IOWA STATE UNIVERSITY
Institute for Transportation

Investigation of Warm-Mix Asphalt Using Iowa Aggregates

tech transfer summary

While warm-mix asphalt benefits continue to drive use of this technology, performance testing will help determine the net benefits.

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RESEARCH PROJECT TITLE
Investigation of Warm-Mix Asphalt Using Iowa Aggregates

SPONSORS
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The mission of the Institute for Transportation (InTrans) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, reliability, and sustainability while improving the learning environment of students, faculty, and staff in transportation-related fields.

Objectives

Test the binder and mix properties of warm-mix asphalt (WMA) technologies for both field- and laboratory-produced mixes to determine performance compared to traditional hot-mix asphalt (HMA).

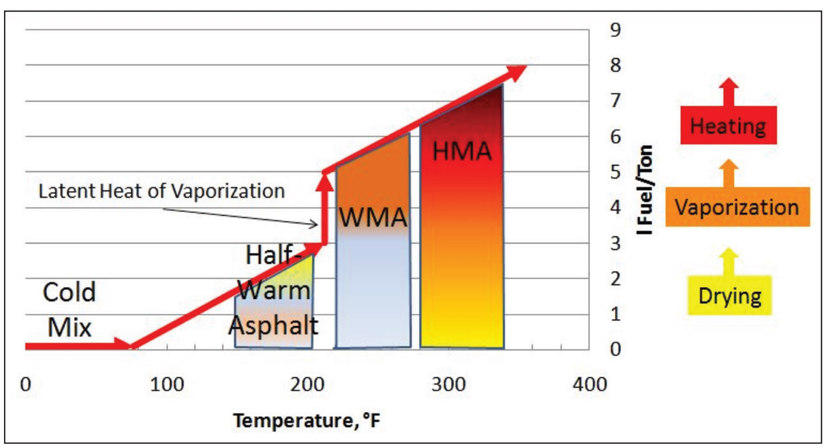
Problem Statement

The implementation of WMA is becoming more widespread with a growing number of contractors using various WMA technologies. Early research suggests WMA may be more susceptible to moisture damage than traditional HMA mixes. Asphalt performance tests can be a good way of measuring material responses that can be correlated with pavement performance. It is important for owner/agencies to know that the WMA technologies and/or the reduction in mixing and compaction temperatures do not impact the durability and long-term pavement performance.

Experimental Plan

Field- and laboratory-produced mixes were studied. The laboratory-produced mixes compared HMA control mixes with WMA mixes that had the same mix design. The WMA technologies used for the laboratory study were Advera, Sasobit, and Evotherm. The addition of 30 percent recycled asphalt pavement (RAP) was investigated.

The field study tested four WMA field-produced mixes. Each of the four mixes had a corresponding control HMA mix. The WMA technologies used in the field study included: Evotherm 3G/Revix, Sasobit, and Double Barrel Green Foaming.



Warm-mix asphalt temperatures range from 30 to 100 degress Farenheit cooler than hot-mix asphalt (and stay above 212 degrees) (Prowell 2007) http://international.fhwa.dot.gov/pubs/wma/summary.cfm

The three main factors for this study were WMA/HMA, moisture-conditioned/not moisture-conditioned, and reheated/not reheated. Mixes were evaluated based on the following performance tests: Indirect Tensile Strength (ITS) (AASHTO T-283), Dynamic Modulus, and Flow Number.

The ITS test helps to determine the moisture susceptibility of a mix by comparing the tensile strength of moisture-conditioned samples with the strength of unconditioned samples. The dynamic modulus test characterizes the material response under dynamic loading at a range of temperatures (4 to 37 degrees Celsius). The flow number test is performed to evaluate rutting potential and permanent deformation. Binder testing was performed to determine the rheological differences between HMA and WMA binders to determine if binder grade requirements change with the addition of WMA additives.

Key Findings

1. Reduced mixing and compaction temperatures were achieved.
2. The WMA additive did not impact the binder grade for three of the four binders tested.
3. Statistical differences were found when comparing tensile strength ratio (TSR) values for both laboratory- and field-produced mixes. In the laboratory, none of the WMA additives performed as well as the HMA. For the field mixes, all TSR values passed Iowa's minimum specification of 0.8 but, on average, WMA TSR values are lower than HMA TSR values.
4. Dynamic modulus results show that, on average, HMA will have higher dynamic modulus values. This means the HMA exhibits stiffer material properties compared to WMA; however, this may not necessarily mean superior performance in all cases.

Compacting field-produced WMA samples at the asphalt plant

5. Flow number results show that WMA has reduced flow number values compared to HMA. The only exception was the fourth field mix and weather-delayed production of the control mix by nine days. The laboratory mixes showed that flow number values increased significantly with the addition of RAP.
6. In the laboratory study, Advera reduced TSR values. Given that Advera is a foaming agent, the increase in moisture susceptibility is likely attributed to the release of water necessary for the improvement of the workability of the asphalt mixture.

Recommendations

1. Continue data analysis within this study by incorporating the Mechanistic-Empirical Pavement Design Guide (M-E PDG) to investigate long term pavement performance.
2. Conduct a field survey of the actual WMA pavement and compare with M-E PDG results over time.
3. Investigate the use of high percentage RAP/fractionated RAP and/or recycled asphalt shingles (RAS) used in conjunction with WMA. Conduct performance testing to evaluate differences in mixing and compaction temperatures and address potential moisture susceptibility concerns. The extent of blending of the recycled materials at reduced mixing temperatures is an area of concern.
4. Investigate how using two WMA technologies in conjunction with each other impacts mix properties (e.g. foaming using a WMA additive).
5. Reinvestigate field-produced foamed WMA and control HMA mixes under a more controlled setting, wherein production occurs on consecutive days. A plan that would address several of these concerns would be to produce a foamed WMA mix with a chemical modifier, such as Revix; on the following day, produce a foamed WMA mix; and, on the final day of paving, produce the control HMA mix. The samples procured from these mixes could undergo ITS, dynamic modulus, and flow number testing.
6. Beam fatigue testing on control HMA and WMA mixes with high percentages of RAP/fractionated RAP or RAS would help determine the flexural stiffness and fatigue life of the mixes.
7. Conduct low-temperature fracture testing on the paired field-produced HMA and WMA mixes to ensure low-temperature mix performance will be met.

Implementation Benefits

WMA reduces emissions and fuel and energy use. The paving benefits are the ability to incorporate higher percentages of RAP, less compaction effort, longer haul distances, and reduced production and placement temperatures.