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CAL POLY

Performance Evaluation of Fiber-Reinforced Hot Mix Asphalt Containing Reclaimed Asphalt Shingles

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Introduction

Reusing asphalt pavement and shingles in new asphalt can reduce waste, conserve natural resources, and lower the demand for virgin materials. However, increasing recycled content creates a difficult engineering tradeoff. Reclaimed asphalt pavement (RAP) and reclaimed asphalt shingles (RAS) can reduce demand for virgin binder and aggregate, cut waste, and support environment improvement goals. RAS brings a valuable asphalt binder, but that binder is aged and stiff. More RAS can help a mix resist rutting (permanent depressions that form in wheel paths) while making it more brittle and vulnerable to cracking. The study examined whether polymer fibers can help RAP/RAS asphalt retain recycled-material rutting benefits while restoring cracking resistance. The findings have important implications for California and other states seeking to increase recycled content under performance-based asphalt mix design.

Study Methods

The research team evaluated dense-graded hot mix asphalt (the most common type of asphalt used for roads) mixtures designed around a constant 25% RAP content. RAS was added at two levels—3% and 5% by total mix weight. Each RAS level included a control mix with no fiber- and six fiber-reinforced mixtures. Two para-aramid fiber products were tested. Fiber A was wax coated and contained at least 63% para-aramid material. Fiber B was treated with a liquid emulsion binder and contained at least 75% para-aramid material. Each fiber was added at 0.05%, 0.10%, and 0.15% by total mix weight, producing 14 mixtures in all. Materials and job mix formulas (the recipes used to produce asphalt) were provided by Granite Construction. The base asphalt binder (the material that holds the aggregate together) was PG 58-22, with an optimum binder content of 5.2% by total mix weight. Specimens were prepared with a Superpave Gyratory Compactor (a standard laboratory device that simulates field compaction) and controlled to a target air void content of 7.0%, plus or minus 0.5%, so performance comparisons would not be driven by inconsistent compaction. The team used two common Balanced Mix Design performance tests. The Hamburg Wheel Tracking test measured rutting and moisture sensitivity while specimens were submerged in warm water and loaded by repeated wheel passes. Rut depth at 15,000 passes was used to compare deformation resistance, and the stripping inflection point was used to screen moisture damage. The IDEAL Cracking Test measured intermediate-temperature cracking resistance. Its main output—CTindex—increases as cracking tolerance improves.

Findings

The study confirmed the core tradeoff associated with reclaimed asphalt shingles. In control mixtures without fibers, increasing RAS from 3% to 5% reduced rut depth from 3.66 mm to 2.87 mm at 15,000 wheel passes, indicating better resistance to rutting (the permanent grooves that develop in wheel paths). However, the CTindex (a measure of cracking resistance) fell from 55.42 to 21.04, indicating a substantial loss in the pavement's ability to resist cracking. Fiber reinforcement generally improved performance, but the best dosage depended on RAS level and fiber type. In the 3% RAS mixtures, both fibers reduced rut depth compared with the control, although the rutting changes were not statistically significant. Fiber B at 0.15% produced the lowest rut depth for that group (2.79 mm). For cracking, Fiber B at 0.10% was the standout; the CTindex reached 119.79, more than double the 3% RAS control, and this was the only statistically significant cracking improvement at the lower RAS level. The fiber effect was stronger in 5% RAS mixtures. Fiber B at 0.05% produced the lowest rut depth in the study, 1.87 mm. Fiber A at 0.10% and 0.15% and Fiber B at 0.05% and 0.15% produced statistically significant rut depth reductions. Cracking also improved sharply. Fiber A was statistically significant at 0.15%, reaching a CTindex of 97.23. Fiber B was statistically significant at all three dosages, with the highest CTindex, 106.90, at 0.15%. No mixture showed stripping (moisture-related separation of the asphalt binder from the aggregate) before 10,000 Hamburg wheel passes, indicating adequate moisture resistance. Overall, Fiber B performed especially well for cracking resistance, likely because of its higher active para-aramid content and liquid emulsion treatment, which may improve dispersion and bonding in the asphalt mastic.

Policy/Practice Recommendations

Agencies should evaluate RAP-RAS mixtures through Balanced Mix Design (an approach that tests both rutting and cracking performance) rather than relying only on fixed recycled-content limits. The findings support the use of engineered polymer fibers as a practical tool for restoring cracking resistance in high-recycled asphalt mixtures, especially mixtures with 25% RAP and up to 5% RAS. Specifications should not assume one universal fiber dosage. Fiber type, RAS content, binder grade, aggregate structure, and plant mixing practices all influence performance. Instead, agencies should require mixture-specific rutting, cracking, and moisture testing before approving higher RAS contents. For implementation, the most promising next steps are pilot field sections, plant-scale checks of fiber dispersion, long-term aging evaluation, and assessing life-cycle cost and environmental impacts.

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