Executive Summary, Research Readiness Level Assessment, and Technology Transfer

The Use of Recycled Plastic in Asphalt Pavements Feasibility Study

Research Objectives

The goal of this multi-phase study is to evaluate the feasibility of using recycled plastics in asphalt pavements by considering the effect of recycled plastics on the rutting, cracking, moisture damage resistance of asphalt mixtures through Balanced Mix Design (BMD) approach. More specifically, this study aims to:

- Identify waste plastics sources in Nebraska and select a few of them based on their physic or chemical properties that are considered important for use in asphalt mixtures through the dry process.
- Develop a laboratory procedure for introducing selected waste plastics that can mimic the production of recycled plastic modified mixtures at asphalt plants.
- Evaluate the performance of plastic modified asphalt mixtures prepared with various sources and types of wastes plastics in the laboratory. The focus of this objective is on developing a mix design for plastic modified mixtures via a BMD approach.

Research Benefits

The analysis of performance testing results of various asphalt mixtures produced with different WPR contents can lead to optimum blends that meet the short- and long-term performance requirements. The results can contribute to minimizing the consumption of natural resources for construction and potentially improve the durability of asphalt pavements, resulting in significant cost savings and more sustainable asphalt pavements. The successful development and implementation of this research in our state will also provide significant environmental benefits, such as preservation of limited natural resources, reduction of energy consumption, reduction of disposed and discarded solid waste, and reduction of emissions.

Principal Investigator

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Background

Recently the world's population has been paying more attention to severe climate changes and environmental pollutions, by focusing primarily on ways to control and reduce the CO2 through reusing and recycling a broad range of waste materials. The asphalt pavement industry has a long history of using recycled materials in asphalt mixtures to achieve engineering, economic, and environmental benefits. Besides reclaimed asphalt pavement (RAP) being recycled at a rate of approximately 94 percent, other recycled materials such as recycled asphalt shingles (RAS), recycled tire rubber (RTR), waste engine oils, steel slag, recycled glass, and many others have been and will continue to be used in some markets or applications. A recycled material that has recently gained attention for paving purposes is waste plastic residues (WPR). The plastics industry has been actively exploring new end market opportunities for over 30 million tons of waste plastics generated yearly. One of the potential applications identified is asphalt pavements. In late 2016, media reports began suggesting the use of WPR in asphalt as an opportunity to improve the performance of asphalt pavements while eliminating the growing amount of waste plastics being landfilled or polluting the environment. However, using WPR in asphalt mixtures can be challenging due to variations in its composition and the presence of non-plastic contaminants. To ensure the quality of asphalt mixtures containing WPR, requirements are needed to specify the key properties of these materials and how they should be used to improve the overall pavement life cycle benefits while protecting the environment. Therefore, the goal of this multi-phase study is to evaluate the feasibility of using recycled plastic in asphalt pavements by considering the effect of WPR addition on the rutting, cracking, moisture, and aging resistance of asphalt mixtures using well-established mixture performance test methods.

Conclusion

The plastics industry has been actively exploring new end-market opportunities for the more than 35 million tons of waste plastics generated annually. The use of recycled WP in asphalt presents an opportunity to improve pavement performance while reducing the growing amount of WP being landfilled or released into the environment. However, the use of WP in asphalt mixtures poses challenges due to variations in plastic composition and the presence of non-plastic contaminants. The absence of standardized procedures has resulted in inconsistent integration methods and unclear roles of WP within asphalt concrete (AC) mixtures. Therefore, the goal of this multiphase study is to evaluate the feasibility of using recycled plastics in asphalt mixtures. This Phase 1 study focused on the dry process, assessing the differences on the physical and chemical characteristics of various WPs, checking the effects of different laboratory mixing protocol to produce WP-modified mixtures, and investigating bonding mechanisms at the binder–aggregate interface when WP was added to pre-heated aggregates. Performance-based parameters from the Hamburg Wheel Tracking Test (HWTT) and the Indirect Tensile Asphalt Cracking Test (IDEAL-CT) were compared. Results showed that WP-modified mixtures produced with higher aggregate pre-heating temperatures exhibited enhanced rutting and moisture-damage resistance while maintaining short-term cracking resistance compared to a reference (no WP) mix. When comparing two different types of WP (LDPE and PP), both improved moisture-damage resistance, with LDPE demonstrating superior performance. Bonding tests revealed that aggregates coated with WP exhibited reduced water wettability and increased binder–aggregate bonding strength. At the end, the practical implementation of a WP-modified mixture was further evaluated in a field project. A Nebraska Superpave Recycled Mixture (SPR) using 25% RAP incorporating 1% post-consumer LDPE was produced at an asphalt plant and used in a local paving project in South Sioux City, Nebraska. Comparisons between laboratory- and plant-produced mixtures confirmed the feasibility of producing WP-modified mixtures and the validity of the mixing procedure adopted in the lab, with similar performance tests results. Overall, the mixtures exhibited improved rutting and moisture resistance while maintaining short-term cracking resistance. Future work will focus on the long-term performance evaluation and field monitoring of WP-modified mixtures, as well as assessing their recyclability potential.

