

## New Technology

*To help roads better endure cold climates, Minnesota Department of Transportation (Mn/DOT) researchers are studying the impacts of warm mix asphalt.*

Thermal cracking is the predominant distress mode of Hot Mix Asphalt (HMA) pavements in Minnesota. Studies at the MnROAD facility are exploring Warm Mix Asphalt's (WMA) potential for better low-temperature cracking performance. Researchers hypothesize reduced oxidation levels at the mix plant, caused by reduced temperatures, will lead to enhanced long-term pavement performance.

The study is also monitoring other performance measures such as rutting, fatigue cracking, top-down cracking, and ride.



Producing the Warm Mix Asphalt at MnROAD went smoothly; no smoke behind the paver provided cooler working conditions for the paving crew.

## BENEFITS OF LOWERING THE TEMPERATURE

Lowering asphalt mix temperature will decrease fuel usage and emissions, preserving resources and addressing environmental concerns. Specifically, lower temperatures promise to benefit the asphalt industry by providing:

- Earlier start dates
- Late season paving
- Longer haul distances when needed
- Cooler working conditions
- Reduced plant wear
- Improved compaction with stiff mixes

Environmental benefits experienced with WMA include reduced emissions, fumes, and odors. With a cooler work environment enabled by WMA technology, reduced production temperatures add up to energy savings.



## What is WMA?

WMA is a paving strategy that produces and places mixes at temperatures between 200° and 275°F. This temperature range is substantially less than what is required for HMA, which is 280° to 320°F. Preliminary data from a research project on I-70 in Colorado compared WMA with conventional HMA. The data showed WMA had approximately the same optimum asphalt content, lower air voids in field-produced mixes, comparable tensile strength, and generally favorable rutting characteristics.

## POTENTIAL ENGINEERING CHALLENGES



WMA technology presents some potential engineering challenges. Asphalt binders may not harden as much at lower production temperatures. Due to the presence of a softer binder in WMA mixtures when the pavement is opened to traffic, the mixture may have greater potential for rutting. The mixtures may have to cool beyond conventional HMA temperatures after the compaction process, prior to allowing traffic on the pavement.

Additionally, because binders may be softer and water is used as a workability aid in some WMA technologies, WMA may be more susceptible to moisture damage. The relationships between the engineering properties of these mixes and their performance will be investigated in an upcoming NCHRP project.

**In December 1997, the European Union (EU) signed the Kyoto Accord, a treaty where countries agreed to reduce their greenhouse gas emissions. This compelled the EU to investigate practices to reduce emissions in many ways.**

**By the year 2000, the EU had introduced WMA and other new paving strategies. Though the Europeans had a head start on the technology, the United States has rapidly gained ground with 17 warm mix technologies currently available.**

---

## What is MnROAD Researching?

The environmental, health, and construction-related benefits realized by WMA are well-documented. However, MnROAD is most interested in determining its potential for satisfactory low-temperature cracking performance. WMA's tendency toward reduced thermal cracking may show significant improvements over HMA pavements' susceptibility to thermal cracking.

---

## Field Tests

To test WMA's performance, six cells were paved with WMA on the MnROAD Mainline. The Mainline carries just under one million equivalent single axle loads (ESALs) per year. The mix is a level 4 Superpave (3-10 million ESALs) with PG 58-34 binder and 20 percent Recycled Asphalt Pavement (RAP) from MnROAD millings.

Five cells were constructed consisting of 5-inch WMA (3-inch wear, 2-inch non-wear) over a 12-inch recycled aggregate base, 12-inch aggregate subbase, 7-inch select granular, and clay subgrade. A single asphalt mixture was used to cover all five cells with a recycled aggregate-base, which included 100% recycled concrete, 50-50 blend of Portland Cement Concrete -class 5, 100% RAP, taconite railroad ballast, and class 5 control.

The sixth cell is a 3" WMA overlay of an existing HMA pavement, representing a "typical" Minnesota rehabilitation strategy. Evotherm 3G was used in all mixes. It is a chemical-based additive that does not use water, but still promotes coating at lower temperatures.

MnROAD also included a control cell on the Low Volume Road (15,000 ESALS/Year). The control cell mix has the same design as the WMA, but is produced at typical HMA temperatures without the additive. *The figure on the next page illustrates the mix, base, and subgrade used in the tests.*



WARM MIX ASPHALT						CONTROL
3" WM 58-34	5" WM 58-34	5" WM 58-34	5" WM 58-34	5" WM 58-34	5" WM 58-34	3" 58-34
11" 1993 HMA	12" 100% recycle PCC	12" 50% RePCC 50% Class 5	12" 100% RAP	12" Class 5	12" Mesabi Ballast	4" Class 6
Clay	12" Class 3	12" Class 3	12" Class 3	12" Class 3	12" Class 3	Sand
Microsurfacing 2003 & 2004	7" Select Granular	7" Select Granular	7" Select Granular	7" Select Granular	7" Select Granular	
	Clay	Clay	Clay	Clay	Clay	

## Construction Observations

The mix was produced approximately 50°F cooler than normal hot-mix production. Compaction was measured with a nuclear density gauge and showed equal compaction to HMA with less effort. The paving crew found the mix easy to work with, and they enjoyed the cooler temperatures and lack of fumes behind the paver. The following morning it was still slightly tender, but it stiffened with time.

