Warm Asphalt Mix Technology – The Canadian Perspective

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Abstract

Warm mix technology has become the latest buzz word in the area of asphalt technology. Worker health and safety, as well as environmental concerns have caused many people to look for different ways of producing asphalt concrete that maintains the physical properties and performance characteristics of traditional hot mix, but are more worker and environmentally friendly.

This paper discusses the various warm mix processes being evaluated in Canada as well as a more detailed review of projects carried out by McAsphalt Industries to study the effects of warm mix technology using the Evotherm® technology. The projects involved the placement of various asphalt mixes on prepared granular base as well as existing asphalt pavement. Recycled asphalt pavement (RAP) was utilized in two of the projects. Environmental testing has been performed on both the hot and warm mixes to monitor the greenhouse gases during production.

Based on the results achieved the warm mix technology provides lower emissions (greenhouse gases) than hot mix without compromising the performance properties of the mix; can be produced at hot mix plants with very little changes needed if any. Also, it has shown that less oxidation is occurring in the warm mix, which certainly will translate into longer service life.

1.0 BACKGROUND

The use of warm mix technology has many benefits to the environment. Lower mixing and compaction temperatures can provide numerous construction and performance-related benefits including reduced aging of the binder, reduced fumes and odours at the paving machine, as well as increased percentages of Reclaimed Asphalt Pavement (RAP) within the mixes.

The Kyoto Accord protocols, as well as stricter environmental regulations coming into effect, Indicate that the pressure is mounting to reduce greenhouse gases throughout the country. The increased environmental pressure to reduce greenhouse gases has started to put pressure on industries to become more proactive in reducing emissions. Warm mix technology is one way of reducing greenhouse gases without adversely affecting the long term quality of the road mixes. Lower mixing temperatures can benefit both the contractor and the environment. As energy costs increase, reduction in mixing temperatures can greatly reduce energy consumption and lower emissions at both the hot mix plant and at the paving operation. With decreased mixing temperatures there is a reduction in the oxidation of the asphalt cement during the manufacturing process, which can translate into longer service life without compromising the quality of the paving mix.

In order to evaluate the warm mix process, field trials are required to compare the physical properties and performance of the warm mix to conventional hot mix.

2.0 INTRODUCTION TO WARM MIX TECHNOLOGY

As originally discussed by Davidson, Tighe and Croteau[1], several new processes have been developed to reduce the mixing and compaction temperatures of hot mix asphalt. These processes are known as warm mix asphalt. The lower temperatures should result in lower plant emissions and lower fuel consumption. Currently there are four of the five main processes being evaluated in Canada:

- Aspha-min® zeolite developed by Eurovia
- Sasobit® developed by Sasol International
- WAM Foam by Shell and Kolo Veidekke
- Low Energy Asphalt by Fairco and Appia
- Evotherm® developed by MeadWestvaco

The Aspha-min® is produced in granular form [2]. The product contains approximately 20 percent water by weight. When the Aspha-min® is added to the mix the water is released under high temperatures. The high temperatures (100 to 200ºC) cause the asphalt cement to foam slowly while mixing with the HMA aggregate. The foamed asphalt has greater workability and allows for improved compaction and coating of the aggregate particles at a lower temperature. Typically, the mixing and compaction temperatures can be lowered 30ºC.

Sasobit® is a Fischer-Tropsch wax [3]. This wax is produced from coal gasification using the Fischer-Tropsch process. The Sasobit® lowers the viscosity of the asphalt cement at the mixing and compaction temperatures but still maintains the original viscosity at the in-service pavement temperatures. The Sasobit® can be combined with polymers to give the added benefit without creating issues with the warm mix temperatures. Typically the mixing and compaction temperatures can be lowered 15º to 20 ºC.

The WAM Foam process is a two-component binder system where a soft binder is used in conjunction with a foamed hard binder during the mixing stage [4]. The soft binder is mixed with the aggregate at a lower temperature (100 to 120ºC) and then a hard asphalt based foamed asphalt cement is added and foaming occurs. The foaming action gives the mix workability at lower temperatures.

The Low Energy Asphalt (LEA) process is produced by only heating and drying the coarse aggregate fraction of the mix [5]. The second phase of the process is to add the fine aggregate portion of the mix to the hot asphalt coated coarse aggregate. The fine aggregate portion is in a cold and wet state. The LEA process utilizes the interaction of the hot asphalt with the water to create a low temperature mix (90 to 100ºC). Specifically formulated additives are added to the hot asphalt binder to allow for asphalt foaming and coating of the wet particles as well as to prevent stripping.

