

Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Field Demonstration of GPR and UAV Technologies for Evaluation of Two US 75/77 Bridges

Research Objectives

1. Collect GPR and imaging data on two US75 bridges prior to removal of asphalt overlay. UAV will be used to acquire imaging data on both top and bottom surfaces.
2. Analyze GPR data, top surface images, and bottom surface images. Estimate repair area and compare to actual repair area.
3. Evaluate performance of UAV aided visual inspection based on GPR results and develop an NDE data analysis system for future application to other Nebraska bridges with overlays.

Research Benefits

Nebraska is applying asphalt overlay and waterproof membrane on most bridges to improve the lifespan of concrete bridge decks. In order to evaluate the bridge decks with asphalt overlay, there is a need to develop and validate NDE data analysis methods using field testing data that is essential for future application to large numbers of Nebraska bridges. Data fusion between surface images and in-depth GPR results provided a quick screening tool based on images and a comprehensive evaluation of bridge decks using multiple NDE methods. This research will aid bridge managers in making decisions about rehabilitation strategies for bridge decks.

Principal Investigator

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Background

Asphalt overlay is increasingly applied on many Nebraska bridges. The asphalt overlay prevents visual inspection and many nondestructive evaluation (NDE) methods. Ground Penetrating RADAR (GPR) is currently the only proven NDE method that can be used to evaluate a concrete bridge deck with asphalt overlays (ASTM 2015). GPR can penetrate through the asphalt layer and the amplitudes of GPR reflection signals from reinforcing bars are used to evaluate the deck condition. In a previous NDOT project (M-065), the PI's team developed a complete procedure of GPR data analysis for bridge deck evaluation, which has been used to evaluate bridge decks with various types of overlays (bare, concrete overlay, asphalt overlay).

In this implementation project, GPR and Unmanned Aerial Vehicle (UAV) imaging technologies will be used for rapid nondestructive evaluation (NDE) of two bridges (S075 17062, S075 17596). Collecting data on bridges during the repair construction will provide valuable information to improve the accuracy of the NDE technologies for other aging bridges. This phase I project will focus on data collection prior to asphalt removal during Fall 2020. The main tasks include field data collection using GPR and UAV imaging system, data analysis and final report.

Conclusion

Two Nebraska bridges with asphalt overlay were selected for nondestructive testing and evaluation (NDT/NDE). Three NDT techniques were conducted on these two bridges, including Ground Penetrating Radar (GPR), Half-Cell Potential (HCP) and Unmanned Aerial Vehicle (UAV) imaging. NDT data were collected during three construction stages of the bridges: (1) before repair on existing asphalt overlay; (2) on bare concrete after asphalt removal; (3) and after repairing delaminated concrete.

A machine learning technique, autoencoder, is used to build the quantitative relationship between different NDT data sets. On bare concrete, the GPR amplitude and HCP voltage show a strong linear relationship. Then a threshold for GPR amplitude (-6.4 dB) can be determined based on the well-established HCP criteria. The GPR amplitudes on asphalt overlay also show a clear correlation with GPR amplitudes on bare concrete. Direct comparison of two GPR amplitude maps indicates GPR data collected on asphalt overlay could detect all severely deteriorated areas but may miss some mild deterioration.

A big data image pipeline was created for mapping cracks and repair patches with images collected from an UAV. Comparing surface defects on asphalt overlay with HCP and GPR data suggests that UAV images may be used as an initial decision criterion for deploying and extending NDT inspection of bridge decks. Further studies are needed to evaluate the performance of UAV imaging based visual inspection through quantitative analysis of surface defects and severity of deterioration.

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Final report is available at:
[NDOT Research Website](#)

NDOT Recommendations Based on Completed Research Project

Asphalt overlay is increasingly applied on Nebraska bridges. GPR is the only proven NDE technique for evaluation of bridge decks with asphalt overlays. The research team has successfully developed data analysis software for ground-coupled GPR in this project and determined the threshold values. However, the need for traffic control limits widespread application of the ground coupled GPR.

Therefore, the Department has funded a new project starting in July 2022 with the purpose of evaluating air-coupled GPR and vehicle mounted HD imaging systems as potential technologies for high-speed NDE of bridge decks.

The current GPR analysis software has many limitations, driving the need to develop air-coupled GPR data analysis algorithms for evaluation of bridge decks with asphalt overlay. Data fusion analysis will be used to determine the threshold values for air-coupled GPR amplitude on bridge decks with and without asphalt overlays.

- *As provided by Fouad Jaber, Lead TAC Member*

Research Readiness Level (RRL) Assessment

Level 4: Implementation–

RRL 4

Research/Technology refined and adopted by the Department. Benefits of the implementation will be evaluated for a time frame of 5 years.

Technology Transfer

Principal Investigator did not have any technology transfer for this research project.

**This brief summarizes Project SPR-P1 (21) FY21(012)
“Field Demonstration of GPR and UAV Technologies for Evaluation of Two US 75/77 Bridges”
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