Influence of Bio-Rejuvenators on High-RAP Mixtures: Design Optimization and Performance Evaluation

Arun Sagar K M

Second Open Seminar

Abstract

Pavement construction necessitates substantial quantities of natural mineral aggregates, asphalt binders, and other critical construction materials. In addition to new construction, the rehabilitation of flexible pavements significantly increases material demand. The depletion of high-quality natural aggregates has therefore intensified the search for sustainable alternatives. In line with the United Nations Sustainable Development Goal 12 on responsible consumption and production, pavement engineering has increasingly adopted recycling practices, particularly the use of Reclaimed Asphalt Pavement (RAP). RAP is a recycled material obtained through the milling of asphalt layers, containing 90 to 95 % mineral aggregates with limited degradation, making it a viable substitute for virgin mineral aggregates. Its incorporation reduces dependence on natural resources and lowers construction costs.

High RAP mixtures, typically defined as those containing more than 30 % RAP, are gaining attention due to their economic and environmental benefits. However, the aged binder in RAP exhibits increased stiffness due to oxidation, which adversely affects mixture performance and restricts the allowable RAP content. To mitigate this limitation, rejuvenators are employed to restore the maltene fractions lost during service life. With the growing emphasis on sustainability and the use of naturally derived materials, bio-rejuvenators have gained popularity as sustainable additives for asphalt mixtures. However, the existing literature provides limited comprehensive guidance on mix design practices involving bio-rejuvenators while maintaining the desired performance standards of asphalt mixtures. Consequently, there is a need for systematic research to establish selection criteria and determine optimum dosages of bio-rejuvenators, develop and evaluate the performance of the bio-rejuvenated high-RAP asphalt mixtures.

The present study addresses this gap through five objectives: (i) development of a comprehensive literature database on RAP utilization and bio-rejuvenation; (ii) selection and

characterization of virgin and RAP materials; (iii) development of the framework for the selection of rejuvenators for the high-RAP asphalt mixture applications; (iv) determination of optimum rejuvenator dosage through rheological and consistency testing to replicate virgin binder properties; and (v) development and performance evaluation of high RAP mixtures incorporating rejuvenators at optimal dosages. Performance evaluation focused on high-, intermediate-, and low-temperature behavior, as well as moisture susceptibility. This research aims to establish a systematic framework for the development of high RAP mixtures incorporating bio-rejuvenators, thereby enabling large-scale recycling in India's road sector. The outcomes are expected to contribute to resource conservation, reduced environmental impact, and alignment with global sustainability goals, while supporting the rapid expansion of India's highway infrastructure.