The Evotherm® process is based on a chemical process that includes additives to improve coating, workability, adhesion and emulsification [6]. The Evotherm® product is delivered in the form of a high residue emulsion containing between 67 and 69 percent asphalt residue. The Evotherm® process can also be incorporated using a concentrated form directly to the asphalt cement in the pugmill during the wet mix cycle.

3.0 PROCESS TRIALS

The following sections give an overview of the four processes currently being evaluated in Canada. The Low Energy Asphalt (LEA) process has not been evaluated in Canada but a number of trials have been placed in the United States in 2006 and 2007.

3.1 Aspha-Min®

The Aspha-min® process has been placed in the Province of Quebec since August of 2005. Construction DJL Inc. (a large hot mix contractor in Quebec) has been promoting the benefits of warm mix using the Aspha-Min.® process since late 2004 and early 2005.

3.1.1 2005 Season

Three trial sections were placed in 2005 using approximately 500 metric tonnes of mix. All three projects were placed on streets within the City of Montreal during August and September. Two grades of PGAC were used PG 64-28 (one project) and PG 70-28 (two projects). The projects did not use any recycled material in any of the surface mix trials. The hot mix portion was mixed at 160ºC and the Aspha-min® warm mix sections were mixed between 130-135º C. The laydown temperatures were 140 - 150°C for the hot mix and 110 - 125°C for the warm mix.

For all three trials a special batch plant which had been modified ten years ago with a rotary mixer was used. The rotary mixer converted the plant into a continuous type plant. The aggregates are heated and dried in the batch plant dryer and travel up the elevator but bypass the hot screen deck and go directly into the rotary mixer where the bitumen and Aspha-min® are injected.

Figure 1: Warm Mix Placement on Rue Ball in August 2005 and One Year Later

3.1.2 2006 Season

During 2006 three projects were completed by Construction DJL Inc [7]. The first project was a demonstration for the provincial highway department (MTQ) at the end of August using 280 tonnes of surface mix and PG 64-34. The project was located on Autoroute 55 southeast of Drummondville. The hot mix plant used for the project was a drum plant with mixing temperatures of 160°C for the control hot mix section and 130°C for the Aspha-min® warm mix. The laydown temperatures were 150°C for the hot mix and 110 - 120°C for the warm mix.

The last two projects were placed in late November with air temperatures ranging from -1 to +5°C. The first trial on Rue McGill used PG 70-28. Hot mix temperatures used a mixing temperature of 160°C and laydown of 150°C, while the warm mix was mixed at 130-135°C and placed at 110 - 120°C. The second trial was placed on Rue des Sommets using PG 58-28. The hot mix temperature for mixing was 145°C. In these two projects, the use of zeolite in the conventional hot mix (same mixing temperature) during late season paving showed the easy compaction behavior compared to the same mix without zeolite.

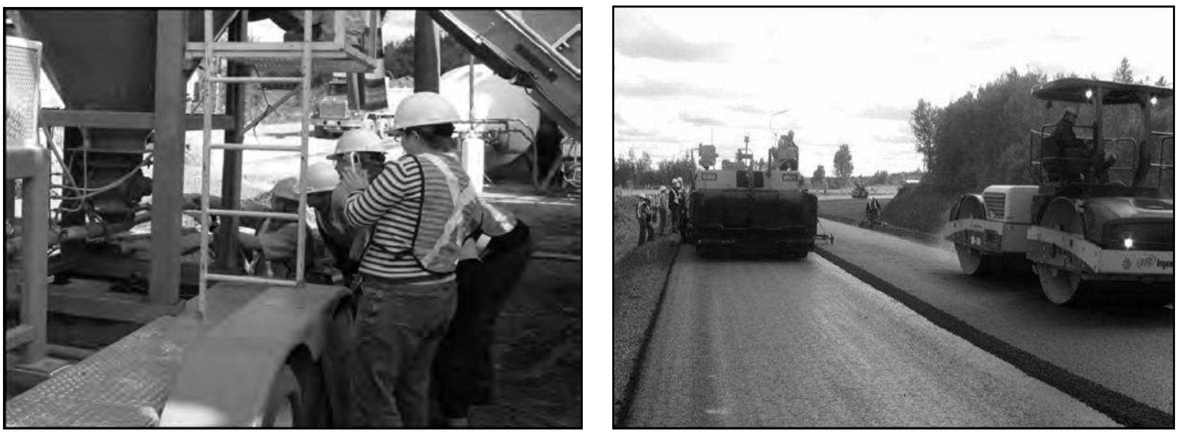

Figure 2: Injection of Zeolite and Laydown of Aspha-min® Warm Mix on Autoroute 55

In conversations with Construction DJL Inc. personnel the warm mix trials in 2005 and 2006 went very well and there were no issues with temperature in achieving the required compaction even during the late season construction.

