Stress Absorbing Membrane Interlayer (SAMI) using the FiberMat™ process

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FiberMat™ is a process that sandwiches strands of chopped fiberglass between two layers of polymer modified asphalt emulsion, and is applied using specialized equipment. The first layer of emulsion provides a bond to the existing hard surface, with random interweaving of the fiberglass strands providing tensile strength to the mix, the second application of asphalt emulsion encapsulates the fiberglass, ensures the existing pavement is sealed, and is quickly covered with a thin veil of aggregate. The aggregate is seated into this second layer of emulsion using traditional rolling techniques and the SAMI is capable of accepting traffic in approximately 20 minutes.

This reinforced layer can be used as a temporary wearing surface, on high volume roads, and is usually covered with a thin layer of hot mix asphalt within 14 days. Once capped with hot mix, it becomes a true SAMI. Its function is to seal the existing pavement with a resilient waterproof membrane, reduce reflective cracking through the new wearing surface, and ultimately prolong the useful service life of the road.

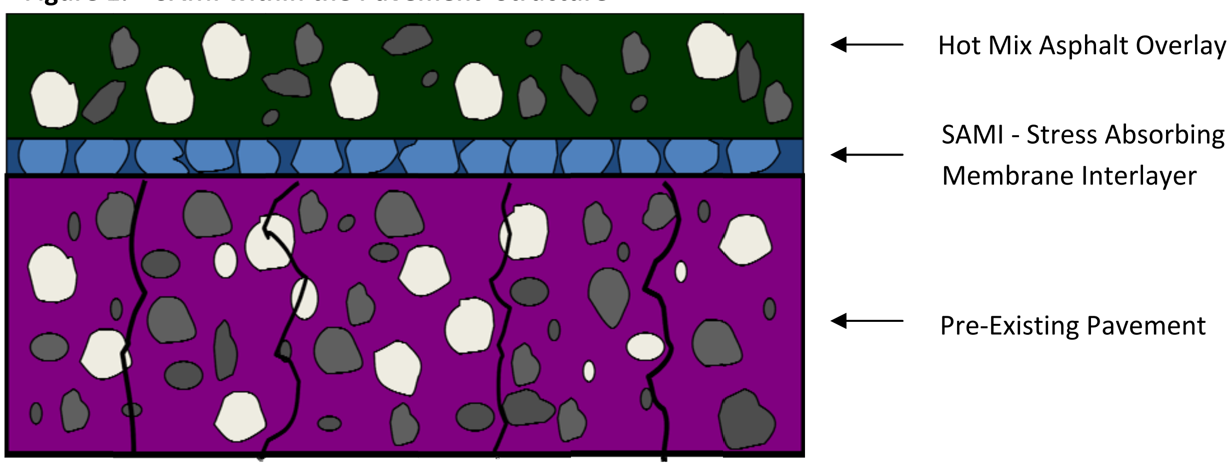
This paper will focus on a specific project in 2009 on MTO Highway 62 north of Ivanhoe, detailing the use of FiberMat™ as a SAMI, given the original construction, traffic volumes and existing pavement conditions. A special provision to ensure a quality mix design, quality materials and quality workmanship of the FiberMat™ layer; was developed by the MTO as part of this project and has subsequently been used in other areas of the province.

Stress Absorbing Membrane Interlayer (SAMI)

Asphalt interlayer systems consist of a wide variety of products and processes, each with unique benefits and specific placement methods to ensure good adhesion to the underlying pavement. The products may be classified in a number of categories such as; sand asphalts, grids, nonwovens, steel reinforcements and SAMIs.

In general, a SAMI is placed on top of an existing pavement and subsequently capped with a hot mix asphalt overlay (Figure 1). Its purpose is to delay the propagation of cracking that originates in the pre-existing pavement that will eventually reflect through to the new surface layers. Cracking in the surface layers allows penetration of water, salt and other deleterious materials that can accelerate the deterioration of the entire pavement structure once it penetrates the aggregate base.

