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Transportation Research Division

Technical Report 12-02

Use of Warm Mix Asphalt Pavement along Rt. 27 in the towns of Farmington and New Portland

Construction and 1st Interim Report, May 2012

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Transportation Research Division

Use of Warm Mix Asphalt Pavement along Rt. 27 in the towns of Farmington and New Portland

Introduction

A number of new technologies have been developed to lower the production and placement temperatures of hot-mix asphalt (HMA). Generically, these technologies are referred to as warm-mix asphalt (WMA). In Europe and to a lesser extent in North America, WMA has been used in all types of asphalt concrete, including dense-graded, stone matrix, porous, and mastic asphalt. It has also been used in a range of layer thicknesses, and sections have been constructed on roadways with a wide variety of traffic levels.

WMA Technology

Several methods are used to classify WMA technologies. One method of classification is by the degree of temperature reduction. Warm asphalt mixes are separated from half-warm asphalt mixtures by the resulting mix temperature. There is a wide range of production temperatures within warm mix asphalt, from mixes that are 30 to 50 C° (55 to 85 F°) below HMA to temperatures slightly above 100 °C (212 °F).

Another way to classify the technologies is by how they reduce viscosity. There those that use water and then others that use some form of organic additive or wax to affect the temperature reduction. Processes that introduce small amounts of water to hot asphalt, either via a foaming nozzle (Double Barrel Green) or a hydrophilic material (Zeolite), or damp aggregate (Low Energy Asphalt), rely on the fact that the steam expands the asphalt binder providing improved mix characteristics. Chemical (Evotherm, Rediset WMX) and organic (Sasobit) additives use different mechanisms to provide improved mix characteristics such as enhanced viscosity, coating, adhesion and workability.

Benefits of Warm Mix Asphalt

Reduced emissions. Data indicate plant emissions are significantly reduced. Typical expected reductions are 30 to 40 percent for CO2 and sulfur dioxide (SO 2), 50 percent for volatile organic compounds (VO C), 10 to 30 percent for carbon monoxide (CO), 60 to 70 percent for nitrous oxides (NO x), and 20 to 25 percent for dust. Actual reductions vary based on a number of factors. Technologies that result in greater temperature reductions are expected to have greater emission reductions.

In addition to lowered plant emissions, the jobsite release of aromatic hydrocarbons is reduced for WMA. Industry tests show that releases of asphalt aerosols/fumes and polycyclic aromatic hydrocarbons (PAHs) is lower for WMA as compared to HMA. Potentially a 30 to 50 percent reduction. It should be noted, however that the worker exposure data for these compounds from conventional HMA are below the current acceptable exposure limits.

Reduced fuel usage. Burner fuel savings with WMA typically range from 11 to 35 percent. Fuel savings could be higher (possibly 50 percent of more) with processes such as low-energy asphalt concrete

(LEAC) and low energy asphalt (LEA) in which the aggregates (or a portion of the aggregates) are not heated above the boiling point of water.

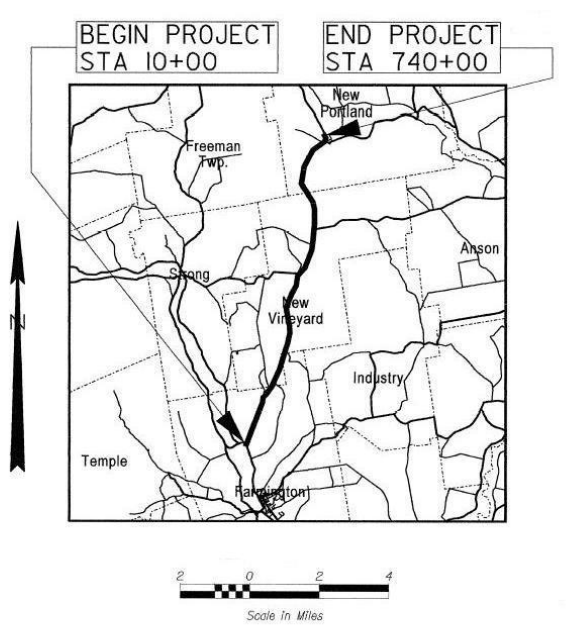
Paving benefits. Paving-related benefits discussed included the ability to pave in cooler temperatures and still obtain density, the ability to haul the mix longer distances and still have workability to place and compact, the ability to compact mixture with less effort, and the ability to incorporate higher percentages of recycled asphalt paving (RAP) at reduced temperatures. In addition since the mix is produced at lower temperatures there is less aging to the asphalt binder which could result in improved long term durability. It has also been documented on some WMA projects that there was less mat segregation.

