Thesis Project Portfolio

The Sustainability of Recycled Plastic Modified Asphalt: A Life Cycle Assessment and Performance Based Approach

(Technical Report)

Closing the Waste Loop: Converting Single-Use Plastics into a Sustainable Resource

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2023

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Executive Summary

Introduction

Plastic waste in the United States is proliferating at a rapid rate that according to the United States Environmental Protection Agency (EPA), in 2018, there were an approximate 35.6 million tons of plastics that were categorized as municipal solid waste. However, only 3.09 million tons 9.5% of these plastics were recycled while 6.62 million tons were used in energy recovery via combustion and the rest were landfilled (EPA, 2018). Moreover, the plastics waste accumulation in the United States increased following the Chinese government ban on importing plastic waste from other countries in 2018 which prompted the exploration of possible means of plastic reuse for the 106 million tons of plastic waste that are accumulating annually with no consumption decrease in sight (Brooks, 2018). Plastic waste is a complex problem that requires a multifaceted solution. Some solutions include reducing the overall consumption of Single Use Plastics (SUP), increasing recycling rates, and developing new technologies to reduce plastic waste and pollution. One of the viable recycling potentials for SUP waste diversion is asphalt, considering that asphalt is the most recycled material in the United States and has a versatile mixture design range to incorporate a variety of materials into its formula (Williams et al, 2019). The use of recycled materials in asphalt is not new, and there have been successful examples of incorporating other types of waste into asphalt mixtures, such as recycled rubber tires, recycled asphalt shingles, and glass. Using SUP waste in asphalt requires a specific type of plastic that can withstand the high temperatures and stresses of asphalt production and road use. Several studies and pilot projects have explored the use of SUP waste in asphalt, and the results have been promising (Willis, 2020). This approach can potentially reduce the amount of plastic waste going to landfills or the environment while also improving the performance of asphalt roads. However, it is important to note that this approach is not a complete solution to the plastic waste problem and may be constrained by microplastic leakage into watershed via stormwater runoff over long-term use of Recycled Plastic Modified (RPM) asphalt pavement service life. The SUP implementation in asphalt should be combined with other strategies, such as reducing overall plastic use, redesigning plastic-intensive products, supplanting plastic used in packaging with alternative sustainable material, and increasing recycling rates. In an effort to close the waste loop and promote sustainability, this essay examines the interplay between the sustainability of Recycled Plastic Modified (RPM) asphalt, analyzed through a life cycle assessment, and the conversion of SUP waste into a recovered resource, driven by shifts in plastic consumption and production patterns.

Capstone Project

The Virginia Transportation Research Council (VTRC) is currently testing RPM asphalt mixtures to determine if they are suitable for use on Virginia roadways via AASHTO and VDOT specifications. This project aims to supplement VTRC's knowledge of RPM asphalt mixes with the goal of completing a rigorous comparison of RPM asphalt with respect to conventional asphalt in terms of both performance and sustainability. The sustainability of RPM asphalt must be considered from three perspectives: environmental, economic, and social. VTRC has successfully produced RPM asphalt mixtures with various polyethylene (PE) and polyethylene terephthalate (PET) polymers, or plastic with resin identification codes (RIC) #1 (polyethylene terephthalate), #2 (high-density polyethylene), and #4 (low-density polyethylene). The four phases of the technical work were designed to provide a thorough assessment of the RPM asphalt mixtures as following: 1) lab-based assessment of RPM mixtures, 2) field-scale assessment of a placed RPM asphalt roadway, 3) estimation of roadway service life for RPM based on mechanistic simulation software provided by Federal Highway Administration (FHWA), and 4) integration of results from all tasks into a Life Cycle Assessment (LCA) to compare RPM vs. conventional roadway service life in terms of global warming potential (GWP) and dollar cost for maintenance and rehabilitation (M&R). The lab test results establish key performance parameters that help assess the durability and long-term aging of both RPM and conventional asphalt mixtures. While the field-scale observations provided real-time feedback on how the RPM and control mixtures performed. The lab and field test data were inputted into advanced simulation software to develop a life cycle assessment to provide a holistic view of the true sustainability of the RPM versus conventional asphalt mixtures.

STS Research Paper:

This paper aims to provide an understanding on the shifting consumption trend towards single-use plastics (SUP) in the United States by addressing how these plastic types can be transformed from waste to a new commodity. The research approach seeks to employ a combination of the Science, Technology, and Society (STS) frameworks of wicked problem and paradigm shift, and how these frameworks analyze certain case studies to establish points of comparison between the United States and Europe in terms of governing regulations, mass production and consumption, recycling, and waste management. Specifically, this research paper seeks to identify how has the plastic industry experienced a paradigm shift from its introduction to major facets of consumer goods in the 1950's to the present and how the plastic industry's future will be affected by the sustainability-driven policies and paradoxical consumer trend. This paper determines an evaluation of the recycled plastic's environmental and economic feasibility via comparative analyses of life cycle assessment in terms of user responsibility patterns and construction material applications. Furthermore, the environmental cost of recycled plastic that is sourced from the waste stream and utilized into quantifiable combined products in the construction industry would provide potential benefits to improve the manufacturing of a more sustainable built environment.

Concluding Reflection

Overall, there are many potential avenues for transforming single-use plastics from waste to a lucrative new commodity within the possible shift towards circular economy. It is important to note that while OECD countries may possess the most updated datasets on plastic waste management and have implemented policies to address the issue, it is crucial to also consider the impact of plastic waste on underdeveloped parts of the world. These underdeveloped regions face unique challenges in terms of waste management infrastructure, lack of funding and resources, and cultural attitudes towards recycling waste. It is necessary to explore the perspectives and experiences of these regions to gain a more comprehensive understanding of the global impact of plastic waste. Furthermore, it is important to acknowledge that simply adapting policies from OECD countries may not be feasible for all regions, as they may have different socioeconomic parameters and require tailored solutions. It is essential to consider the cultural, economic, and political contexts of each region when developing strategies to address plastic waste management. Finally, in reflecting on my experience working on both projects simultaneously, I have gained valuable insights into the transformation of single-use plastics from waste to a recovered resource within the context of a resource constrained economy. The results of this project are promising and indicate untapped potential not only for Virginia but for other states and countries looking to incorporate recycled plastic into their roadways.

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