Unfortunately in 2007 no Aspha-min® demonstrations have occurred as of the end of August.

3.2 Sasobit®

The use of Sasobit® technology is in its infancy here in Canada. Bitumar Inc. (an asphalt supplier in Quebec and Ontario) has been pursuing the process in conjunction with a consultant for Sasobit®, Larry Michaels. In conversations with one of their technical marketing representatives, Vince Aurilio there are two trial projects planned for later this year.

3.3 WAM Foam

The use of WAM-Foam has been experimented with in western province of Alberta, specifically the City of Calgary. LaFarge Canada in 2005 added a foaming kit to one of their asphalt plants in Calgary and produced some warm mix for a subdivision in northeast Calgary. Since that time there have been no further trials of WAM Foam. It is my understanding that there is the potential of a second trial later this year.

3.4 Evotherm®

The Evotherm® process has been promoted by McAsphalt Industries since the early spring of 2005. Since 2005, seven (7) trials and demonstrations have been placed using approximately 9150 tonnes of warm mix. Three more projects are scheduled this year using approximately 3000 tonnes of warm mix. These projects should be completed by the end of September 2007.

3.4.1 2005 Season

During the construction 2005 season three Evotherm® emulsion warm mix trials were completed using approximately 1700 tonnes of warm mix. For all three trials the warm mix was produced in batch plants. The mixing temperatures for the warm mixes were typically 25 to 30°C lower than the corresponding hot mix and the laydown temperatures for the warm mix varied from 85 to 95°C, which was typically 50°C below the laydown temperature for the hot mix equivalent. The bitumen grade used in all three trials was PG 58-28. For one of the projects environmental emissions testing at the hot mix plant was done for both the hot mix and warm mix. The environmental aspects of the warm mix technology will be discussed in the section 4.0 of the paper. Figure 3 shows the typical operation of the warm mix. Notice in Figure 3b how close the breakdown roller can approach the spreader without any concern to harming the pavement mat.

Figure 3a: Ramara Plant **Figure 3b: Warm Mix Placement**

Figure 3: Production and Placement of Evotherm® Warm Mix

3.4.2 2006 Season

The 2006 season was a disappointment in that only one trial was done. The single trial involved the placement of two lifts of base mix covered with a single lift of surface mix. Both the base mix and the surface mix contained 15 % recycled asphalt pavement (RAP). The base bitumen used in the trial was PG 58-28. A total of 1250 tonnes of warm mix was placed.

This particular trial showed the benefits of warm mix with regards to the large reduction in age hardening that occurs with hot mix compared to warm mix. The recovered penetration of the hot mix was 48 and the recovered penetration for the warm mix averaged 80. The PG 58-28 typically has a penetration of 115 - 120. Even though there is only 15% RAP (penetration = 16) in the mix the hot mix is well on its way to a short service life while the warm mix has a typical penetration value for a virgin hot mix. Table 1 shows the penetration data obtained on the first four trials.

Table 1: Recovered Penetration Data

Location	Mix	Original Penetration	Mix Type		% Loss	
			HMA	WMA	HMA	WMA
Aurora	HL8/HL3	118		105		11.02
Calgary	B Mix	163		138		15.34
Ramara	HL4	124	81	107	34.68	13.71
London	HL8R15	116	49	77	57.76	33.62
	HL3R15	121	45	81	62.81	33.06

Typically the warm mix arrived at the asphalt spreader between 90 - 95°C and after the initial breakdown rolling with the vibratory roller the temperature was in the middle 80’s. Figure 5 shows temperature readings illustrating this condition.

Figure 4a: Prior to Rolling **Figure 4b: After Initial Breakdown**

Figure 4: Evotherm Laydown Temperatures

3.4.3 2007 Season

The 2007 season gave an opportunity to utilize the DAT (Dispersed Asphalt Technology) system to inject the Evotherm chemical into the mix. At present two of the three demonstrations done so far this year utilized the DAT concept. The one demonstration done and the three remaining projects have or will use the emulsion process.

The DAT system is very easy to use and ties into the existing asphalt system. In a batch plant as the bitumen is released into the pugmill at the start of the wet mix cycle the concentrate is also added to the pugmill on a timer to deliver the proper quantity of concentrate to the mix. Typically it runs for 20 to 25 seconds and shuts down. Because there is water in the concentrate it creates a foaming action which allows for coating and mixing the material completely even at lower temperatures. The aggregate temperatures have been lower by 5 to 10°C than with the emulsion system and still have a discharge temperature of around 100°C.