Cost Considerations

WMA technologies may increase cost, through plant modifications or additive costs. Although there is potential to reduce plant operational costs in fuel reduction, these savings may not offset the increased material costs. The potential to increase RAP usage without sacrificing performance could reduce the cost per ton of WMA.

Project Location

In 2010 a warm mix asphalt overlay project along Rt. 27 in the town of Farmington, New Vineyard and New Portland (PIN 16828.00) was paved. The project begins at Station 10+00, the intersection of Rt. 4 and Rt. 27, and extends northeasterly to Station 740+00, approximately 13.826 miles to the intersection of Rt. 146 and Rt. 27. The section begins at Fairbanks Road and extends northerly to 0.15 mi. north of the intersection of Lemon Stream Road/Chick Road/River Road.



Location Map

Project Scope

The scope of this paving project consists of a ½” minimum shim with 1 ¼ “overlay. The typical section is below.

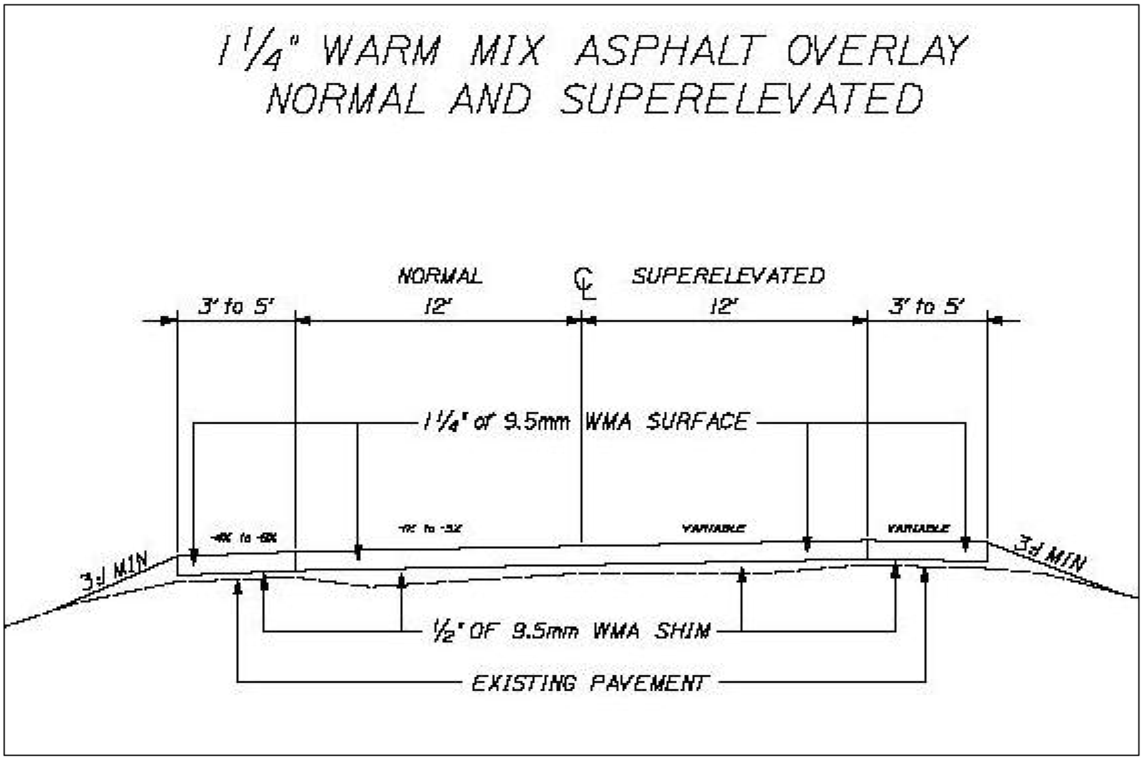


Figure 1-Typical Section

A control section was constructed that consists of traditional hot mix asphalt shim and surface. This begins at Station 699+25 in the left lane and Station 701+75 in the right lane and extends to Station 740+87 for both lanes. The remainder of the project was paved with the warm mix asphalt pavement. Pavement data from the ARAN will be used to compare performance of the control and test sections. Data will be used from network collection on a two year cycle in the right lane only.