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NDOT Recommendations Based Off Research Project – 2026 – RRL3

This research showed that waste plastic mixes can improve rutting and moisture resistance while maintaining short-term cracking resistance. These results were evaluated in a field project in South Sioux City, Nebraska, using a Nebraska Superpave Recycled Mixture using 25% RAP and 1% LDPE, which further proved the feasibility of the mixing procedure adopted in the lab. Even still, the lab-produced mixtures were not fully validated against the variability of plant production, long-term field performance removes unknown, and the recyclability of the mixtures was not addressed. Phase II of this product, SPR-FY27(067), will investigate these aspects.

- *As provided by Robert Rea, Lead TAC Member*

Research Readiness Level (RRL) Assessment

Level 3: Development

Follow up after completion of Phase II, SPR-FY27(067), in 2028.

RRL 3

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Technology Transfer

Webinars/Presentations

- Cunning, K., Tighi, J., Olson, B., Bastola, N., Bueno, I., Teixeira, J., E., S., L., & Deters, J. Enhancing Engineering Education through Undergraduate Research Experiences: A Case Study on Waste Plastic in Sustainable Infrastructure. Presented at the *2023 ASEE Midwest Section Conference*. Lincoln, NE, 2023.
- Bueno, I., M., Tighi, J., & Teixeira, J., E., S., L. Enhancing Cracking, Rutting, and Moisture Damage Resistance Through Dry Method Addition of Polypropylene Waste Plastic. Presented at the *2024 International Society of Asphalt Pavement Conference*, Montreal, Canada, 2024.
- Teixeira, J.E. S. L. University of Nebraska Research Updates: UNL Asphalt Research Program. Presented at *2024 Nebraska Asphalt Paving Conference*, Kearney, NE, February 27-28, 2024.
- Bueno, I., M., Tighi, J., & Teixeira, J., E., S., L. Effects of Waste Plastic Addition Via Dry Method on Asphalt Concrete BMD Performance-based Parameters. Presented at *Geo-Omaha 2024 Conference*, Omaha, NE., 2024.
- Cunning, K., Tighi, J., Olson, B., Bastola, N., Bueno, I., Teixeira, J., E., S., L., & Deters, J. Effects of Grain Bag Waste Plastic on the Mechanical Performance of Asphalt Mixtures and the Role of Undergraduate Research in Engineering Education. Presented at the *2024 ASEE Midwest Section Conference. Lawrence*, KS, 2024.
- Bueno, I., M., & Teixeira, J., E., S., L. Assessment of Moisture Damage Resistance of Asphalt Mixtures containing Waste Plastic based on Physical-, Mechanical-, and Thermodynamical Binder-Particle Adhesion Methods. Presented at the *Transportation Research Board Annual Meeting*, Washington, D.C., 2025
- Teixeira, J.E. S. L. University of Nebraska Research Updates: UNL Asphalt Research Program. Presented at *2025 Nebraska Asphalt Paving Conference, Kearney*, NE, February 4-5, 2025.
- Teixeira, J., E., S., L., Hedquist, L., & Bestgen, B. Nebraska's 1st Plastic Road: South Sioux City Case Study. Presented at *American Public Works Association Fall Conference (Iowa Chapter)*, Des Moines, IA, 2025.
- Teixeira, J., E., S., L. Plastic Roadway Project. Presented at *Solid Waste Association of North America 2025 Joint Fall Conference (Nebraska Chapter)*, Kearney, NE, 2025.
- Teixeira, J., E., S., L., & Bestgen, B. Incorporating Recycled Plastics in Asphalt Paving. Presented at *American Council of Engineering Companies NE Transportation Conference, Lincoln*, NE, 2025.

Journal Papers Submitted for Review and In Progress Journal Papers and Theses

- Bueno, I. M., & Teixeira, J. E. (2024). Waste plastic in asphalt mixtures via the dry method: a bibliometric analysis. *Sustainability*, 16(11), 4675. https://doi.org/10.3390/su16114675.
- Madeira Bueno, I., Tighi, J., & Teixeira, J. E. S. L. (2025). Effects of waste plastic addition via dry method and pre-mixing temperature on the mechanical performance of asphalt concrete. *Road Materials and Pavement Design*, 1–18. https://doi.org/10.1080/14680629.2025.2487832

This brief summarizes Project SPR-FY24(027)
"The Use of Recycled Plastic in Asphalt Pavements Feasibility Study"
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