



# Transportation Research Division



## **Technical Report 12-04**

*Use of Warm Mix Asphalt Pavement on  
Route 9, in Durham*

*Construction and 1<sup>st</sup> Interim Report, June 2012*

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## *Use of Warm Mix Asphalt Pavement on Route 9 in Durham*

### **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 is rapidly being adopted by many states in the country.

### **WMA Technology**

There are currently over twenty different commercial technologies used to produce WMA. Several methods are used to classify the different technological approaches to WMA. One method of classification is by the degree of temperature reduction. (See Appendix II for a list of commercial technologies and classifications.) 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 that plant emissions are significantly reduced in producing WMA. Typical expected reductions are 30 to 40 percent for CO<sub>2</sub> and sulfur dioxide (SO<sub>2</sub>), 50 percent for volatile organic compounds (VOC), 10 to 30 percent for carbon monoxide (CO), 60 to 70 percent for nitrous oxides (NO<sub>x</sub>), 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 or 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.

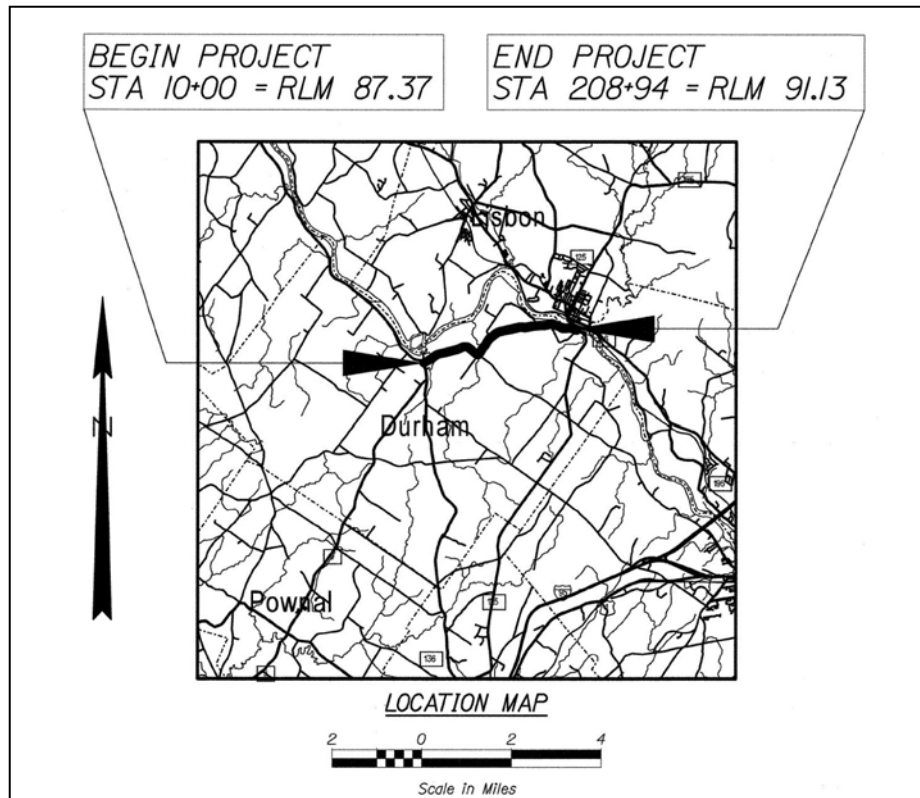
*Paving benefits.* Paving-related benefits discussed included the ability to pave in cooler temperatures and still obtain density, the ability to haul the mix longer distances and still have workability to place and compact, the ability to compact mixture with less effort, and the ability to incorporate 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 pavement preservation overlay project along Rt. 9 in the Town of Durham (PIN 16801.00) used warm mix asphalt. The project begins at Station 10+00, 0.01 miles northerly of Rt. 136 (Royalborough Rd.), and extends northeasterly to Station 208+94, approximately 3.768 miles to Rt. 125 (Pinkham Brook Rd.) The map below shows the project location.



## Project Scope

The project special provisions stated that:

*"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."*

For this project, the Contractor chose Option A, which states:

*"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"*

The scope of this paving project consists of a 1/2" minimum shim with 3/4" overlay. The typical section is below.

