CTIPS Center for Transformative Infrastructure Preservation and Sustainability

USDOT Region 8 University Transportation Center

Wicking Fabrics for Mitigating Freeze-Thaw Effects in Pavement Systems

CTIPS-077 – UTC Project Information

Recipient/Grant Number:	North Dakota State University, South Dakota State University Grant No. 69A3552348308
Center Name:	Center for Transformative Infrastructure Preservation and Sustainability
Research Priority:	Preserving the Existing Transportation System
Principal Investigator(s):	Aritra Banerjee, Ph.D., P.E. Rouzbeh Ghabchi, Ph.D., P.E.
Project Partners:	USDOT, Office of the Assistant Secretary for Research and Technology – $55,000 South Dakota State University (SDSU) – $33,924 South Dakota Department of Transportation – $20,330 SDSU Foundation – $6,746
Total Project Cost:	$116,000
Project Start and End Date:	10/29/2026 to 11/30/2029

Project Description

Moisture accumulation in pavement base and subgrade layers reduces stiffness, increases deformation, and accelerates deterioration, particularly in cold regions where repeated freeze–thaw (F–T) cycles intensify damage. Although wicking geotextiles have demonstrated effective moisture removal under unsaturated conditions, their ability to mitigate F–T-induced distress remains largely unexplored. This study will evaluate the effectiveness of wicking geotextiles in controlling moisture and improving the resilience of pavement foundation layers subjected to cyclic freezing and thawing.

The research will investigate the moisture transport capacity of wicking fibers and geotextiles with different fiber configurations through controlled laboratory testing. Instrumented small-scale test boxes representing unpaved pavement sections will undergo repeated wetting–drying and freeze–thaw cycles in an environmental chamber while monitoring moisture content, soil suction, temperature, deformation, and stiffness. Comparisons between wicking-stabilized and control sections will quantify improvements in moisture reduction, frost heave mitigation, and post-thaw stiffness recovery.

The study will identify minimum effective wicking fiber configurations that balance performance and cost. Outcomes will include performance-based design guidance and life-cycle cost implications for

transportation agencies, supporting the development of more durable, cost-effective, and climate-resilient pavement infrastructure.

USDOT Priorities

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Outputs

This research will evaluate the effectiveness of different wicking fiber configurations for improving pavement durability under wetting–drying and freeze–thaw conditions. Laboratory testing will generate performance data on moisture reduction, stiffness retention, and durability while identifying cost-effective wicking configurations suitable for implementation.

Key outputs will include performance-based guidance for wicking fiber selection and placement, comparative evaluation of stabilized and control pavement sections, and life-cycle cost analyses quantifying potential long-term savings. These results will be synthesized into implementation guidance for transportation agencies in cold-region environments.

The project will be conducted in collaboration with the South Dakota Department of Transportation (SDDOT) and industry partners to ensure practical relevance. Results will be disseminated through meetings, webinars, workshops, and presentations to SDDOT, the National Road Research Alliance, TRB, and ASCE GeoCongress.

The project will provide transportation agencies with practical guidance for selecting wicking geotextile configurations to mitigate moisture-related distress, including fluctuating moisture, weak base or subgrade conditions, flooding, and freeze–thaw heave. Combined with life-cycle cost analysis, the results will support evidence-based implementation decisions under Region 8 conditions.

Outcomes/Impacts

This project will improve understanding of how wicking fiber configuration influences moisture redistribution, stiffness retention, and deformation of pavement foundation layers subjected to wetting–drying and freeze–thaw cycles in Region 8.

The results will provide transportation agencies with performance-based guidance for selecting cost-effective wicking geotextile configurations. Identifying minimum effective fiber concentrations will enable lower-cost solutions while promoting sustainable material use and efficient infrastructure investment.

Improved moisture control is expected to extend pavement service life, reduce maintenance and rehabilitation needs, and enhance transportation reliability. By minimizing freeze–thaw damage and moisture-related deterioration, the project will reduce user costs and support implementation of wicking geotextiles as a practical strategy for improving pavement resilience in cold climates.

Final Report

Upon completion, the final report link will be added to the project page on the CTIPS website.