Modified Asphalt-Rubber Green Pavement (MARGPave) Mixtures: Synthesis, Characterization, and Performance Assessment

ABSTRACT

Globally, several types of modifiers are being used in asphalt mixtures to alleviate premature failure of flexible pavements occurring due to high temperatures and multiple repetitions of heavy loads. For instance, crumb rubber (CR) obtained from discarded tires has proven to be a viable asphalt modifier commonly utilized by the pavement industry as it helps augment the rheological and mechanical properties of asphalt pavement materials. However, blending CR with asphalt binder typically poses durability issues accompanied by temporary settlement of rubber particles in the storage tank. Thus, the major objective of this research was to develop **M**odified **A**shphalt-**R**ubber **G**reen **P**avement (**MARGP**ave) range of products that could be applied in roadway construction and maintenance activities such as structural layers, instant pothole patching, and surface treatment. The ingredients of the MARGPave product comprised asphalt binder, CR, clay mineral, and a binder stabilizer at optimized proportions. The modified asphalt-rubber product (MAR) was developed by short-term hot blending followed by pulverization through air drying of the initial asphalt-rubber (AR) material. Material characterization using advanced experimental techniques such as Fourier transform infrared spectroscopy and powder X-ray diffraction established the existence of interlinks between the MAR materials. Further, the MARGpave product was incorporated into the asphalt-aggregate blend in lines with the globally accepted Superpave asphalt mix design procedure. The MARGPave asphalt mix was characterized for its permanent deformation, fatigue cracking, and moisture resistance using the advanced mixture characterization tests at different temperature-frequency combinations.

Based on the mix performance tests, MARGPave dense graded mix outperformed the control dense graded mix as follows: fatigue resistance of MARGPave dense was about 2-3 times higher than control indicating that the new product will have higher design life; stiffness moduli of MARGPave dense at lower temperatures were lower by 4-18% revealing that the new mix will be less prone to low-temperature thermal cracking; moduli of MARGPave dense at higher temperatures were higher than control by 3-40%, illustrating that the indigenously developed material will have higher rut resistance at higher temperatures; MARGPave also had higher resistance (~1-2%) to moisture stripping compared to control unmodified dense graded asphalt mix remarking that the new material is durable as well. Overall, it is envisioned that the implementation of MARGpave product in asphalt paving mixtures would improve the performance of the material against various distresses at a wide range of temperatures and traffic speeds rendering them as durable highway construction materials. It is noteworthy that MARGPave inherently possesses over 12% CR by weight of the total mix in comparison with the AR products that constitute only 1.6% CR by weight of the AR mix, depicting significant amount of recycled CR in the MARGPave mixtures. The outcomes of this research can be used and implemented by roadway engineers, contractors, scientists, and industry to better understand the benefits of using MARGPave mixtures with an aim to achieve "green" pavement systems.

Keywords: Material recyclability; Industrial by-products; Nanoclay materials; Asphalt-rubber; Green pavement technology; Product development; Environmental stewardship.

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