	Control Section Station 701+75 to Station 740+87 Right	Test Section Station 10+00 to Station 701+75 (Right Only)
1 ¼ ” lift - surface	9.5mm HMA	9.5 mm HMA
½” variable shim	9.5 mm HMA	9.5 mm WMA

Table 1 – Test and Control Sections

ARAN data from the “before” paving conditions were reviewed as well as data from immediately after paving. Those results are summarized in Table 2. These are average values of each section. It is noted that the IRI and Rut average values in both lanes for the control section were significantly higher than those in the test section for the “before” conditions. This could potentially have an impact on the pavement performance and will be evaluated closely. For another comparison to the control a Test Section “S” is proposed. This test section is adjacent to the control section beginning at approximate Station 662+00 and ending at Station 701+75. The “before” IRI and Rut average values are more inline with those in the Control Section as can be seen in Table 2.

Before Paving – 2010 data				
	IRI Left Wheel Path	IRI Right Wheel Path	Rut Left Wheel Path	Rut right Wheel Path
Control Section	216 in/mile	271 in/mile	0.26”	0.45”
Test Section	152 in/mile	177 in/mile	0.17”	0.24”
Test Section “S” Station 662+00 to Station 701+75	254 in/mile	299 in/mile	0.27”	0.40”
	After Paving – 2010 data			
Control Section	49	61	0	0
Test Section	51	59	0	0

Table 2 – ARAN Before and After Data

Falling weight deflectometer network level test data from 2006 was reviewed to determine the consistency of the subsurface conditions since localized poor soil conditions could potentially skew the pavement performance comparison. Results of this testing are reported in Table 3. For both Sensor 1 readings and the sum of all sensors the test and control sections are relatively consistent.

FWD Test Data - 2006		
	Average Sensor 1	Average All Sensors
Control Section	10 mils	36 mils
Test Section	9 mils	32 mils

Table 3 – FWD Test Data

Materials

The WMA was covered by a special provision that is in the Appendix to this report. The system used to produce the WMA on this project was the ASTEC Green System, which utilizes a water foaming process, rather than additives, to reduce asphalt viscosity. This system, called the “Double Barrel Green” (as mentioned on page 3 above), uses 3/8” foaming nozzles and a foaming chamber manifold to produce Warm Mix. The manifold is where microscopic steam bubbles are introduced into the liquid asphalt stream to reduce the viscosity of the liquid. This plant system is very flexible with the ability to set and control the amount of water used to foam the asphalt. The equipment vendor recommends 2%, however the amount of asphalt can be adjusted to match production conditions or field conditions. The equipment can make HMA or WMA. Target temperatures for the WMA mix is 250°F to 350°F.

Daily paving inspection reports and Quality Assurance test results for the pavement were collected and reviewed and will be kept on file. Based on a review of the results there appear to be no anomalies. Table 4 contains properties of the HMA and WMA layers. Mixture temperatures for the HMA seemed to average around 300 F while those for the WMA were around 280 F. The construction and paving operations were completed as planned.

Lot Description Nominal Aggregate Size (Amount Placed)	Average Asphalt Content % [Target AC %]	**AverageVoids % [Target Voids %]**	Average Density % [Target Density]
HMA – 9.5 mm Surface w/20% RAP (1009 tons)	6.75 [6.6]	**4.23 [4.0]**	95.13 [92.5 – 97.5]
HMA – 9.5 mm Shim w/20% RAP (947 tons)	6.73 [6.6]	**4.83 [4.0]**	n/a
WMA – 9.5 mm Surface w/20% RAP (17820 tons)	6.73 [6.6]	**3.60 [4.0]**	94.78 [92.5 – 97.5]
WMA – 9.5 mm Shim w/20% RAP (13261 tons)	6.62 [6.6]	4.39 [4.0]	n/a

Table 4 – Material Testing Data Summary

Material Costs

The total project cost was approximately $2.39 million for the resurfacing of the 13.89 mile long section of Route 27. Asphalt bid quantities and estimated costs are shown in the following table. Actual in-place costs are not included in this report. The following items are included for relative comparison only and do not reflect any asphalt price escalators.

