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Editorial

Innovative Materials, New Design Methods, and Advanced Characterization Techniques for Sustainable Asphalt Pavements

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New and innovative materials are continually being researched and developed by asphalt technologists, particularly in the last decade to find the most economical, efficient, and environmentally friendly product to use on roads. Parallel to that, advanced characterization techniques and methodologies are also being developed to characterize materials for best results. Innovative materials include recycled and waste materials (green materials), low-cost and high-performance materials, and materials that reduce energy consumption. Recycled asphalt pavement (RAP) material is considered among the most common materials used in asphalt pavements. The RAP material is a useful alternative to virgin materials because it reduces the need to use virgin aggregate which has limited resources in some areas of the United States and the World [1]. The FHWA continues to encourage the use of waste tire rubber for asphalt paving for its cost-effectiveness, easy handling, and better fatigue performance [2]. Plastic waste is relatively a new material recently introduced in the asphalt technology [4]. Another innovative material is the bioasphalt that is considered a breakthrough in renewable pavements. The bioasphalt is produced from non-petroleum-based renewable resources such as corn, rice, potato starches, and other plants, which are converted into a type of bitumen binder for the asphalt [3]. In this special issue, published papers are dealing with innovative materials, design methods, and characterization techniques that well agree with the main scope and goals of the special issue. The papers are mainly classified into three main categories: (1) new materials and their behavior and performance, (2) the mechanics and performance of composite paving materials, and (3) new design and characterization methods and modeling.

A study by W. S. Brito et al. assessed the reuse of fly ash of Bayer process boilers in geopolymer synthesis. X-ray fluorescence (XRF) and scanning electron microscopy (SEM) techniques were used to characterize the raw materials and geopolymers. The study concluded that synthesized geopolymers have great potential for production of geopolymeric materials with greater mechanical compressive strength. C. Kai et al. utilized silica powder in styrene-butadiene-styrene- (SBS-) modified asphalt. The silica powder was collected from the exhaust gases produced by smelting industrial silicon often used as a cement concrete admixture in China. Rheological tests such as viscosity, dynamic shear rheometer (DSR), and bending beam rheometer (BBR) tests were used to study the behavior of the composite-modified asphalt. The results of the study showed that the high-temperature and low-temperature performances were improved by the increase in silica powder content and ratio of filler-asphalt, and by the increase in the silica powder content with an optimum value of 7%, respectively. However, the increase in the ratio of filler-asphalt reduced the low-temperature cracking resistance of the asphalt. A study by M. Irfan et al. investigated the effect of the cellulose fiber addition (0.3% by total weight of aggregates) on the performance of three stone mastic asphalt (SMA) concrete mixtures with three different nominal maximum aggregate sizes (NMASs): 12.5, 19, and 25 mm.

The results revealed that SMA mixture with an NMAS of 12.5 mm and a binder content of 5.3% showed relatively better resistance to fatigue cracking. On the other hand, SMA mixture with an NMAS of 25 mm (coarser gradation) exhibited excellent resistance to rutting based on the flow test results. D. Wang et al. also used the cement material in a semiflexible mixture to investigate cracking resistance. Optimal material design and ABAQUS numerical simulation were conducted. Matrix asphalt structures with four different air voids and different cement mortar dosages were used. The findings of their study revealed that the internal stress in this semiflexible mixture is mainly determined by the contraction rather than the expansion of cement mortar, and the larger air void and less volumetric variation of cement mortar reduced the internal stress of the matrix structure. J. Wang et al. in another study, to reduce the temperature of asphalt pavement and improve the anti-rutting performance of the asphalt mixture, produced a thermal-resistant asphalt mixture (TRAM), in which a certain proportion of mineral aggregate was replaced by ceramic (CE) or floating beads (FB) with low thermal conductivity. The results showed that the addition of thermal-resistant materials can reduce the thermal conductivity and the temperature of the asphalt mixture. Consequently, the CE and FB can improve the antirutting performance of the asphalt mixture by reducing the temperature inside the pavement.

Although two materials were used in two different papers for concrete structures, their improved performance results rendered them as two innovative materials. The stone powder cement (SPC) in a study by J. Hu et al. was used as a novel cement substitute material in concrete for its good gelling performance and low cost. The addition of stone powder improved the microstructure of the backfill and produced a denser three-dimensional (3D) network structure. The cement powder mixed appropriately with the stone power could meet the strength requirement and reduce the cost of backfilling materials. M. Chen and X. Hou used the reactive powder in a concrete-filled circular steel tube to assess the axial compression and bearing capacity of the tube. The confining coefficient was found to be the main factor affecting the ultimate bearing capacity. The design proposal for an RPC-filled steel tube was recommended based on the experimental analysis results and China's "Design and construction" code for concrete-filled steel tube structure.

While the above studies focused on new materials, a study by M. Guo et al. investigated the effect of aging and rejuvenator recycling on the rheological and micromechanical properties of SBS-modified asphalt binders. The results of infrared spectroscopy tests demonstrated that the crosslinking structure of asphalt was destroyed and SBS modification effect gradually diminished after aging. Scanning electron microscope (SEM) tests showed that the island structure of SBS-modified asphalt disappeared after aging. Energy spectrum analysis showed that the C (carbon) content of aged SBS-modified asphalt decreased, while the O (oxygen) content and S (sulfur) content increased. Results of the fluorescence microscope, SEM, and rheological tests showed that the epoxy functional group compounds of aliphatic glycidyl ether resin had high reactivity, and the triblock molecular structure of SBS and the mechanical performance of SBS-modified asphalt were recovered.

Two papers of this issue studied material modeling. In the first paper, K. Wu et al. studied the effect of voxel size on a three-dimensional microstructural modeling of the asphalt mixture using finite element analysis. The computed tomography (CT) image-based finite element approach was used as an effective method to simulate the micromechanical response of the asphalt mixture. Four micromechanical digital models were generated with voxel sizes of 0.5 mm, 0.67 mm, 1.0 mm, and 2.0 mm, respectively. Simulation results showed that the voxel sizes had a significant effect on creep stiffness modulus, and the most appropriate voxel size was found to be 1.0 mm. In the second paper, C. I. Kim presented a comprehensive linear model for an elastic solid reinforced with fibers resistant to extension and flexure. In particular, the complete systems of differential equations were obtained for the cases of Neo-Hookean and Mooney–Rivlin types of materials from which analytical solutions could be obtained.

Finally, two papers studied design methods and field performance. J. Lv et al. compared the traditional Marshall design method to the gyratory testing machine (GTM) method based on the oil-stone ratio, high-temperature stability, water stability, and rutting resistance of the mixes used in their study. The GTM method was recommended in this paper to be introduced and used on a large scale suitable for high temperatures and heavy traffic in Guangdong Province of China. In the second paper, the effect of macrotexture and microtexture on the skid resistance of aggregates was studied by B. Guan et al. Fractal dimension, root mean square height, and Polished Stone Value (PSV) were tested. The results showed that the PSV development was approximately divided into stages including the accelerated attenuation stage, decelerated attenuation stage, and stabilization stage. When the number of polishing cycles exceeded a critical point, microtexture replaced macrotexture to play a major role in the skid resistance of aggregates. In the accelerated attenuation stage, macrotexture was found to play a major role in the skid resistance of aggregates, whereas microtexture gradually played a major role in the skid resistance of aggregates in the other two stages.

Conflicts of Interest

The editors declare that they have no conflicts of interest regarding the publication of this special issue.

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