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Material Properties and Environmental Benefits of Hot-Mix Asphalt Mixes Including Local Crumb Rubber Obtained from Scrap Tires

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Abstract: This paper presents the results of a laboratory-based experimental investigation on the properties of asphalt binder and hot-mix asphalt (HMA) mixes modified by locally available crumb rubber, which was used as a partial replacement of asphalt by weight. In this study, fine crumb rubber with a particle size in the range of 0.3–0.6 mm, obtained from scrap tires, was added to the asphalt binder through the wet process. Crumb rubber contents of 5%, 10%, 15%, and 19% by weight of asphalt were added to the virgin binder in order to prepare the modified asphalt binder samples, while the unmodified asphalt binder was used as the control sample. The crumb rubber modified binder samples were examined for measuring viscosity indirectly using the penetration test, and temperature resistance using the softening point test. Later, both the modified and unmodified asphalt binders were used to produce HMA mixes. Two categories of HMA mix commonly used in Malaysia—namely, AC 14 (dense-graded) and SMA 14 (gap-graded)—were produced using the modified asphalt binders containing 5%, 10%, 15%, and 19% crumb rubber. Two AC 14 and SMA 14 control mixes were also produced, incorporating the unmodified asphalt binder (0% crumb rubber). All of the AC 14 and SMA 14 asphalt mixes were examined in order to determine their volumetric properties, such as bulk density, voids in total mix (VTM), voids in mineral aggregate (VMA), and voids filled with asphalt (VFA). In addition, the Marshall stability, Marshall flow, and stiffness of all of the AC 14 and SMA 14 mixes were determined. Test results indicated that the modified asphalt binders possessed higher viscosity and temperature resistance than the unmodified asphalt binder. The viscosity and temperature resistance of the asphalt binders increased with the increase in their crumb rubber content. The increased crumb rubber content also led to improvements in the volumetric properties (bulk density, VTM, VMA, and VFA) of the AC 14 and SMA 14 mixes. In addition, the performance characteristics of the AC 14 and SMA 14 mixes—such as Marshall stability, Marshall flow, and stiffness—increased with the increase in crumb rubber content. However, the AC 14 mixes performed much better than the SMA 14 mixes. The overall research findings suggest that crumb rubber can be used to produce durable and sustainable HMA mixes, with manifold environmental benefits, for use in flexible pavements carrying the heavy traffic load of highways.

Keywords: asphalt; crumb rubber; environment; hot-mix asphalt (HMA) mixes; modified binder; performance characteristics; scrap tires; temperature resistance; viscosity; volumetric properties

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