Item		Unit Price	Estimated Quantity	Bid Estimates
WMA 9.5 mm	(Pay Item 403.2103)	$66.35	18,800 tons	$1,247,380.00
WMA 9.5 mm, Shim	(Pay Item 403.2113)	$73.39	9,300 tons	$682,527.50
HMA 9.5 mm, Incidentals	(Pay Item 403.209)	$119.00	300 tons	$35,700.00
Bituminous Tack Coat	(Pay Item 409.15)	$5.59	13,000 gallons	$72,670.00

Photos

The following photos were taken in June 2011 during a site inspection. The photos show visible butt joints and also show signs of wear in the wheel path. The cause of this phenomenon is probably not due to the WMA itself, because the same effect has been seen on HMA pavements statewide. The occurrence and causes for this scour effect is the subject of further investigation.

Figure 2. Butt Joint

Figure 3. Transverse Crack

Figure 4. Wheel Path Wear

Figure 5. Butt Joint Seam

Figure 6. Perspective Showing Wheel Path Wear

Figure 7. Close Up of Wheel Path Wear (Coarse Aggregate compared with a Quarter coin).

Evaluation

The field inspection revealed that some areas showed prominent butt joints along with signs of wear. The premature wear phenomenon is not unique to this project; it has been observed on HMA pavements statewide, and is the subject of ongoing observation. So far the performance of this WMA project is on par with conventional HMA pavement.

Conclusions

The project is a field demonstration for Warm Mix Asphalt. This project, along with other MaineDOT WMA projects will be monitored over a five year period for pavement performance. Work shall include field visits and observations of distresses, analysis of rut and ride data from the ARAN and if needed subsurface investigations (coring, FWD, etc.) should the pavements have premature failure.

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February 3, 2010

SPECIAL PROVISION
SECTION 401
HOT MIX ASPHALT PAVEMENTS
(Warm Mix Asphalt Pavements)

The Special Provision 401 – Hot Mix Asphalt Pavement, has been modified with the following revisions. All sections not revised by this Special Provision shall be as outlined in the Special Provision 400 Pavements, section 401 – Hot Mix Asphalt Pavement. References to Standard Specifications, Special Provisions, or other documents, shall be determined as the most current version available at the time of bid. All references or conditions applied to Hot Mix Asphalt (HMA) pavements shall be replaced with Warm Mix Asphalt (WMA) unless otherwise amended or revised within this specification.

401.01 Description The Contractor shall furnish and place one or more courses of Warm Mix Asphalt Pavement (WMA) on an approved base in accordance with the contract documents and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the plans or established by the Resident. The Department will accept this work under Quality Assurance provisions, in accordance with these specifications and the requirements of Section 106 – Quality, the provisions of AASHTO M 323 except where otherwise noted in sections 401 and 703 of these specifications, and the Maine DOT Policies and Procedures for HMA Sampling and Testing.

MATERIALS

401.03 Composition of Mixtures This section has been amended as follows:

For the purposes of comparative testing, a HMA JMF shall be submitted for the establishment of a control strip. The control strip section shall be constructed with an approved JMF, submitted without WMA technology or additives. The HMA design shall be submitted with the same aggregate, aggregate percentages, asphalt supply, and asphalt target percentages as the WMA JMF.

401.031 Warm Mix Technology
The Contractor shall specify the method or type of WMA technology to be utilized to produce mixtures for use on Department projects. Methods or technologies shall generally be at the Contractors option, but will be limited to proven, Agency and Industry accepted practice. Examples of acceptable methods are listed:

Option A - The use of organic additives such as a paraffin wax and or a low molecular weight esterified wax. Wax derived additives shall be introduced at the rate recommended by the manufacture. Percentages shall be limited at a rate as to not impact on the binder's low temperature properties. Wax derived additives shall be introduced into the hot asphalt binder at the asphalt suppliers facility, or asphalt mixture plant and fully blended using a tank agitator / stirrer. Minimum placement temperatures shall be as per manufactures recommendations. A Quality Control Plan shall be submitted for approval by the Department.