Figure 1. SAMI within the Pavement Structure



"A saturated asphalt concrete is typically unaffected structurally by water unless the asphalt aggregate is stripping prone. In contrast, a saturated base aggregate loses about 40% of its strength when saturated." (Source: Pavement Preservation Task Group of Caltrans)

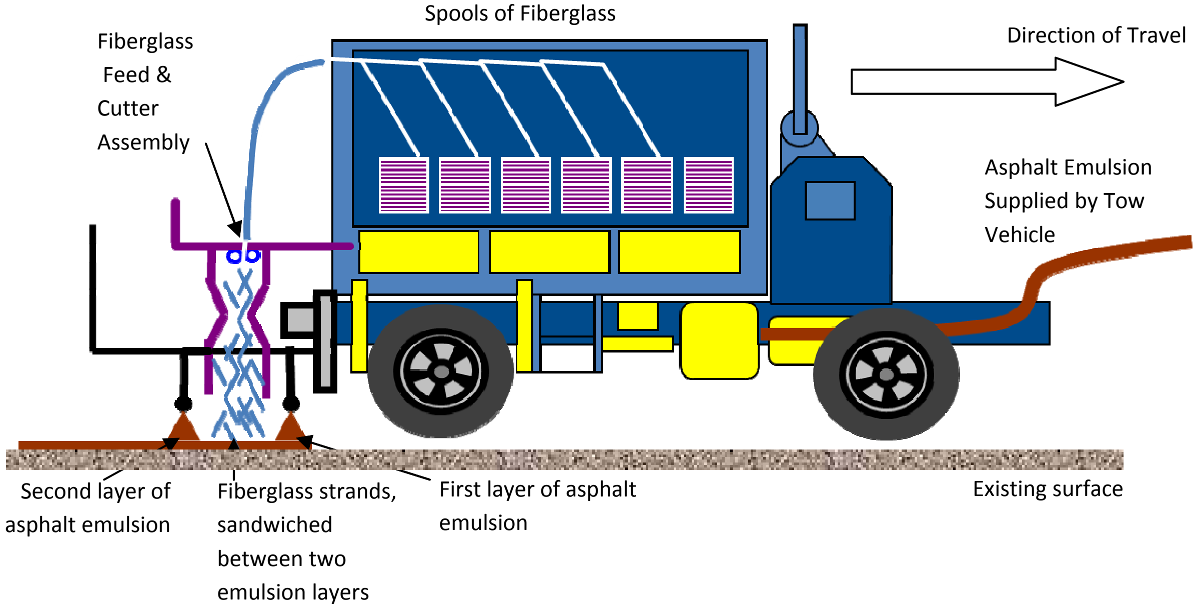
In effect each crack will allow a certain amount of water to enter the road base hence negatively impacting the original engineered design. An effective SAMI should therefore; provide additional tensile strength to the pavement to combat reflective cracking, be flexible enough to allow it to move within the pavement structure as well as providing a waterproof barrier for the ingress water from the surface to the pre-existing pavement.

Constructing a SAMI using the FiberMat™ process

FiberMat™ is a flexible, waterproof membrane that incorporates asphalt emulsion and fiberglass strands to combat reflective cracking, meeting all three requirements of an effective SAMI. Patented equipment, developed specifically for the FiberMat™ process, ensures even distribution of the materials and precise computer controls to allow adjustments in application rates while the machine is in motion.

This equipment is contained within a trailer that houses several spools of fiberglass, the patented cutter assembly system, an asphalt emulsion pump and distribution spray nozzles, plus the computer system that controls the application rate of each component (Figure 2). The unit is pulled by an asphalt emulsion tanker, connecting the output lines of the tanker to the FiberMat™ machine's emulsion pumping system.

Figure 2. The FiberMat™ Application System



The fiberglass strands are pneumatically blown between two separate layers of asphalt emulsion (Figure 3.) ensuring complete and even coverage of both fiberglass and asphalt emulsion (Figure 4).

Figure 3. FiberMat™ Application System

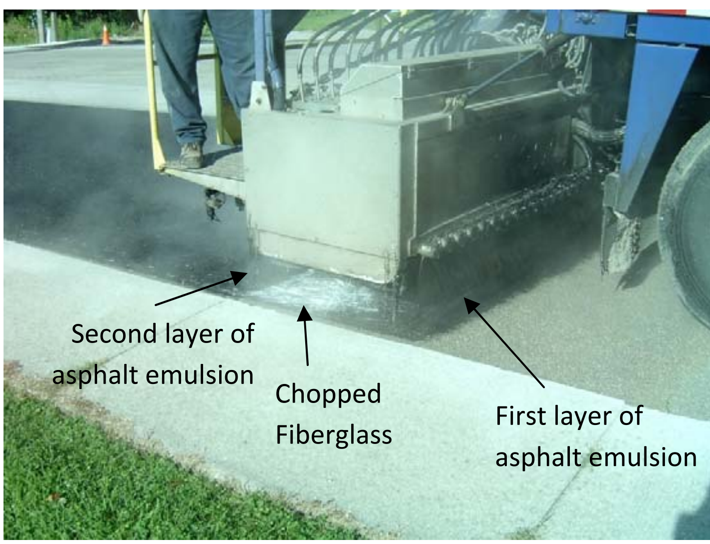


Figure 4. Even distribution of materials

The even distribution of emulsion and fiberglass is achievable in a swath up to 4m wide (easily covering an entire lane width). Computer synchronized nozzles and cutters allow the operator to vary the application width to accommodate changes in pavement width, tapered sections and turning lanes. It is possible to place FiberMat™ as narrow as 1m to a maximum of 4m (150mm increments).

