Enhancing the Fundamental Knowledge and Use of Asphalt Emulsions Using Systematic Scientific and Engineering Approaches

tech transfer summary

This study explored the potential of emulsified asphalts in the field of pavement engineering by comparing non-modified and polymer-modified emulsions.

Objectives

This research aimed to provide a better understanding of asphalt emulsions; explore their use in sustainable pavement construction, preservation, and rehabilitation; and identify future areas of study.

Problem Statement

There is a lack of understanding of the mechanisms by which asphalt emulsions are produced and how they work. Asphalt emulsions have several advantages, but the manufacturing of bituminous emulsions is a complicated process, which includes understanding the chemical design of the emulsions and the emulsifiers that are used.

Background

Asphalt emulsions are gaining in popularity in the US and worldwide due to their lower application temperature, lower energy consumption, and lower viscosity than hot applied asphalts. About 3 million tons of emulsion is produced in the US, which accounts for 5% to 10% of the total asphalt consumption.

However, much of the available information on asphalt emulsions is contained in patented literature rather than in easily accessible peer-reviewed journals, which leads to a lack of understanding about their applications, i.e., which type of emulsion to use in a particular situation.

Research Methodology

The research team compared two emulsions. One emulsion was a standard non-modified emulsion and the other was a polymer-modified emulsion made from a styrene butadiene styrene (SBS) polymer.

Once the emulsions were produced in an emulsion mill, the team conducted the following tests:

- Particle size analysis of both emulsions to investigate their individual microstructures
- Viscosity tests on both emulsions to determine differences in rheology as a result of polymer modification

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RESEARCH PROJECT TITLE
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The Midwest Transportation Center (MTC) is a regional University Transportation Center (UTC). Iowa State University, through its Institute for Transportation (InTrans), is the MTC lead institution.

MTC's research focus area is State of Good Repair, a key program under the 2012 federal transportation bill, the Moving Ahead for Progress in the 21st Century Act (MAP-21). MTC research focuses on data-driven performance measures of transportation infrastructure, traffic safety, and project construction.

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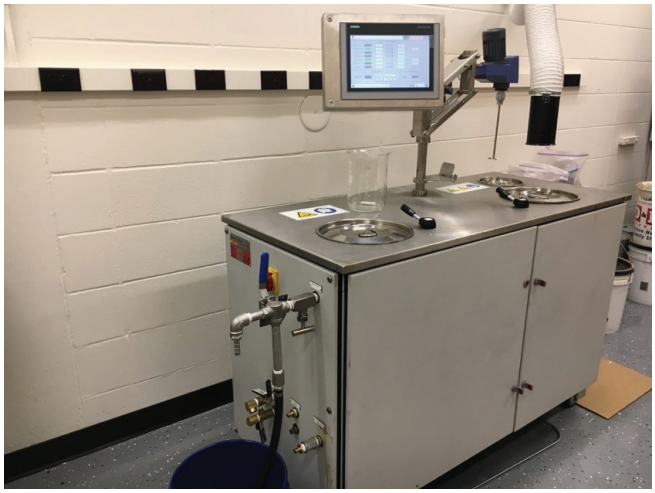
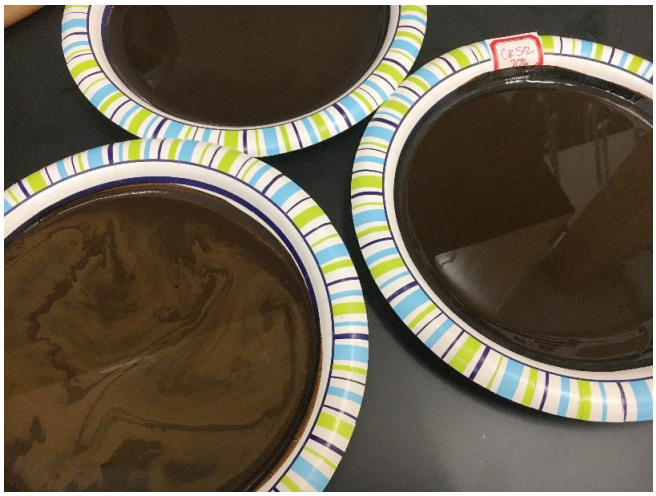
- Dynamic shear rheometer tests on residues obtained from both emulsions to compare with two binders, and master curves of the complex shear modulus versus frequency
- Sweep tests with aggregate and hot applied binder as well as asphalt emulsions to determine their application potential by comparing the performance of the emulsions and neat binder in chip seal applications in the field



Iowa State University's asphalt emulsion mill



Emulsion samples for residue testing

Key Findings

- Particle size testing revealed that while the non-modified emulsion showed a narrower particle size distribution with a relatively larger mean particle size of 6 microns, the polymer-modified emulsion showed a wider particle size distribution.
- Viscosity tests showed that 66% and 68% residue non-modified emulsions have almost identical flow times and that the small increase in percentage does not significantly increase viscosity. The non-modified emulsion had higher viscosity and met current specifications for the Saybolt viscometer, while the polymer-modified emulsion had lower viscosity.
- Findings from the preliminary emulsion formulation and testing indicate that the residues obtained from emulsions compare similarly to the neat binders and have slightly higher G* values than their respective neat binders.
- MSCR tests showed that the polymer-modified emulsion made from an SBS polymer imparted a high stiffness to the base PG 64-22 binder, good recovery was achieved at 25°C, but additional polymer dosage optimization is needed in future studies.
- In the sweep tests, CRS-2 non-modified emulsion performed comparably to a hot applied PG 64-22 base binder but did not perform as well as a hot applied polymer-modified PG 72-28 binder. However, the results did not show a significant statistical difference between the mean weight losses between either application types.

Conclusions and Recommendations for Future Research

This study highlights the potential for using emulsified asphalts in pavement engineering. The results of this research serve as a starting point for the multiple tests and trials that could be run on specially engineered emulsions manufactured to help improve the state of the practice and current knowledge of emulsified asphalt.

Stable standard emulsions, both polymer-modified and non-modified, can now be produced at Iowa State University's laboratory emulsion mill, and emulsion properties can be studied more in detail.

Further research could improve understanding of polymer-modified emulsions and lead to better emulsion formulations. To optimize performance in specific scenarios and environments, a wide range of emulsions can now be formulated and tested in the laboratory.

Experimentation with different emulsifier types and contents could help engineer a broader spectrum of emulsions that could be optimized for various aggregates. Experiments with locally available aggregates in an aggregate-emulsion system would help ensure that the appropriate emulsion is used for each aggregate.

Iowa State University has also been developing biopolymers for use with asphalt binders, which can also be incorporated into emulsions.

Implementation Readiness and Benefits

Asphalt emulsions are a low-temperature alternative to hot applied asphalts that can provide an opportunity for energy savings and that are considerably easier to handle and store.

This research will help disseminate knowledge on asphalt emulsions and help fuel a better understanding of emulsion components to improve standards and test methods for emulsions.

The ability to formulate and manufacture emulsions by varying different parameters will help benchmark and evaluate current practices and drive further innovation in the field of pavement preservation and rehabilitation.