<u>Option B</u> – The use of a manufactured synthetic zeolite (Sodium Aluminum Silicate). Sodium aluminum silicate additives shall be introduced at a rate recommended by the manufacturer. Sodium aluminum silicate additives shall be introduced into the hot mix plant mixing chamber by mechanical means that can be controlled and tied directly to the hot mix asphalt plants rate of production. Minimum placement temperatures shall be as per manufacturers recommendations. A Quality Control Plan shall be submitted for approval by the Department.

<u>Option C</u> – The use of a chemical additive technology and a "Dispersed Asphalt Technology" delivery system. This process utilizes a dispersed asphalt phase (emulsion) in asphalt mixture plant at a rate recommended by the manufacturer. This additive shall be introduced into the hot mix plant mixing chamber by mechanical means that can be controlled and tied directly to the hot mix asphalt plants rate of production. Minimum placement temperatures shall be as per manufacturers recommendations. A Quality Control Plan shall be submitted for approval by the Department.

<u>Option D</u> – The use of a controlled asphalt foaming system. This process utilizes an injection system to introduce water to the asphalt stream and “expand” the asphalt prior to mixing with the aggregate in asphalt mixture plant at a rate recommended by the manufacturer. This shall be introduced into the plant mixing chamber by mechanical means that can be controlled and tied directly to the asphalt plants rate of production. Minimum placement temperatures shall be as per manufactures recommendations. A Quality Control Plan shall be submitted for approval by the Department.

<u>401.04 Temperature Requirements</u> After the JMF is established, the temperatures of the WMA mixture shall conform to the following tolerances:

In the truck at the mixing plant – allowable range determined by manufacturer
At the Paver – allowable range determined by manufacturer

Mixture, placement and volumetric testing details, including temperatures, shall be included in the project specific QCP, and submitted to the Department prior to any work.

<u>401.18 Quality Control Method A, B & C</u> – This section has been amended as follows:

<u>Establishment of Control Strip</u> - The Contractor shall place a control strip for each mixture type consisting of Hot Mix Asphalt Pavement produced without warm mix technology. Prior to the placement of the control strip a passing verification test is required. The control test strip shall be placed over the full width of the travel way section, not to exceed 1000 ton production per lane. The control strip will not be excluded from QA analysis, but will be evaluated in accordance with Section 401.03. The Contractor shall notify the Department at least 48 hours in advance of placing the control strip.

Control strips shall be required for all mixtures to be utilized in the contract. Wearing, shim, or lower lift base mixtures shall be placed as required within the control strip limits. A minimum of three mixture samples shall be randomly selected from the control strips and evaluated under Method B criteria. A minimum of three core samples shall be randomly selected from wearing or lower lift base course control strips and evaluated under Method B criteria. After completion of the control strip, the Contractor shall make any final adjustments to the job mix formula in accordance to Standard Specifications, Section 401, subsection 401.03 - Composition of Mixtures, or compaction method. Any changes to the HMA JMF shall result in a change in the WMA JMF to identical target values. Paving operations shall not resume until the Contractor and the Department determines that material meeting the Contract requirements can be produced, and any changes to the Job Mix Formula have been approved by the Department. The Department shall pay for an accepted control strip as determined Section 401.222 – Pay Factor A and B, for this item. A new control strip shall be required if a current JMF is terminated, and a new JMF is started.

Once established, all production methods, equipment, and JMF's will become part of the QCP. The control strip will allow for any necessary adjustments to the mix design and or plant mixing procedures, as well as for the Department to evaluate the quality of the pavement.

Payments will be made under:

Pay Item	Pay Unit
403.2073 19.0 mm Warm Mix Asphalt Base	Ton
403.2083 12.5 mm Warm Mix Asphalt Surface	Ton
403.2103 9.5 mm Warm Mix Asphalt	Ton
403.2113 9.5 mm Warm Mix Asphalt Shim	Ton
403.2123 4.75 mm Warm Mix Asphalt Shim	Ton
403.2133 12.5 mm Warm Mix Asphalt Base	Ton