Thesis Project Portfolio

THE SUSTAINABILITY OF RECYCLED PLASTIC MODIFIED ASPHALT: A LIFE CYCLE ASSESSMENT AND PERFORMANCE BASED APPROACH

(Technical Report)

CONTRIBUTIONS OF LEAN CONSTRUCTION TECHNIQUES TOWARDS SUSTAINABLE CONSTRUCTION TECHNIQUES BY REDUCING SOCIAL, ECONOMIC, AND ENVIRONMENTAL COSTS OF CONSTRUCTION PROJECTS

(STS Research Paper)

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Executive Summary

Sustainability has become an increasingly important value in our societies as we realize that without sustainable action, we cannot guarantee the health, safety, and prosperity of current and future generations. The emphasis on sustainable action has revealed some aspects of our societies to be less sustainable than others; among these are the built environment and the construction industry. Between building energy use and embodied emissions, the latter of which are emissions generated from construction materials and processes, the construction and use of the built environment account for 40% of greenhouse gas emissions produced annually on a global scale. The construction industry presents many opportunities to decrease global energy consumption and emissions. The steps for reducing emissions from building energy use are relatively well established: using renewable energy to power heating and cooling systems and lighting. This leaves room for sustainable action in other facets of the construction industry, namely the selection of construction materials and methods. The two projects in this thesis project portfolio are meant to explore the ways in which existing construction methods and materials can be made more sustainable on an environmental, economic, and social scale.

The technical aspect of the thesis portfolio evaluates the feasibility and sustainability of incorporating recycled plastic into asphalt pavement. In the United States, plastic accounted for 13.2% of the total waste generated in 2017 with only 8.4% of the plastic waste being recycled. If plastic waste was successfully implemented in asphalt pavement, there are potential benefits such as higher performing asphalt roadways, new end market opportunities for plastic waste, and more incentive to recycle plastic. The incorporation of recycled plastic into asphalt pavement to create recycled plastic modified (RPM) asphalt has been tested many times in a lab setting with the conclusion that RPM asphalt performs better than conventional asphalt. However, research is lacking on whether RPM asphalt will continue to perform better than conventional asphalt in long-term studies, or if RPM asphalt sees a sustainability benefit compared to conventional asphalt. Working with the Virginia Transportation Research Council, the research division of the Virginia Department of Transportation, conventional and RPM asphalt samples were prepared and tested to obtain performance parameters. These performance parameters were then used with modeling software to obtain maintenance lifespans for each of the asphalt mixtures. A life cycle assessment approach was used to determine the global warming potential (GWP) in kg CO_2 equivalent per the functional unit, which was one lane-mile of asphalt roadway over a 30-year period. It was concluded that while the addition of recycled plastic to asphalt mixtures initially increased the GWP in terms of raw materials, the increased performance lifespan of the RPM asphalt mixtures resulted in less frequent intervals of replacement and a lower total GWP in most cases.

The STS research paper explored how construction methods could be made more sustainable by using lean construction techniques. The paper aimed to develop a framework for an intentional intersection of lean and sustainable construction techniques for use in construction projects. The goals of lean construction techniques are to minimize site waste, construction time, and overall construction costs through better project management. Sustainable construction is focused on reducing the environmental, social, and cultural impacts caused by construction projects in order to meet the goals of sustainable development. Lean construction techniques and sustainable construction techniques share the general ideas of promoting resource efficiency and minimizing waste, meaning that lean construction techniques could be used to intentionally produce sustainable results on a construction project. The STS research paper further examined these similarities by way of a literature review in which papers about sustainable construction

and lean construction were studied to determine specific relationships between the two construction techniques. Then, using an existing framework for sustainable construction as a model, a new framework was made to highlight both lean construction and sustainable construction techniques. This framework focuses not only on the use phase of the built environment but also the construction, manufacturing, raw material, and end of life phases. It was concluded that lean construction provides the most sustainability benefits by reducing waste, improving environmental management, maximizing value, improving health and safety conditions, and increasing process efficiency and productivity; and such values are reflected in the framework.

The findings from both the technical and STS research papers reflect the idea that sustainability is becoming more pertinent in the built environment, especially with respect to embodied emissions. It is essential to find new ways to incorporate lower carbon technologies into construction materials and ideologies, RPM asphalt and lean construction techniques being only two examples of this. However, it is also important to consider sustainability by means other than environmental sustainability. There is still much work to be done in exploring what social sustainability can mean for the construction industry and the built environment. Through the work completed in this thesis portfolio, it is my hope that future researchers can look more critically at the current technologies and practices used in the construction industry and contemplate how they can be made both more efficient and more sustainable for all stakeholders.