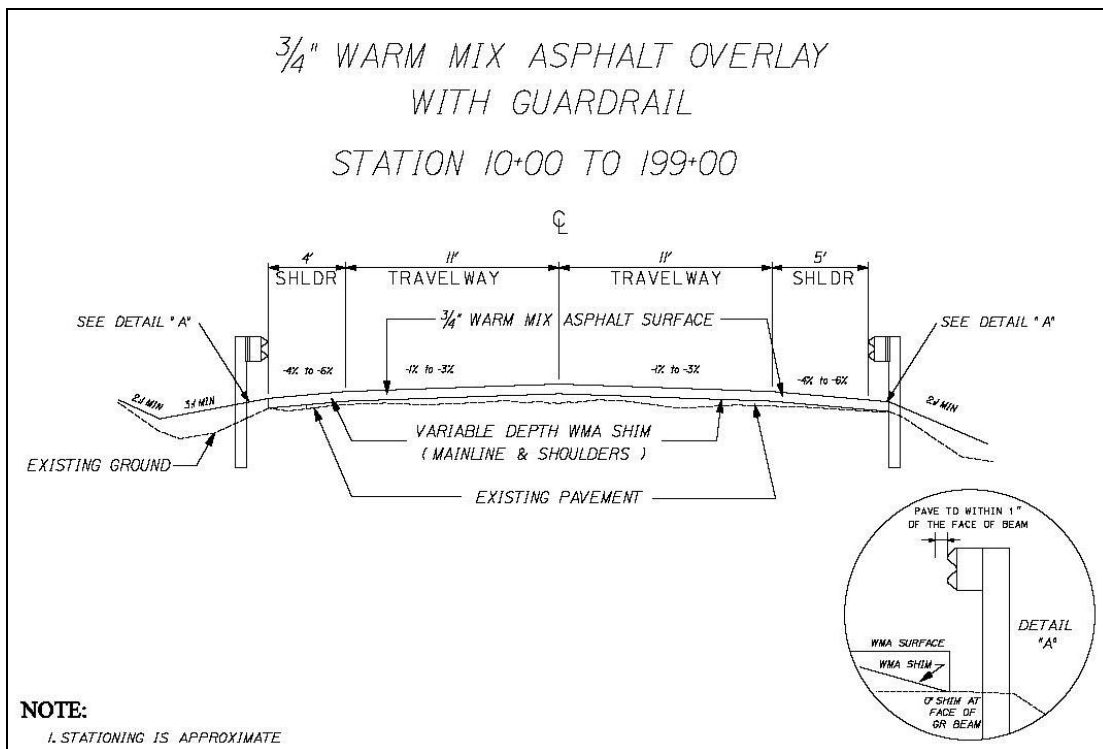
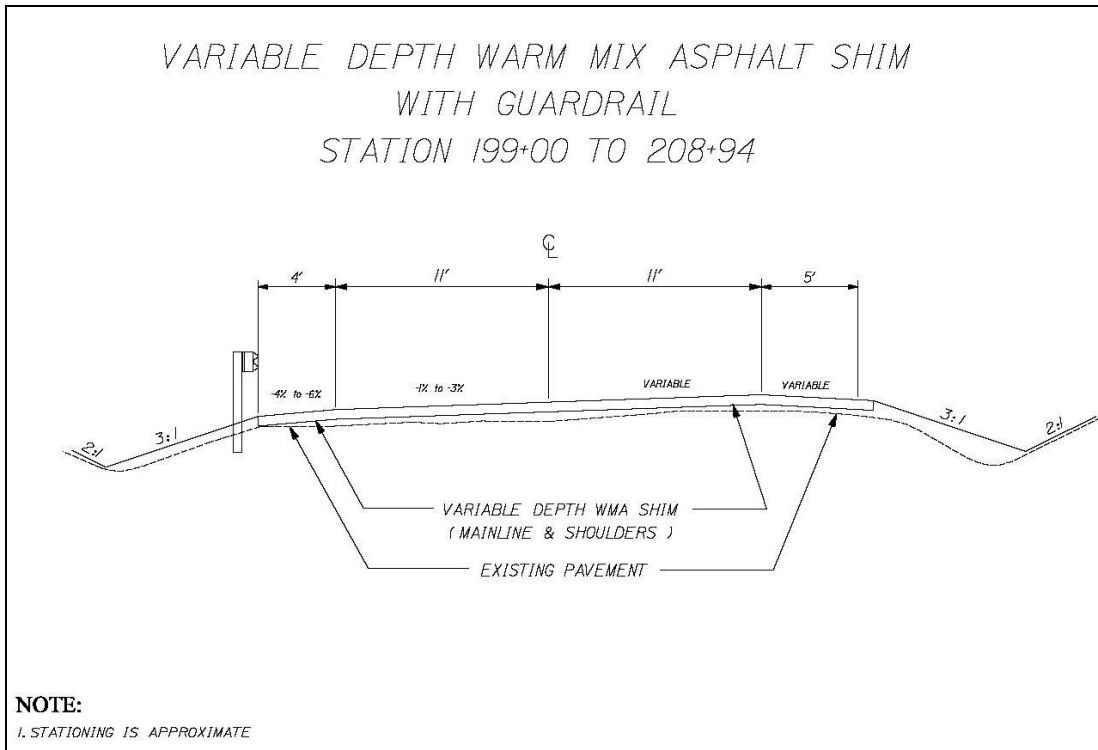


Figure 1 Typical Section- 3/4 " WMA



*Figure 2 Typical Section- Variable Depth WMA*

The additive used to create the mix was SonneWarmix , a Parrafin product made by Sonneborne Inc. The additive was introduced into the binder at Allstates Asphalt terminal (Bangor) at the rate of 0.75%. The paving Contractor was Harry C. Crooker of Topsham, Maine.