Separate spools of fiberglass are individually fed from the trailer to the cutter assembly on the application deck through series of tubes (Figure 5), at the back of the machine.

Figure 5. Application deck, showing separate lines of fiberglass capable of up to 4m width in single pass

To complete the process, it is necessary to imbed a layer of aggregate into the second layer of asphalt emulsion. Aggregate is placed with a traditional chip spreader and seated using pneumatic rollers. The purpose of the aggregate layer is to protect the newly constructed membrane from vehicular traffic and construction equipment. The completed FiberMat™ (SAMI) is capable of accepting traffic within 20 minutes, and should be overlaid with hot mix asphalt prior to the onset of freezing temperatures. The unfinished road, FiberMat™ and aggregate are shown below (Figure 6).

Figure 6. Stages of FiberMat™ application

Pre-Application   Emulsion and Fiberglass   Aggregate application

The entire "train" of equipment consists of the emulsion tanker, FiberMat™ trailer, chip spreader, aggregate trucks and rubber tire rollers (Figure 7).

Figure 7. Tanker, FiberMat™ machine, chip spreader and aggregate delivery truck

Bringing New Technology to Market

Introducing new technologies such as FiberMat™ to the established road building industry has its share of challenges for both contractors and agencies.

Contractors are expected to take on significant risk when developing new technologies. The cost of research and development, purchasing new equipment, training personnel and marketing a yet unproven product, are all investments that may not bring any return. Agencies tend to be more risk averse, developing strict contract specifications that must be adhered to, while trying to ensure the most cost effective solutions are utilized.

Perhaps the biggest detriment to the introduction of new technologies in the public domain, are purchasing policies that require pricing from more than one bidder. If a technology is truly new, then there should only be one offering.

FiberMat™ was developed by Colas S.A. in Europe and provides licensing of the technology to contractors throughout the world. Selected licensees typically have a working knowledge of asphalt emulsions, are reputable contractors and are active in promoting other pavement preservation methods.

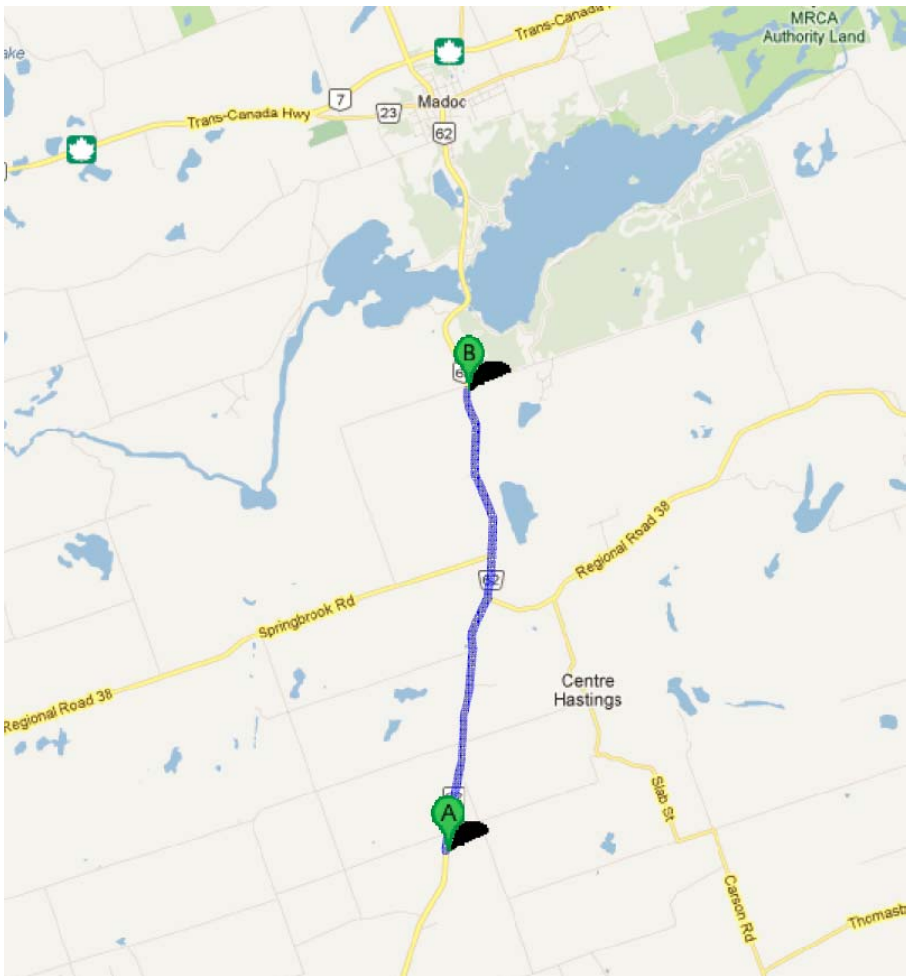
As a licensed contractor, Norjohn has been provided with training, technical support and formulations specific to the FiberMat™ process. As stated earlier, this exclusivity creates challenges when bringing something unique to the market.

