Effectiveness of Warm Mix Asphalt Additives as Compaction Aid in Cold Regions Through Application of Wireless Sensors and Performance Tests

CTIPS-042 – 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):	Rouzbeh Ghabchi, Ph.D.
Project Partners:	USDOT, Office of the Assistant Secretary for Research and Technology – $136,549
	South Dakota State University – $136,549
Total Project Cost:	$273,098
Project Start and End Date:	3/23/2025 to 3/22/2028

Project Description

To achieve an adequate field density in hot mix asphalt (HMA) construction, depending on the asphalt binder type, asphalt mixes are laid down while the mix temperature exceeds 120°C. In the cold regions, the foregoing mix temperature requirements limit the seasonal construction window, negatively affecting the pavement construction and preservation operations. Incorporating warm mix asphalt (WMA) additives in the asphalt mixes provides the workability necessary for the compaction of the mixes at temperatures lower than those required for the HMA while achieving the desired field density. At low ambient temperatures, WMA additives are used as a compaction aid to continue paving operations and still achieve acceptable compaction for HMA. In this process, different types of WMA additives with different amounts are used depending on the project location, product availability, and the experience of the agencies or contractors. However, the effectiveness of the WMA additives in improving the compaction practices based on the local aggregates, asphalt binders, and temperature ranges occurring in the Upper Midwest is unclear. More specifically, laboratory or field data based on which the allowable minimum ambient construction temperature for each type of WMA additive can be determined is missing. Through a laboratory study, this project will evaluate the compaction efficacy of different WMA additives when used as a compaction aid or temperature reduction agent in producing the HMA and WMA mixes using advanced wireless compaction monitoring sensors. The collected data will be applied to determine the minimum allowable mix temperature for compaction in the cold regions based on the type of mix and

additive used. In addition, the minimum allowable ambient temperatures for compaction will be determined based on the available methods of estimating the effect of solar energy, wind, and mat thickness on the cooling rate of the pavement using available thermal diffusivity and conductivity models. Furthermore, the impact of WMA additives on the resistance of the mixes to rutting, stripping, and cracking at intermediate and low temperatures will be determined in this study. The findings of this study are expected to facilitate the data-driven selection of the WMA additives and minimum allowable compaction temperatures in cold regions to maximize the performance, economic, and environmental benefits of the WMA technology and extend the lifespan of the pavements.

USDOT Priorities

The expected outcomes of this project are directly related to the following USDOT strategic goals: Transformation. The outcome of the proposed project will facilitate the selection and the use of WMA additives to improve field densities at ambient temperatures lower than those generally used for the compaction of the HMA mixes using new technologies. This will lead to an extended construction season after implementation but also result in the longevity of the asphalt pavements due to improved field densities, contributing to the sustainability of the ground transportation and conserving energy.

Outputs

This study will implement a new technology: an aggregate-sized wireless compaction sensor. The outcomes will result in a data-driven decision process for selecting and utilizing WMA additives as a compaction aid in cold regions to maximize the additives' compaction benefits. Furthermore, compaction and performance databases for asphalt mixes used in the upper Midwest will be developed as part of this study. Moreover, new partnerships will be established with Ingevity Co. and Penn State University Altoona from outside CTIPS.

The technology transfer plan for this project utilizes different avenues for research dissemination to maximize the project's impact. The findings of this project will be presented to a broad audience with the help of SDLTAP through the South Dakota Annual Asphalt Conference. This well-attended conference allows broader participation by pavement engineers, the asphalt industry, the South Dakota Department of Transportation's personnel, NAPA members, and others. In addition, a webinar will be organized through the Transportation Learning Network (TLN) to reach a broader audience and disseminate the findings. The research team has a successful track record of reaching the public and professionals through TLN's webinars. Furthermore, research papers will be published, and presentations will be made at conferences and other occasions to disseminate this study's findings effectively. Toward building a stronger transportation workforce, a significant component of the CTIPS mission and vision, it is planned to blend research ideas and innovations into the classroom. More specifically, it is expected to bring the research findings into the classroom in the CEE 411-Asphalt Materials and Mix Design course.

Outcomes/Impacts

The outcomes of this project and the database of testing asphalt mixes and their compaction and performance characteristics developed in this study are expected to help facilitate the development of specifications to be used in design and construction using HMA mixes containing WMA additives as compaction aids and temperature-reducing agents in cold regions. More specifically, the developed database is expected to help select the minimum compaction temperatures at the beginning of the cold season in the Upper Midwest region to improve compaction and field densities without compromising the durability and performance characteristics of the mix.

Final Report

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