A control section was constructed that consists of traditional hot mix asphalt shim and surface. This begins at Station 10+00 and extends to Station 45+50 in the left lane and Station 45+75 in the right lane. 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 10+00 to Station 45+75 Right	Test Section Station 45+75 to Station 209+00 (Right Only)
¾" 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 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. IRI average values collected in the left wheel path after the paving was completed are the same for the control and test sections. However the right wheel path shows a 17% higher IRI when comparing the control section to the test section.

Before Paving – 2009 data				
	IRI Left Wheel Path	IRI Right Wheel Path	Rut Left Wheel Path	Rut right Wheel Path
Control Section	106 in/mile	160 in/mile	0.18”	0.47”
Test Section	154 in/mile	214 in/mile	0.21”	0.47”
After Paving – 2010 data				
Control Section	61	71	0	0
Test Section	62	83	0	0

Table 2 – ARAN Before and After Data

Falling weight deflectometer testing was completed 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. The average deflection at sensor 1 is 33% greater for the test section when compared to the control section. For the sum of all sensor deflections the test section is 27% greater. This is noted and will be considered as the long term pavement performance is evaluated.

FWD Test Data - 2010		
	Average Sensor 1	Average All Sensors
Control Section	15 mils	49 mils
Test Section	20 mils	62 mils

Table 3 – FWD Test Data

## Materials and Construction

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 contractor selected to use SonneWarmix from Sonneborne Inc. to produce the WMA. It is a Parrafin product that will be introduced into the binder at the Allstates asphalt terminal in Bangor at the rate of 0.75%. The contractor quality control plan stated mixing and compaction temperatures would be 270 F (+/- 25 F). Placement temperatures would begin at 275 F and work downward as long as testing and placement were satisfactory. The hope was to achieve mixing temperatures between 260 F and 270 F with placing temperatures between 250 F and 260 F. These lower temperatures were not achieved.

Observations from the plant as noted in the post paving meeting report state that lower temperatures could be achieved with moderate changes to the plant.

Lot Description Nominal Aggregate Size (Amount Placed)	Average Asphalt Content % [Target AC %]	Average Voids % [Target Voids %]
HMA – 9.5 mm Surface (575 tons)	6.37 [6.46]	2.93 [2.0 – 6.0]
WMA – 9.5 mm Surface (2345 tons)	6.35 [6.46]	4.63 [2.0 – 6.0]
WMA – 9.5 mm Shim (2041 tons)	6.47 [6.46]	3.57 [2.0 – 6.0]

*Table 4 – Material Testing Data Summary*

### **Material Costs**

The total project bid was approximately \$788,144 for the resurfacing of the 3.77 mile long section of Route 9. Asphalt quantities and estimated costs are shown in the following table. The following selected pay items are included here for relative comparison only and do not reflect any asphalt price escalators.

<b>Item</b>	<b>Unit Price</b>	<b>Estimated Quantity</b>	<b>Bid Estimates</b>
WMA 9.5 mm (Pay Item 403.2103)	\$71.35	3,000 tons	\$214,050
WMA 9.5 mm Shim (Pay Item 403.2113)	\$74.67	3,190 tons	\$238,197
HMA 9.5 mm Incidentals (Pay Item 403.209)	\$138.00	150 tons	\$20,700
Bituminous Tack Coat (Pay Item 409.15)	\$4.43	3,700 gallons	\$16,391



## Photos

The following photos were taken from the Department's Automatic Road Analyzer (ARAN) network collection in 2011, one year post paving.



*Figure 3*



*Figure 4*



*Figure 5*



*Figure 6*



*Figure 7*



*Figure 8*



*Figure 9*

## Conclusions

The project is a field demonstration for Warm Mix Asphalt. This project utilized an additive to give the asphalt its WMA properties. Future evaluations could compare this section with other pavements that utilized other WMA technologies. The rapid adoption of WMA by many states across the country has been accompanied by some concerns on durability. One concern is that WMA may be more susceptible to moisture damage (stripping). The evaluation of this project should include observations to determine if moisture deterioration is a problem or not. 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. An interim report will be prepared after two years service and final report after five years. Some wheel path scour is visible on this test project, nevertheless, the performance of this WMA pavement is comparable with conventional HMA pavement.

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**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.

February 3, 2010

Option B – 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.

Option C – 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.

Option D – 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.

401.04 Temperature Requirements 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.

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

Establishment of Control Strip - 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:

<u>Pay Item</u>	<u>Pay Unit</u>
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

## Appendix B

List of Commercial WMA products and technologies, classified by method or additive.

### Chemical

- Cecabase RT
- Evotherm
- HyperTherm
- Rediset WMX
- Qualitherm
- SonneWarmix

### Organic

- Sasobit
- Thiopave
- TLA-X

### Foaming

- AccuShear
- Advera
- Aquablack foam
- AquaFoam
- Aspha-Min
- Double Barrel Green/Green Pac
- ECOFOAM-II
- Low Emission Asphalt (LEA)
- Meeker Warm Mix foam
- Terex foam
- Tri-Mix foam
- Ultrafoam GX
- WAM-Foam

*Source: Federal Highway Administration, Asphalt Institute*