The collaborative efforts of the Ministry of Transportation of Ontario and Norjohn Contracting and Paving Limited have overcome these barriers together, successfully introducing FiberMat™ as a SAMI to provincial highways, the first of which for the MTO was Highway 62.

MTO Contract 2009-4021 Rehabilitation/Resurfacing

The limits of the Highway 62 project were from Ivanhoe northerly 7.6 km to 1 km south of Quinn-Mo-Lac Road and from South limit of Madoc southerly for 1.7 km (9.35 c.l. kms), the limits of which are shown in Figure 8.

Figure 8. Limits of the contract 2009-4021



The characteristics of the existing pavement structure were summarized in the contract documents encouraging contractors to review the site, to determine if the technologies proposed for a SAMI were appropriate.

Existing Pavement Structure

- Originally constructed in the late 50's to early 60's, and last resurfaced in the early 80's.
- AADT of 6500 with 6.3% commercial traffic.
- The maximum grade is 5.9%
- The existing pavement is 140mm in depth (average). The surface consists of a 40mm lift of HL-4 over an HL2 levelling course (+/- 25mm) completed under Contract 80-011.
- Prior to treatment the 30 year old section currently exhibits the following distresses:
  - Extensive ravelling and coarse aggregate loss
  - Several moderate distortions
  - Extensive alligatored longitudinal wheel track cracking
  - Frequent moderate centerline, edge of pavement and midlane cracks, with alligatoring
  - Extensive severe transverse cracking
- Some newer machine patches had been placed, predominantly south of Quinn-Mo-Lac Road

Pavement Evaluation - Ride Comfort Index

In addition to the notes regarding pavement structure, the MTO employs two components in their pavement evaluation system to measure how comfortable the ride is. When measuring ride comfort an Automatic Road Analyzer (ARAN) equipped van with 37 sonar sensors, takes ultra-sound readings every 10 metres (Figure 9). The unit is also equipped with 2 South Dakota Laser Profilometres to measure IRI in the wheel paths. This information is collected annually to verify official ride information gathered by consultants.

The Ride Comfort Index for this section of highway prior to rehabilitation was measured as 4.7 on a 10 point scale (very poor).

Figure 9. MTO Automatic Road Analyzer (ARAN)

Pavement Condition Index

The MTO SP-024 Manual for condition rating of flexible pavements, was also used to evaluate the pavement prior to rehabilitation. This technique requires the completion of a comprehensive form that considers; Ride Condition Rating at 80km/hr, surface defects and deformations, shoulder distresses, maintenance treatments, and of course cracking (see Appendix A).

The density and severity of these distresses are tabulated to provide a score from 0-100. Scores above 90 indicate the pavement is in excellent condition, those around 60 are deemed to be in fair condition.

The pre-existing Pavement Condition Index for this section of Highway 62 measured 36 and was considered in very poor condition (Figure 9).

Figure 9. Photograph of typical pre-existing conditions

Pavement Strategy

When determining the pavement rehabilitation strategy for Highway 62, two separate phases were adopted.

