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Enhancement of Asphalt Performance by Graphene-Based Bitumen Nanocomposites

Project 1918
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Investment in research for innovative materials for California's highway infrastructure promotes the preservation, improves integrity, and increases sustainability of assets due to an extension of service life and lengthened maintenance intervals. Modified asphalt binders have shown to increase the resilience of highway paving materials and increase the time between scheduled maintenance that local agencies and transportation authorities have set for preventative maintenance activities. The purpose of this research is to investigate the effects of various mixing methods and sequence modification of PG64-10 asphalt binder with graphene nanoparticles and SBS (styrene-butadiene-styrene) polymer over a range of component compositions, testing the resultant materials' physical and mechanical properties in accordance with standard specifications. The motive for this study is to expand on the current method for material production of polymer-modified asphalt binders. Altering the incorporation of graphene nanoparticles with asphalt binder and SBS polymer is performed with the ambition of integrating the favorable mechanical properties of graphene nanoparticles to the polymer-modified asphalt binder mixture.

Study Methods

Production of samples included several combination designs of asphalt binder, graphene nanoparticle, and SBS polymer components. The samples of varying component compositions and mixing methodologies were tested to determine the following physical and mechanical properties: temperature susceptibility, resistance to external stress, elasticity, oxidative aging, and storage stability. The test results drive the comparison of rheological effects and material behavior of the different methods of graphene nanoparticles and SBS component incorporation within the asphalt binder. Various test methods demonstrate how effective sample composition and component incorporation influence the overall material performance.

Findings

Upon the conclusion of testing each sample for various rheological properties, the data suggests that the introduction of nanoparticles into the asphalt binder slightly improves the asphalt mixture by increasing the rigidity of the sample's properties, and that the nanoparticles have a positive effect on resilience to brittleness after aging. After enduring manufactured aging, the nanoparticle samples maintained favorable rheological properties that have the potential to promote a longer lifespan. Overall sample performance of the mixing methodology of incorporating the graphene nanoparticles into the asphalt binder, followed by the addition of the SBS polymer indicates superior capabilities in terms of resistance to permanent deformation, high-temperature rutting, and oxidative aging when compared to the graphene-coated SBS samples. The ability to withstand added stresses that culminates in improved durability is attributed to the mix procedure of the SBS added to graphene-modified asphalt binder.

Addition of higher nanoparticle content slightly increases the stiffness; however, the non-coated graphene and SBS bitumen suggests an unquestionably lower susceptibility to rutting.

Policy/Practice Recommendations

Adoption of graphene nanoparticle-modified asphalt binders for use on California's State Highway network has the potential to increase the time intervals between scheduled road maintenance and reduce locations of unanticipated deterioration, leading to a direct result in reduction of traffic congestion and an increase in cost savings for residents.

About the Authors

Dr. Sara Moghtadernejad joined the CSULB Department of Chemical Engineering as an Assistant Professor in Fall 2018. Dr. Moghtadernejad's Multiphase Flow Lab (MFL) pursues various interdisciplinary and multidisciplinary research directions in Chemical Engineering. She studies processes and phenomena involving fluid and powders that depict phase changes and have multiple states.

Dr. Ehsan Barjasteh joined the CSULB Departments of Mechanical & Aerospace Engineering and Chemical Engineering (joint position) as an Assistant Professor in Fall 2015. His research focuses on development and optimization of advanced polymer and composite materials and processes.

Ren Nagata and Haia Malabeh attended California State University Long Beach for undergraduate degrees and for graduate studies in the Chemical Engineering department. Haia Malabeh also holds a Professional Engineering License in Mechanical Engineering.

To Learn More

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