficient, economic, environmentally friendly pavement meeting the needs of present-day users without compromising those of future generations. The main criteria established for a sustainable pavement are:

- 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

CIR and CIREAM address all of these criteria. These technologies support a "zero waste" approach to pavement rehabilitation where the existing road material is reprocessed and reused in place, without offsite transportation. Essentially, no resources are wasted and the need for additional pavement materials is minimized.

5.0 ENVIRONMENT BENEFITS

5.1 Aggregate Conservation

Aggregate is a non-renewable natural resource. Aggregate extraction, production and transportation generates GHG, consumes energy and have a negative environmental impact. To calculate the aggregate resource consumption of CIR/CIREAM compared to a traditional rehabilitation technique, the Ministry compared the new aggregate quantities required by CIR/CIREAM, to the new aggregate quantities required to mill 100 mm and place 130 mm HMA. The analysis was based on 1 km sections with a pavement cross section of 7.5 m width and existing 150 mm HMA depth.

New aggregate quantities for CIR/CIREAM were based on a 50 mm HMA overlay, versus 130 mm overlay for the traditional treatment. For a 1 km section, CIR/CIREAM consumed 920 tonnes of aggregate compared to 2,400 tonnes for mill and three-lift overlay, a 62% savings in aggregate consumption. When the quantity is multiplied by the 5,730,000 m^2 of CIR and CIREAM completed since 1989, aggregate savings are in the order of 1,212,000 tonnes.

5.2 Greenhouse Gas (GHG) Emissions

To analyze the GHG emissions of CIR / CIREAM compared to a traditional rehabilitation technique (mill 100 mm and 130 mm HMA) a computer model (PaLATE) created by Dr. Arpad Horvath of the University of California Berkley was used (*3)*. One of the functions of the PaLATE (Pavement Life-Cycle Assessment

Tool for Environmental and Economics) model is to calculate the energy required to perform specific rehabilitation techniques and the associated GHG emissions that result from the process.

The PaLATE model was used to compare the GHG emissions from CIR, CIREAM and a traditional rehabilitation technique. The analysis is based on 1 km sections with a pavement cross section of 7.5 m width and existing 150 mm HMA depth.

Results indicate that CIR and CIREAM emit significantly less GHG compared to traditional rehabilitation techniques. When the quantity is multiplied by the amount of CIR and CIREAM completed since 1990, MTO has reduced emissions of carbon dioxide by 88,400 tonnes (52%), nitric oxide/ nitrogen dioxide by 720 tonnes (54%) and sulphur dioxide by 15,400 tonnes (61%) when compared to a traditional rehabilitation technique, figure 1 and figure 2. By promoting and using CIR/CIREAM, MTO is striving towards its own environmental goals and assisting Canada to attain its Kyoto Protocol commitments.

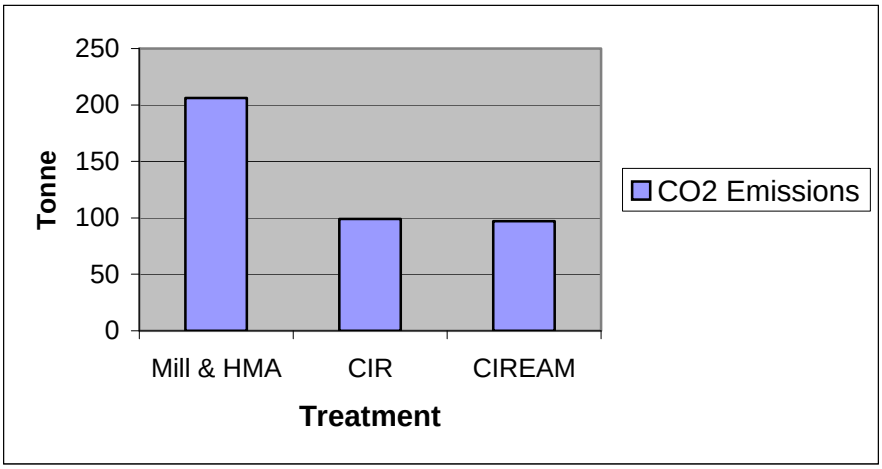

FIGURE 1 Carbon Dioxide emissions according to rehabilitation strategy.