- Phase 1 – SAMI with single lift resurfacing
- Phase 2 – deferred surface course (5 to 6 years)

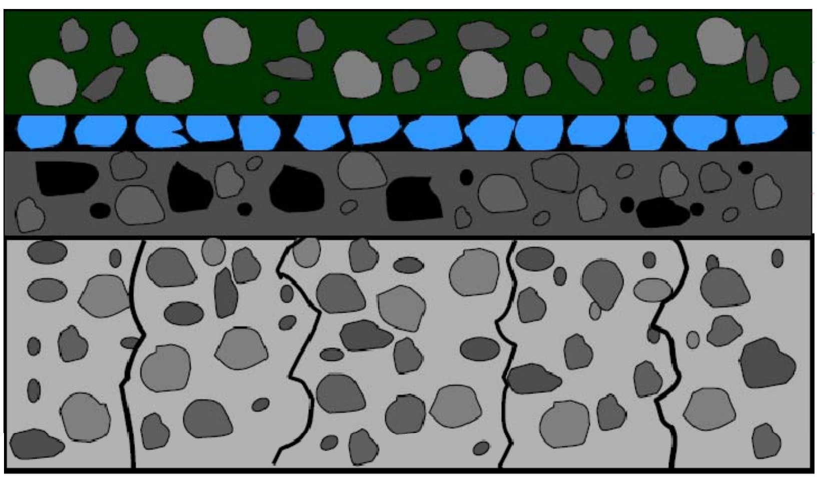
The purpose of the SAMI was to:

- Seal the original pavement surface, providing resilient waterproof membrane
- Reduce reflective cracking
- Provide a cost effective balance between initial cost vs. service life
- Rejuvenate the existing oxidized HMA surface
- Accommodate future rehab strategies (FiberMat™ can be recycled)

- Reduce greenhouse gas emissions, energy and material requirements associated with deferred surface course applications
- Evaluate potential treatment for pavements exhibiting premature cracking due to suspected low temperature PGAC performance issues
- Indicate suitability for for use in other Regions
- Determine if this is a cost effective rehabilitation strategy

Deterioration of the pavement was not consistent throughout the entire 9.35km section, allowing even further variations on the use of the SAMI. A small urban section through the village of Ivanhoe required milling (in order to maintain elevations at curb and gutter). The SAMI was placed on milled surface with the hot mix overlay to follow. The majority of the project utilized SAMI directly on the existing pavement, capped with hot mix asphalt, as seen described earlier (Figure 1). A third variation consisted of asphalt padding/levelling, then SAMI, and the final hot mix overlay (Figure 10). The padding was required to correct cross fall, potholes and severe deterioration in select areas.

Figure 10. SAMI in a three layer system



A 100m Control Section that received no SAMI, but was capped with the hot mix overlay will be used as a benchmark to determine the efficacy of the SAMI

FiberMat™ SAMI Design

Based on the recommended formulations provided by COLAS SA and Norjohn Contracting and Paving Limited, a detailed special provision for this particular project included the following:

- Contractor to complete a detailed mix design
- Certificate of Conformance for all materials (asphalt emulsion, aggregate and fibreglass)
- Calibration of equipment
- Certificate of Conformance (verified by an Engineer) upon completion

Additional measures were required to ensure the integrity of the SAMI and protect the travelling public:

- Traffic to travel on final compacted (swept) SAMI surface
- SAMI exposed to traffic for two consecutive weekends
- Reduced speed zone until hot mix overlay was complete
- Contractor responsible for damage to vehicles caused by loose aggregate

