TDOT Department of Transportation

Research Summary

Concrete Bridge Deck Deterioration Assessment Using Ground Penetrating Radar

Project Number:
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WHAT WAS THE RESEARCH NEED?

Bridges are critical infrastructure systems to support transportation. There are about 20,000 highway bridges in the state of Tennessee that need to be inspected periodically to ensure safety and plan possible maintenance and repair. Traditional methods for concrete bridge deck condition assessment such as visual inspection, chain dragging, and hammer sounding are subjective and time-consuming. Ground penetrating radar (GPR) is a non-destructive testing technique that can complement these traditional methods to provide quantitative data for bridge deck inspection and condition assessment. For the Tennessee Department of Transportation (TDOT) to adopt GPR for bridge inspection and assessment, critical issues had to be investigated to assess the practical applicability of GPR for concrete bridge deck deterioration assessment.

WHAT WERE THE RESEARCH OBJECTIVES?

The objectives of the research included:

1. identify appropriate GPR system configurations and parameters to achieve efficient and effective bridge data collection.
2. Develop a workflow and associated tools for processing GPR data and produce deterioration maps of bridge decks.

WHAT WAS THE RESEARCH APPROACH?

The research team reviewed relevant GPR studies and the state of practice to examine and identify appropriate GPR system configurations and parameters most suitable for concrete bridge deck survey and inspection. Computer

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simulations were performed to generate GPR scans of bridge defects; experiments were conducted to collect real GPR scans on concrete decks with artificial defects. The GPR scans were used to investigate the signal patterns and features of defects to examine the potential of using GPR to detect and characterize bridge deck defects and deterioration areas. Workflow and machine-learning based data processing tools were developed to detect, map, and visualize potential deterioration areas of a bridge deck from collected GPR data. Lastly, case studies were conducted to use the developed workflow and tools for processing the GPR data collected from three concrete bridge decks, which demonstrated the usability of the developed methods and tools.

WHAT WERE THE FINDINGS?

The research produced four major findings:

- As GPR system configurations and scanning parameters impact data collection efficiency and data quality, a GPR system with antenna frequency from 1.5 GHz to 2.6 GHz should be used. The following parameters may produce good quality data in an efficient manner: 6-10 nanosecond (ns) time window, 512 samples per scan, 79 scans per meter, and 0.3-0.6m scan spacing. A perpendicular scanning direction to the top rebar mat should be maintained.
- Rebar corrosion and concrete deterioration exhibit attenuated signal amplitudes or blurry hyperbolic features at rebar locations, which can be used to indicate potential deterioration areas.
- Detecting and locating rebars in GPR scans and assessing the signal amplitude attenuation are critical steps to process GPR data to indicate the areas of potential deterioration in concrete bridge decks.
- After signal amplitude normalization and depth correction, median absolute deviation can be used to set the threshold value to detect potential deterioration areas.

IMPLEMENTATION AT TDOT

The research team recommended TDOT use GPR as a complementing technique to existing methods for concrete bridge deck deterioration assessment. To expedite the use of GPR in bridge deck assessment, appropriate system configurations and scanning parameters should be used to ensure data collection efficiency, and automated processing methods should be used to reduce the efforts in manual analysis and interpretation. Estimating and visualizing potential deterioration areas of bridge deck from GPR scans should be implemented to provide quantitative information for inspection, asset management, and decision-making. GPR results should be carefully examined and interpreted when used for detecting and characterizing specific defects such as delamination. For complete and more accurate bridge deck deterioration assessment, GPR should be used in conjunction with other methods to improve the assessment performance.

MORE INFORMATION

Find the final report here: https://www.tn.gov/content/dam/tn/tdot/long-range-planning/research/final-reports/res2019-final-reports/RES2019-17_Final_Report_Approved.pdf.

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