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Rejuvenation of aged asphalt binders by waste engine oil and SBS blend: Physical, chemical, and rheological properties of binders and mechanical evaluations of mixtures

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ABSTRACT

Due to the poor cracking performance of aged binders, the use of reclaimed asphalt pavement (RAP) in road pavements is limited. When applying a greater RAP percentage, the use of a rejuvenator is necessary. The rejuvenator's unfavourable softening impact, on the other hand, causes the pavement to be vulnerable to rutting. As a result, RAP binders with optimized rutting and fatigue cracking properties are required. Therefore, this study was carried out to evaluate the simultaneous effects of 70% waste engine oil (WEO) and 30% SBS copolymer as a compound rejuvenator (WS-rejuvenator) on the performance of asphalt binders and mixtures containing RAP binders of 30% and 50%. The physical, chemical and rheological properties of asphalt binders were evaluated using the conventional tests, SARA (Saturate, Aromatic, Resin, and Asphaltene) analysis, FTIR test, thermal gravimetric analysis (TGA), DSR, and BBR. The mechanical properties of mixtures were examined using the Marshall, indirect tensile strength, moisture damage, rutting, and aggregate coating tests. The findings showed that WS-rejuvenator at 5% and 10% recovered the physical characteristics of asphalt binders containing 30% and 50% RAP, respectively. Furthermore, WS-rejuvenator was able to compensate for the light components of the RAP binder that were lost over time. As a consequence, the behavior of the RAP binder at high, moderate, and low temperatures was recovered to that of the virgin binder. By mixing the RAP binder with the compound rejuvenator, the oxygenation indices were effectively reduced. The TGA revealed that the thermal stability of regenerated binders was equivalent to that of the virgin binders. In addition, the mechanical properties of regenerated mixes were enhanced in comparison to the control mixture. In summary, the adoption of RAP and WEO-SBS rejuvenator in asphalt mixtures show promising outcomes to enhance greener pavement materials application in the future.

1. Introduction

Hot mix asphalt (HMA) is designed to withstand continuous traffic loads and environmental assaults over its service life, which inevitably leads to distress like cracking and rutting [1]. When the performance of the HMA pavement surface deteriorates to a certain degree, it must be scrapped and restored, and reclaimed asphalt pavement (RAP) is then produced [2]. According to statistics, the total RAP generation in the world is rising considerably year after year [3]. Simultaneously, massive amounts of nonrenewable natural resources, such as gravel and asphalt binder, are depleted during accelerated road development. With growing awareness of environmental preservation and sustainable development, several nations have encouraged the usage of recycled materials in asphalt mixtures (i.e., RAP) [4].

Unlike fresh HMA, the RAP binder has been exposed to the environment for an extended period [5]. The combined action of oxidative condensation and light component evaporation is the fundamental process of asphalt aging, which results in notable changes in the asphalt

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