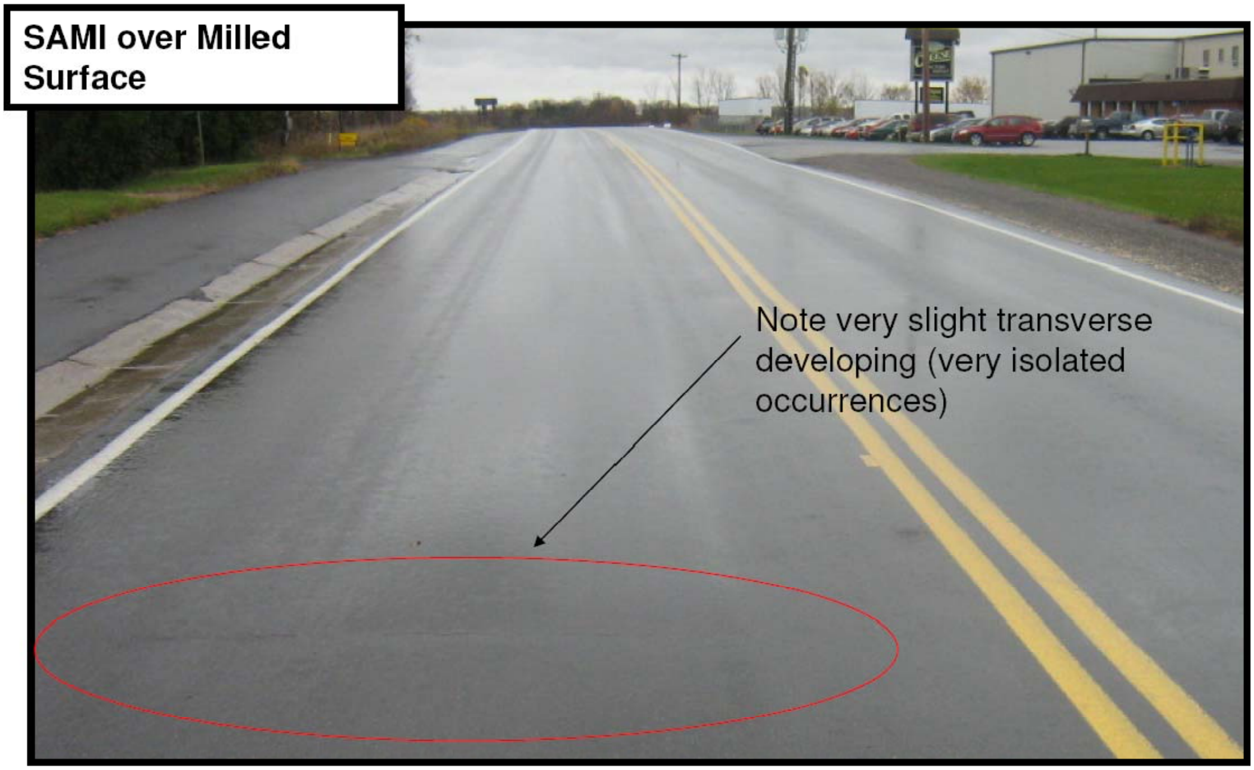
Condition Review – October 2010

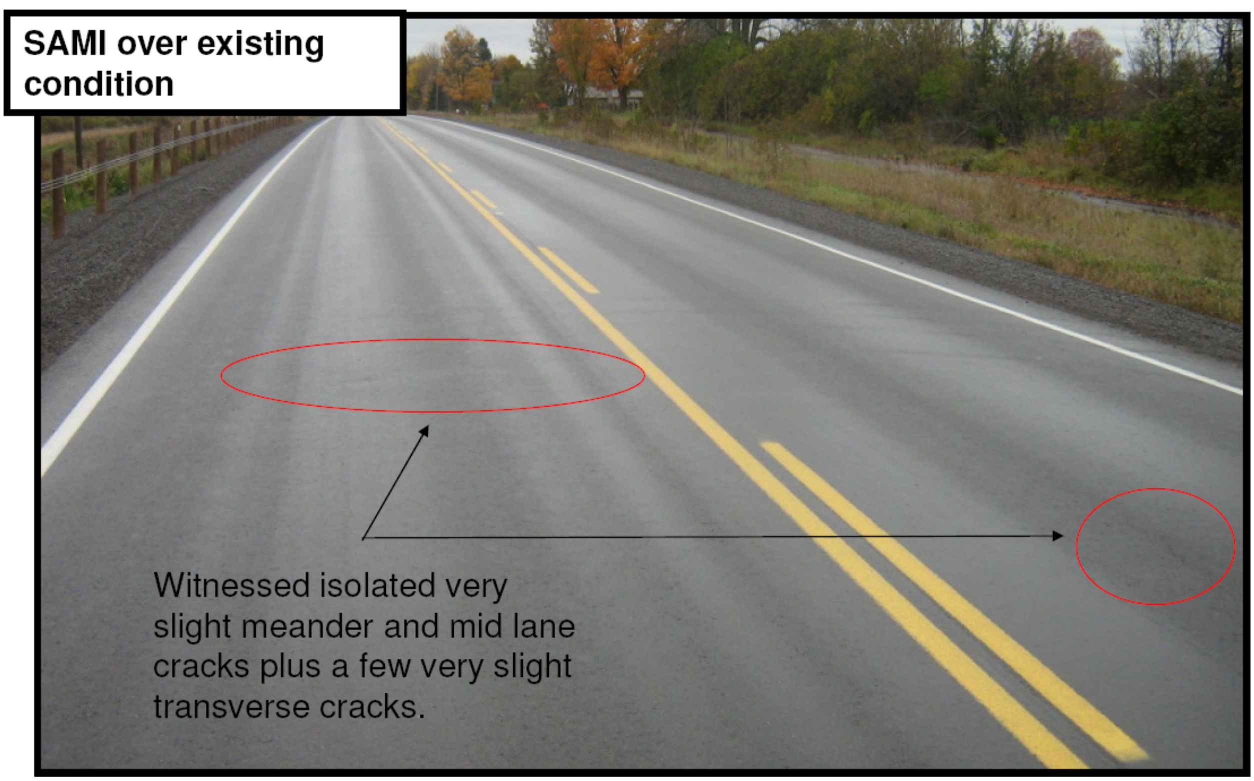
Intermittent monitoring of the site has occurred since the completion of the project in September 2009 with a formal condition review completed one year later. Additional studies, specific to reflective cracking will continue during the life of the pavement to ensure the product is performing as expected.

