Assessing Condition of Rehabilitated Concrete Pavement with Slab Fracturing and Asphalt Overlay Using Distributed Fiber Optic Sensors

CTIPS-002 – UTC Project Information

Recipient/Grant Number:	North 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):	Pan Lu, Ph.D. Ying Huang, Ph.D.
Project Partners:	USDOT, Office of the Assistant Secretary for Research and Technology – $115,079 North Dakota State University – $115,079
Total Project Cost:	$230,158
Project Start and End Date:	4/17/2024 to 4/16/2026

Project Description

The United States is experiencing a significant increase in registered motor vehicles, resulting in increasing traffic loads on transportation infrastructure, particularly on roads prone to cracking. Asphalt overlay is commonly used to rehabilitate concrete pavements. However, asphalt overlay often results in reflective cracking, leading to expensive repairs. To address this issue, slab fracturing and asphalt overlay has been popularly applied to rehabilitate cracked concrete pavements in recently years. To investigate the effectiveness of the slab fracturing and asphalt overlay for concrete pavement rehabilitation, his research focuses on understanding how crack propagate through the asphalt overlay. While current crack detection methods struggle to assess bottom-up cracking effectively, posing safety hazards and financial burdens, this project proposes to use distributed fiber optic sensing (DFOS) to monitor bottom-up cracking of the rehabilitated concrete pavements using slab fracturing and asphalt overlay in real time. Through a comprehensive approach combining numerical simulations and laboratory experiments, this research aims to expand our understanding of crack formation mechanisms while assessing the effectiveness of DFOS for monitoring bottom-up cracks in pavements. Numerical simulations using finite element analysis replicate real-world pavement conditions and consider factors such as traffic loading and material properties. Laboratory experiments entail constructing pavement specimens with different layers, installing DFOS sensors to measure strain during crack emergence, and subjecting specimens to

controlled loading conditions resembling real-world scenarios. Anticipated outcomes include providing effective pavement condition monitoring alternatives for rehabilitated concrete pavements using slab fracturing and asphalt overlay, contributing to safer and more sustainable management of transportation systems.

USDOT Priorities

The proposed project aligns closely with the USDOT strategic goal of Safety, which serves as the primary focus of the initiative. By implementing DFOS to monitor crack propagation and assess the condition of rehabilitated concrete pavement, the project directly contributes to enhancing road safety. Through early detection of cracks and identification of potential penetration paths, the project aims to mitigate the risks associated with deteriorating road infrastructure, thereby reducing the likelihood of accidents and injuries for motorists. Furthermore, the project's secondary alignment with the strategic goal of Climate and Sustainability underscores its broader impact on transportation systems. By promoting proactive maintenance strategies and minimizing the need for costly repairs and reconstruction, the project contributes to the sustainability of transportation infrastructure, reducing resource consumption and environmental impact associated with extensive pavement rehabilitation efforts. Overall, the project's focus on safety and sustainability underscores its significant relevance to the strategic goals outlined by USDOT, positioning it as a vital initiative in ensuring the resilience and efficiency of transportation networks.

Outputs

This project will transfer technology through peer-reviewed research report, one to two peer-reviewed journal articles, one to two peer-reviewed conference papers, in addition to newsletters, workshops, webinars, seminars, the CTIPS website, etc. This project will also participate the CTIPS T2 programs to engage clients and disseminating research results through (1) virtual delivery via live webinars, recorded online modules, videoconferences; (2) in-person seminars or presentations; (3) conferences or workshops that organize related T2 topics into day-long or multi-day events.

Outcomes/Impacts

The expected outcomes of this research include:

1) Advancements in pavement condition monitoring through the innovative application of distributed fiber optic sensing (DFOS) technology and assessing the effectiveness of DFOS in real-world scenarios;
2) Comprehensively understanding crack formation mechanisms by integrating numerical simulations and laboratory experiments;
3) Providing insights into crack propagation dynamics, crack initiation and propagation, and pavement behavior prediction, and enabling early identification of pavement issues.

The outcomes of this project promise to revolutionize infrastructure maintenance practices by providing stakeholders with accurate and timely information for informed decision-making, ultimately enhancing the longevity and sustainability of transportation networks.

Final Report

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