Abstract

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Thesis title: **Development of Hydrophobic Bitumen Emulsion for Bituminous Road in Sub-Zero Temperature Regions**

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The accumulation of snow and ice on asphalt pavements in colder regions poses significant safety risks, including accidents, reduced friction, decreased skid resistance, and increased emergency braking distances, endangering drivers and pedestrians. Therefore, it is paramount to maintain safe and drivable road conditions during and after snowfall through some of the engineering approaches. Traditional methods like spraying salts and chemicals, although effective in melting snow, it causes environmental pollution by contaminating water bodies, harming aquatic life. Such methods also corrodes nearby metal installations. Similarly, other methods like snow ploughing also helps in removing the snow; however, it requires significant manpower and resources and struggle with thin ice layers, especially black ice, which is hazardous and difficult to detect. Given these challenges, there is pressing need for innovative solutions that can mitigate the accumulation of snow and ice without causing environmental harm or requiring intensive labour. Innovative solutions are needed to address these challenges without environmental harm or intensive labour. One promising approach is to enhance the pavement surfaces themselves to prevent ice adhesion and formation. By introducing hydrophobic materials into the pavement composition, it is possible to create surfaces that repel water and reduce the likelihood of ice formation. Polytetrafluoroethylene (PTFE) is known for its excellent hydrophobic properties and durability, making it an ideal material for this purpose. This study investigates the development and performance of hydrophobic bitumen emulsions, incorporating PTFE as a hydrophobic agent, to enhance the water-repellent properties of asphalt pavements in sub-zero temperature regions.

The methodology involved preparing hydrophobic bitumen emulsions with varying PTFE concentrations and testing their potential as hydrophobic coatings for bituminous roads in low-temperature regions. Basic ice repellency was characterized using contact angle measurements, and the result showed significant enhancement in hydrophobicity with PTFE addition. The prepared emulsion coating was then subjected to performance-based experiments such as adhesion tests (ice-asphalt bonding), impact tests (simulating vehicle force on ice), water droplet icing time tests (freezing delay), and skid resistance tests (pavement performance). To begin with the experiment, a self- designed adhesion mould, compatible with the Universal Testing Machine (UTM) was developed to measure the peak load between ice-asphalt interface accurately. An impact test setup, was designed, featuring a mechanism to release a ball from a specified adjustable height. These setups were crucial for mechanistic evaluation of ice-pavement surface coated with bitumen emulsion.

The thesis findings show that incorporating PTFE into bitumen emulsions significantly enhances hydrophobicity. Adhesion tests indicated a notable reduction in ice-pavement bond strength, enabling effective ice detachment. Impact testing revealed that treated pavement surfaces were more susceptible to breaking ice under tire pressure. Water droplet tests demonstrated significant delays in freezing times, indicating improved water repellency with various PTFE concentrations. Although there was a slight reduction in skid resistance measured by the British Pendulum Tester (BPT), all formulations met safety standards for adverse weather conditions. Rheological assessments using a Dynamic Shear Rheometer (DSR) and a rotational viscometer highlighted favourable high temperature performance characteristics of emulsions with optimal PTFE levels, showing their suitability even in high summer temperatures. Overall, the research demonstrates the potential of PTFE-based hydrophobic emulsions to enhance road safety in colder regions.