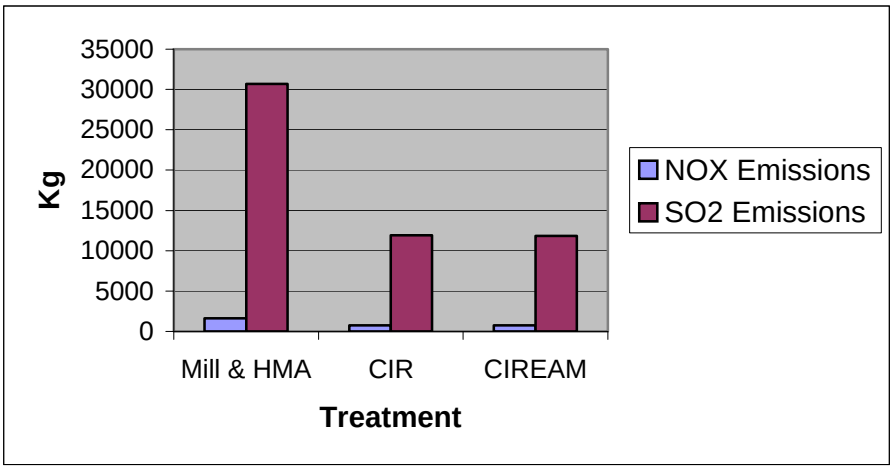

FIGURE 2 Nitrous Oxide and sulphur dioxide emissions according to rehabilitation strategy.

6.0 ECONOMIC BENEFITS

6.1 Cost Effectiveness

When analyzing the cost effectiveness of CIR and CIREAM compared to a traditional rehabilitation technique, identical 1 km sections were evaluated. Results are presented in table 1.

TABLE 1. COST COMPARISON

	CIR / CIREAM	Mill & Overlay
Depth – Milling	-	100 mm
Depth – CIR	100 mm	-
Width	7.5 m	7.5 m
Surface Course	50 mm	40 mm
Binder Course	-	90 mm
Price	$100,000 / km	$173,000 / km

In addition to environmental benefits results, CIR/CIREAM cost 42% less than a traditional rehabilitation technique.

7.0 PERFORMANCE

The performance of CIR/CIREAM contracts are continually monitored and compared to traditional rehabilitation methods using internationally recognized performance measures such as the Pavement Condition Index (PCI) and International Roughness Index (IRI).

Data is collected, stored and analyzed in the ministry's Pavement Management System (PMS2). This system includes prediction models for various reconstruction and rehabilitation strategies. Figure 3 illustrates the performance trends of CIR/CIREAM compared to a traditional rehabilitation technique (mill and overlay).