Figure 5a: Totes of Concentrate **Figure 5b: Pump/Metering System**
Figure 5: DAT System

The data collected so far has shown as good as or better results than the emulsion system with regard to compaction and ease of handling.

Figure 6a: Production of DAT **Figure 6b: Laydown of DAT**
Figure 6: Production and Laydown of DAT System

4.0 ENVIRONMENTAL DATA

The author is currently aware of environmental data relating to greenhouse gas emissions at the hot mix plant comparing the hot mix to the warm mix and as well the fumes at the asphalt spreader for the Aspha-min® and the Evotherm® processes. In the following two sections the information collected will be discussed in some detail.

4.1 Aspha-min®

Environmental testing has been done on the Aspha-min® product in France. Emission testing has been done at the hot mix plant to measure the greenhouse gases that are being released through the stack both for the conventional hot mix and the warm mix. Comparison testing has also been done at the paving operation to measure the fumes that the workers are exposed to while working around the laydown operation. Table 2 shows how the use of warm mix has lowered the greenhouse gases being produced as well as how much cleaner the air is for the workers at the spreader. Also by using lower temperatures the quantity of fuel required to produce a tonne of mix has typically been lowered by 20 to 30%.

Table 2: Emission Data – Aspha-min®

Combustion Gas	Emission Reduction
Carbon Monoxide	-19%
Sulphur Dioxide	-18%
Carbon Dioxide	-18%
Oxides of Nitrogen	-23%
Energy Reduction	-23%
Fume Reduction @ Paver	-50%

Figure 7a: Emission Equipment at Plant

Figure 7b: Emission Testing at Paver

Figure 7: Emission Testing with Aspha-min®

4.2 Evotherm®

Similar studies have been done by McAsphalt Industries and the Heritage Research Group on the emissions generated by the warm mix in comparison to hot mix [8, 9]. In all cases the data has shown significant reductions in greenhouse gases and the fumes at the asphalt spreader [10]. The limited data on the warm mix regarding energy savings has shown values from as low as 10 percent to as high as 55 percent reduction compared to the same mix produced as hot mix. We have seen this reduction using both the emulsion form of Evotherm® as well as the DAT system of Evotherm®. Table 3 shows one set of emission data obtained from an Evotherm® emulsion trial done at Ramara in 2005.

Table 3: Emission Data - Evotherm®

Combustion Gas	Emission Reduction
Carbon Dioxide	-45%
Carbon Monoxide	-63%
Sulphur Dioxide	-81%
Oxides of Nitrogen	-58%
Energy Reduction	-55%
Fume Reduction	-41%

Figure 8a: Emission Equipment

Figure 8b: Stack Location of Probe

Figure 8: Emission Testing of Evotherm® at Ramara

5.0 PERFORMANCE TESTING

As part of the Ramara trial, samples of loose mix as well as slabs and cores were taken from both the hot mix and warm mix sections. These samples were delivered to the Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo for performance testing, including the resilient modulus and dynamic modulus tests [11,12].

The resilient modulus had some differences in the laboratory prepared and field core samples, overall the variation between the WMA and HMA were statistically the same and the two materials may be considered structurally equivalent. The testing of the warm and hot mix material for dynamic modulus showed the same results as the resilient modulus. This would further reinforce the fact that the materials are structurally the same based on the performance testing that was carried out in this study.

Further testing of resilient and dynamic modulus is being carried out by CPATT under Dr. Susan Tighe's direction on material taken from an Evotherm demonstration project, which occurred in June of 2007 in the City of Hamilton. Half of the project was paved with a Superpave 12.5 mm mix using PG 64-28 and the second half with Evotherm Emulsion 64-28. Data to-date indicates no difference between the hot and warm mixes with respect to void properties as well as some permeability testing performed along the longitudinal joints.

6.0 SUMMARY

Based on the trials of warm mix placed so far in Canada there have been no issues with mixing, laydown or compaction. The physical properties of the warm mixes have been equivalent to the hot mix in all respects. After two and one half years of service all trial sections are performing as well as the hot mix sections.

7.0 THE FUTURE

Certainly to the companies promoting the warm mix processes in Canada the feeling is that the trial and demonstration phases are over and it is time to seriously consider full scale contracts. The trials have clearly demonstrated the environmental benefits in greenhouse gas reductions, reduced energy consumption while still maintaining the physical properties needed to meet the traffic demands placed on the road network.

Warm mix technology is the way of the future and will allow our industry to be leaders in the fight against global warming.

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