To date:

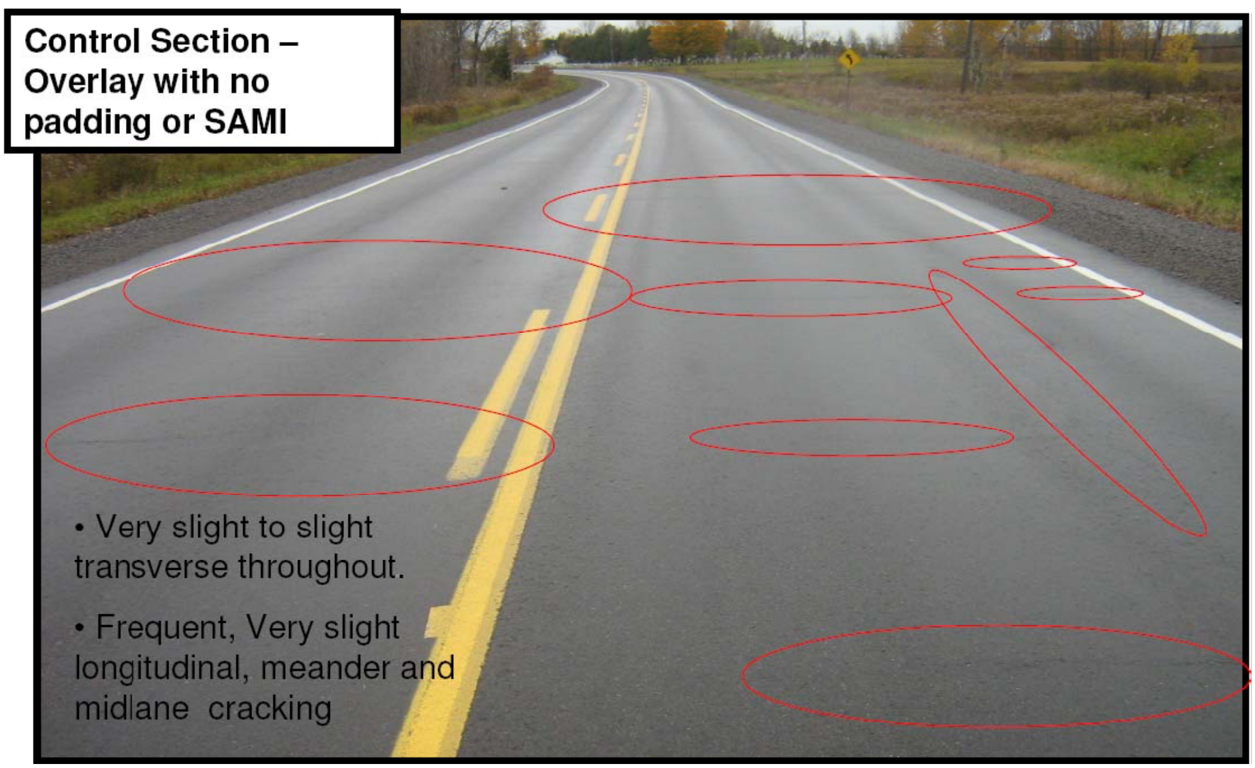
- The SAMI treatment is performing as expected
- Extensive cracking is evident in the control section that did not receive the SAMI
- Ride Comfort Index has improved significantly compared to the original condition
- Pre-padding, SAMI and hot mix overlay areas (Figure 10) are performing the best
- Considering the staged approach, the FiberMat™ SAMI is cost effective

Photographs from Condition Review October 2010


SAMI over Milled Surface
Note very slight transverse developing (very isolated occurrences)


SAMI over existing condition
Witnessed isolated very slight meander and mid lane cracks plus a few very slight transverse cracks.


