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Monte Carlo modeling of asphalt surface wear under studded-tire traffic

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This study investigates the evolution of asphalt pavement surface damage caused by studded-tire traffic using a combined experimental and stochastic modeling approach. Laboratory tests on six asphalt mixtures were integrated into a Monte Carlo simulation framework that models rutting as the cumulative effect of random stud impacts. The model incorporates parameters describing cumulative damage, particle detachment energy thresholds, and material susceptibility to wear. The simulations successfully reproduce the transition from an initial nonlinear damage phase to a stabilized linear rutting regime observed experimentally. A strong linear relationship was identified between the stochastic detachment parameter, the laboratory rutting rate, and the abrasion resistance of the mixtures. These results confirm the model's capacity to reproduce measurable material behavior. By linking mixture characteristics to probabilistic descriptions of surface deterioration, the proposed framework provides a predictive tool to support the design of more wear-resistant pavements in cold-climate regions.

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