## Laboratory Results

Several samples were collected for further analysis in the laboratory by MnROAD. Our research partners tested for mixture and binder properties.

### MOISTURE SUSCEPTIBILITY TESTING

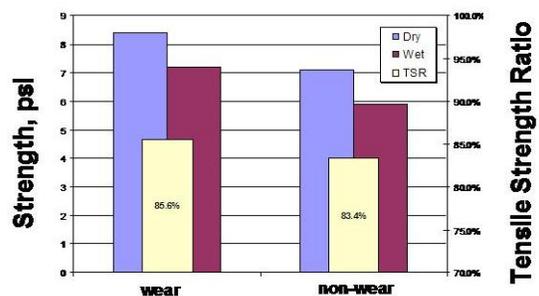
As illustrated in the graph below, the WMA mixes produce a good Tensile Strength Ratio (TSR), indicating this mixture is not prone to moisture damage.

### BINDER TESTING

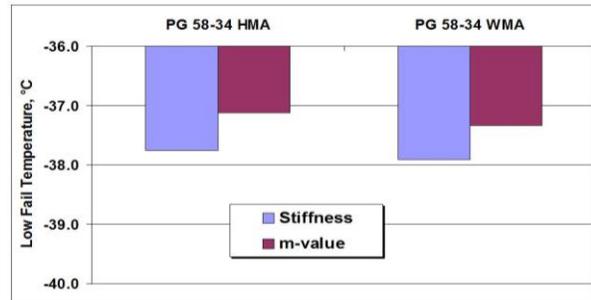
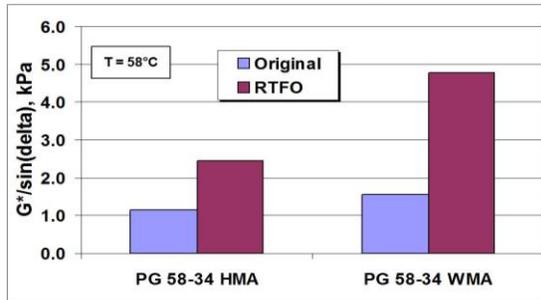
Asphalt binder deformation and flow is important to overall pavement performance. The binders were aged through the Rolling Thin-Film Oven (RTFO) procedure to simulate short-term aging, and they were aged through the Pressure Aging Vessel (PAV) to simulate long-term aging. A Dynamic Shear Rheometer (DSR) was used to characterize the viscoelastic

behavior of the WMA and the HMA binders at higher temperatures. The Bending Beam Rheometer (BBR) test was used to determine the low temperature cracking properties.

**HMA and WMA pavements that deform and flow too much may be susceptible to rutting and bleeding, while those that are too stiff may be susceptible to cracking.**



The below graphs compare the WMA and HMA binders' performance. Both the WMA and HMA binders failed at approximately the same temperature. The DSR testing revealed the WMA binders may be more susceptible to short-term aging.



## Recommended Practices

According to Dave Newcomb of the National Asphalt Pavement Association, at least 72 WMA field trials have been conducted in 39 states. Newcomb recommends the following practices:

- Minimize aggregate moisture through proper handling and stockpiling practices.
- Make sure the burner is properly tuned for the temperature.
- Keep baghouse temperature above the condensation point.
- Consider superheating aggregate ahead of RAP addition.
- Follow normal placement practices.

## Other Local and National Interest

The WMA testing at MnROAD will help disseminate results to city and county engineers, consultants, contractors, and researchers throughout the entire country. WMA test sections have been placed in recent years on several county roads, recreational trails, and in the City of St. Paul. Local contractors are beginning to modify their plants to produce warm mix with various technologies.

### ONGOING STUDIES

A number of related studies being conducted at MnROAD include research into Low Temperature Cracking, Recycled Asphalt Pavements (RAP), and Recycled Shingles. Warm mix asphalt has the potential to affect these topics and more. The interest in WMA is growing, and MnROAD has one of the few test sections located in a cold weather climate.

## For more information:

For more information about MnROAD and the Road Research program at Mn/DOT:

Tim Clyne  
Office of Materials & Road Research  
Phone: 651-366-5473  
E-mail: [Tim.Clyne@dot.state.mn.us](mailto:Tim.Clyne@dot.state.mn.us)

Ben Worel  
Office of Materials & Road Research  
Phone: 651-366-5522  
Email: [Ben.Worel@dot.state.mn.us](mailto:Ben.Worel@dot.state.mn.us)

[www.dot.state.mn.us/mnroad](http://www.dot.state.mn.us/mnroad)