SAMI over leveling
course (pre-pad)
No Discernable distresses


Control Section –
Overlay with no
padding or SAMI
• Very slight to slight
transverse throughout.
• Frequent, Very slight
longitudinal, meander and
midlane cracking

SAMI School

This particular project generated considerable interest within the MTO Eastern Region's Geotechnical and Construction offices. During the project, a seminar was held, to help explain the benefits of using FiberMat™ as a SAMI and naturally there is continued interest to see if the process is performing as expected.

Ongoing monitoring continues (compared to the control section), and Eastern Region has since called 2 more projects with FiberMat™ as a SAMI. Internal reports on the design process have been shared with other regions and in 2011, Northern Region completed a similar project on Highway 17.

The Future …….

- Eastern Region has 15 pavement sections or 195 centre lane kms with a PCI less than 55 representing a now need
- If 5 sections @ 13 km ea x $100 k savings per c.l. km = $6.5 million can be deferred = equals the ability to deliver another construction project
- Norjohn Contracting and Paving Limited is currently working with an independent engineering firm to better determine the life cycle benefits of using FiberMat™.

APPENDIX A

Ministry of Transportation
Ontario

FLEXIBLE PAVEMENT CONDITION EVALUATION FORM

Location From: ______________________ **To:** ______________________

LHRS [ ] BEGINS [.] OFFSET km **Section Length** [.] LENGTH km **District** [ ]

Survey Date [ ] YEAR [ ] MONTH **PCR** [ ] **RCR** [.] **Traffic Direction** [ ] B : BOTH DIRECTIONS, N : NORTH BOUND, S : SOUTH BOUND, E : EAST BOUND, W : WEST BOUND **Highway** [ ]

Contract No. [ ] – [ ] **WP No.** [ ] – [ ] – [ ] **Facility** [ ] A : ALL LANES, C : COLLECTOR, E : EXPRESS, O : OTHERS (Additional Lanes) **Class** [ ] F : FREEWAY, A : ARTERIAL, C : COLLECTOR, L : LOCAL, S : SECONDARY

Ride Condition Rating (at 80 km/h)
- 10
- 8 EXCELLENT Smooth and pleasant
- 6 GOOD Comfortable
- 4 FAIR Uncomfortable
- 2 POOR Very rough and bumpy
- 0 VERY POOR Dangerous at 80 km/h

Pavement			Severity of Distress: Very Slight 1	Slight 2	Moderate 3	Severe 4	Very Severe 5	Density of Distress (Extent of Occurrence, %): Few <10 1	Intermittent 10-20 2	Frequent 20-50 3	Extensive 50-80 4	Throughout 80-100 5
SURFACE DEFECTS	Ravelling & C. Agg. Loss	1										
	Flushing	2										
SURFACE DEFORMATIONS	Rippling and Shoving	3										
	Wheel Track Rutting	4										
	Distortion	5										
CRACKING – Longitudinal Wheel Track	Single and Multiple	6										
	Alligator	7										
CRACKING – Centre Line	Single and Multiple	8										
	Alligator	9										
CRACKING – Pavement Edge	Single and Multiple	10										
	Alligator	11										
CRACKING – Transverse	Half, Full and Multiple	12										
	Alligator	13										
CRACKING	Longitudinal Meander and Midlane	14										
	Random	15										

Shoulders – Dominant Type	One ✓	Distress	Severity of Distress Right Mod 1	Right Severe 2	Left Mod 1	Left Severe 2	Density of Distress (Extent of Occurrence, %) Right 10-30 1	Right >30 2	Left 10-30 1	Left >30 2
PAVED FULL		Cracking								
		Pavement Edge/ Curb Separation								
PAVED PARTIAL		Distortion								
SURFACE TREATED		Breakup/Separation								
		Edge Break								
PRIMED		Breakup								
GRAVEL										

Maintenance Treatment		Extent of Occurrence, % <10 1	10-20 2	20-50 3	50-80 4	>80 5
PAVEMENT	Manual Patching					
	Machine Patching					
	Spray Patching					
	Rout and Seal Cracks					
	Chip Seal					
SHOULDERS	Manual Patching					
	Machine Patching					
	Rout and Seal Cracks					
	Chip Seal					

Distress Comments (items not covered above) ______________________

Other Comments (e.g. subsections, additional contracts) ______________________

Evaluated by ______________________

PH-0-534 86-01

Figure A-1 Pavement Condition Rating Form

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