2022 Mid-Continent Transportation Research Symposium
Ames, Iowa
September 14–15, 2022
intrans.iastate.edu/events/midcon2022/

Mitigating Frost Heaving in Roadways by Engineered Water Repellency

Md Fyaz Sadiq, Michigan State University
Mohammad Wasif Naqvi, Michigan State University
Bora Cetin, Michigan State University
Micheal Uduebor, University of North Carolina-Charlotte
John Daniels, University of North Carolina-Charlotte

Abstract

Frost heaving and thaw weakening have a significant effect on performance and maintenance of transportation infrastructure in regions with seasonal subfreezing temperatures. Frost heave occurs under the following three conditions: (1) freezing temperature, (2) frost-susceptible (typically silt-sized) soil, and (3) water availability. Under these conditions, the water turns into the form of ice lenses that grow in the direction of heat loss and causes heaving in soils. When the temperature increases during the spring season, the ice melts inducing thaw settlement and causing a reduction in soil strength. Limiting any one of the three conditions would limit the frost action and its subsequent damages. Water repellent additives can be very effective in limiting water movement toward the frozen fringe by inducing soil hydrophobicity. In this study, frost susceptible soils were stabilized with a water repellent organo-silane (OS) chemical. OS is a silicon-based coupling agent capable of producing hydrophobicity in soils. The effects of OS incorporation on the contact angle, water movement, frost penetration, and heave rate were evaluated. Water migration was significantly reduced due to the influence of OS-treated soil layers. The heave rate of one treated soil was reduced by 84% from 16 mm/day to 2.5 mm/day compared to the untreated soil. These results are expected to be useful for the agencies aiming to minimize the frost heave potential in new construction as well as rehabilitation of existing pavements.

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