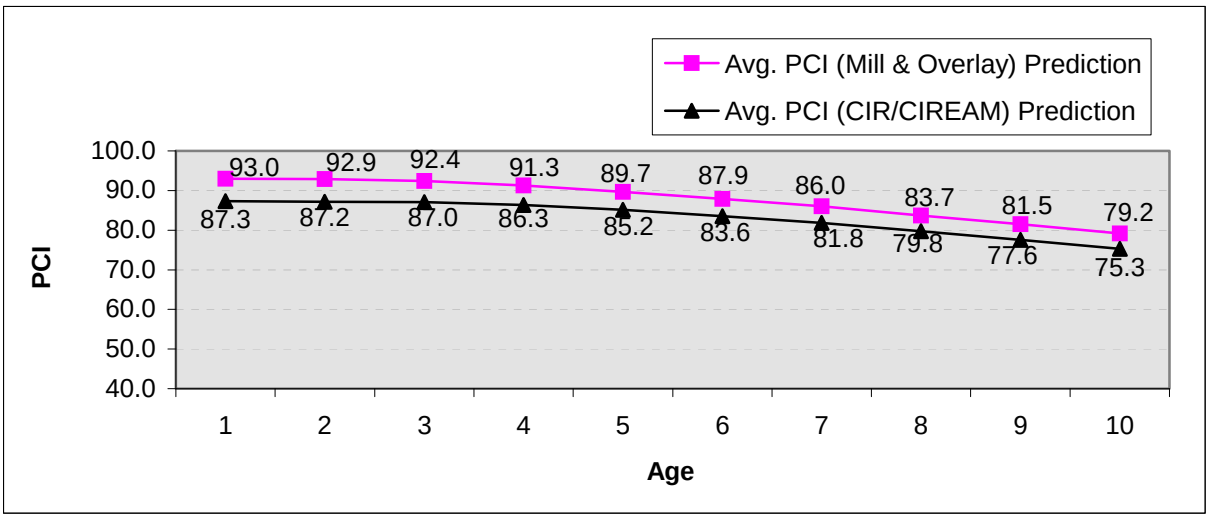

FIGURE 3 Pavement Condition Index (PCI) comparison

The Performance of the two rehabilitation techniques is similar, however the traditional mill and overlay technique is marginally smoother to start, resulting in a marginally better performance. However, the life cycle cost analysis (LCC) over a 30 year period shows that the CIR/CIREAM is the more cost effective solution in terms of life cycle costs, which include initial construction, maintenance and future rehabilitation treatments.

8.0 SOCIAL BENEFITS

8.1 Quality of Life

Since 1990, the MTO has actively promoted in-situ recycling technologies such as CIR, and more recently CIREAM as viable rehabilitation options that fulfil the requirements of a sustainable pavement and are consistent with the social desire to use technology that reduces, recycles and reuses. Technology transfer at technical forums and symposiums has occurred both on a National and International level through technical papers and presentations.

Other social benefits of in-situ recycling are:

- High production rates improve safety by reducing traffic disruptions and user inconvenience.
- While the process is underway, there are no exposed edges for motorists to avoid.
- Paving can continue through periods of uncertain weather. The process can be temporarily stopped while raining and quickly started once the rain has passed.
- Less noise and disruption from aggregate and hot mix production.

9.0 CONCLUSIONS

The Ontario Ministry of Transportation Environmental Bill of Rights has a mission statement to support its mandate of being a provincial leader in cost effective transportation, supporting the province's broader economic, social, and environmental objectives:

> *"We will facilitate the mobility of people and goods, and promote the development of industries that provide transportation systems, services, and products, in ways that reflect the needs of Ontario's diverse population and support the broader economic, social and environmental objectives of the province."*

One of the main environmental commitments of the MTO is to protect air, water and land resources for future generations and the long-term survival of plants, animals and aquatic life *(4).* As part of putting this environmental commitment into action, MTO is reducing construction-related emissions (GHG) by promoting, monitoring and encouraging innovative pavement recycling techniques such as CIR and CIREAM.

This commitment to recycling is helping address Canada's Kyoto Protocol commitments and refining highway rehabilitation to achieve a zero waste, environmentally conscious, rehabilitation contract. To date, CIR and CIREAM are the most cost effective, socially conscious and environmental friendly pavement rehabilitation options in terms of:

- Lowering greenhouse gas emissions.
- Re-using existing non-renewable resources.
- Minimizing use of new material.
- Reducing costs.
- Minimizing disruption to motorists and residences.
- Reducing transportation of construction materials.

The Ontario Ministry of Transportation has contributed and continues to contribute to the protection and enhancement of the environment though implementation and promotion of innovative, sustainable pavement recycling techniques such as Cold In-place Recycling (CIR) and Cold In-place Recycling with Expanded Asphalt Mix (CIREAM).

8.0 REFERENCES

1. Lane, B., and T.J. Kazmierowski. Implementation of Cold in-place Recycling with Expanded Asphalt Technology in Canada. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1905*, TRB, National Research Council, Washington, D.C., 2005.

2. Environment Canada. *Canada's Fourth National Report on Climate Change: Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change.* Government of Canada, 2006.

3. Hovrath, A. *A Life-Cycle Analysis Model and Decision-Support Tool for Selecting Recycled Versus Virgin Materials for Highway Applications*. Final report for RMRC Research Project No. 23. University of California at Berkeley, 2004.

4. Ministry of Transportation Ontario. *Environmental Bill of Rights, Statement of Environmental Value.* Government of Ontario, 1994.