Research Brief

Wisconsin Highway Research Program
Project 0092-19-04
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Recycled Asphalt Binder Study

Research Objectives

- Investigate how the quantity and quality of recycled asphalt materials affects the performance of resultant binders
- Validate resultant binder test results using mixture performance testing
- Develop procedure for evaluating the quality of recycled asphalt materials and virgin asphalt binder blends used in Wisconsin

Research Benefits

- Developed a step-by-step guide to evaluate the quality of asphalt blends with high recycled asphalt materials content
- Developed guidance on using recycling agents to balance rutting and cracking performance of recycled asphalt mixtures

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Background

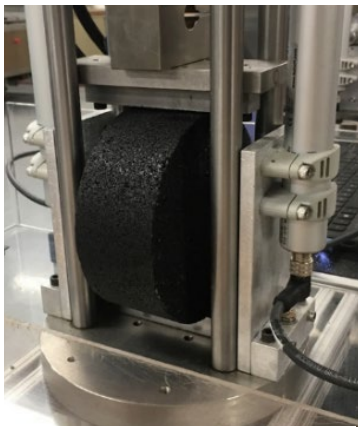
The use of recycled asphalt materials (RAM), including reclaimed asphalt pavements (RAP) and recycled asphalt shingles (RAS), has significant economic and environmental benefits that include cost savings, conservation of natural resources and reduction in energy consumption and emissions. Increasing the amount of RAM in asphalt mixtures typically increases rutting resistance but can also increase susceptibility to cracking and durability issues.

Current Wisconsin Department of Transportation (WisDOT) specifications limit the quantity of RAM that can be included in new pavement. WisDOT allows up to 40 percent of virgin asphalt binder to be replaced with RAM binder in lower pavement layers and 25 percent in upper layers. The objective of this research was to evaluate how the quantity and quality of RAM affects the performance of binder blends and to determine if a higher binder replacement contents could be allowed without sacrificing pavement performance.

Methodology

The research team conducted rheological and chemical tests on asphalt blends with various RAM contents to investigate the effect of RAP/RAS binders on the properties of the blends. In addition, blends containing recycling agents (RAs) were tested to assess the ability of the RAs to improve the properties of the blends. These tests included performance grading (PG), multiple stress creep recovery (MSCR), linear amplitude sweep (LAS), Fourier transform infrared spectroscopy (FTIR) and gel permeation chromatography (GPC).

Binder results were validated with performance testing of mixtures. Mixtures were tested for rutting resistance (Hamburg Wheel Tracking Test [HWTT]) after being subjected to short-term oven aging (STOA), and cracking resistance at intermediate temperature (Indirect Tensile Asphalt Cracking Test [IDEAL-CT]), and low temperature (Disc-Shaped Compact Tension Test [DCT]) after being subjected to STOA plus long-term oven aging (LTOA).In addition, dynamic modulus (|E*|) testing was conducted after STOA and LTOA to assess the stiffness and aging resistance of the mixtures.



IDEAL-CT measuring resistance to cracking at intermediate temperatures.

"Deliverables from NCAT will enable WisDOT to approve use of highly recycled asphalt mixture designs without sacrificing quality."
– Erik Lyngdal, WisDOT

Interested in finding out more?

Final report is available at:
WisDOT Research website

Results

The addition of RAM to virgin binders significantly increased the stiffness of the resultant recycled binder blends, which improved rutting resistance but decreased fatigue resistance, thermal cracking resistance and stress relaxation properties. These effects tend to be more pronounced as RAM content increased. However, the degree to which material properties changed depended on RAM source and use of recycled agents.

|E*| testing showed mixed results for rejuvenated mixtures after STOA and LTOA when compared to the control mixtures (with unmodified and modified binders). Some of the rejuvenated mixtures showed higher stiffnesses while others showed lower stiffness at different frequencies and temperatures.

HWTT and DCT testing of mixtures with RAM and RAs exceeded the preliminary test thresholds for Wisconsin mixtures recommended in Wisconsin Highway Research Program (WHRP) *Balanced Mixture Design Implementation Support* project, while the IDEAL-CT results showed that some of the recycled mixtures with RAs narrowly failed the preliminary IDEAL-CT index criteria.

Recommendations for implementation

The results of this research were used to develop a step-by-step guide to evaluate the quality of asphalt blends with high RAM contents, and to guide the use of RAs to produce recycled asphalt mixtures with balanced rutting and cracking performance. The design steps are summarized as follows:

1. Determine the high-temperature and low-temperature performance grade (PG) of the component materials to be used for blending.
2. Determine the RA dosage by targeting the low-temperature PG and ΔTc (relaxation properties) for the recycled binder blends after being subjected to rolling thin-film oven aging (RTFO) and 40 hours in a pressure aging vessel (PAV).
3. Perform the rheological characterization of the recycled binder blend with RA at the dosage selected in step 2, using standard test methods (AASHTO M320, AASHTO M332) and data analysis.
4. Conduct mixture performance tests to ensure compliance with the BMD performance criteria.

The complete step-by step guide can be found in the final report.

This brief summarizes Project 0092-19-04,
"Recycled Asphalt Binder Study"
Wisconsin Highway Research Program