

JOINT TRANSPORTATION RESEARCH PROGRAM

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Synthesis Study: Overview of Readily Available Culvert Inspection Technologies

Introduction

Culverts, conduits that facilitate passage of water through embankments or beneath roadways and other structures, represent important components of infrastructure systems, helping to drain, direct, or divert surface water and prevent the disruption of roadways by overtopping flows or erosion. According to the Indiana Department of Transportation, there are likely more than 80,000 culverts beneath Indiana roadways with a cross-sectional width between 10" and 42". Their efficient inspection and maintenance is thus critical to safe operation of Indiana's transportation infrastructure.

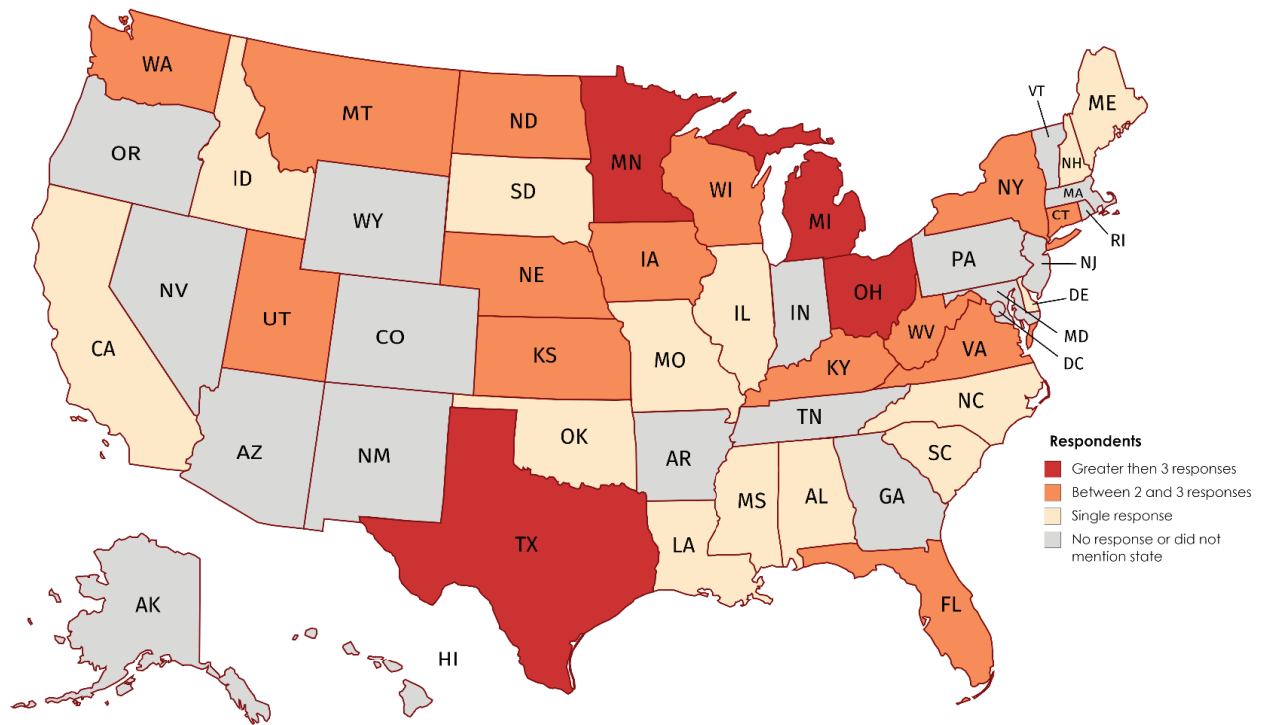
Approximately 25% of culverts associated with INDOT-managed roadways are inspected each year under INDOT Work Performance Standard 2320, with enhancements to the inspection procedure recommended and implemented as recently as 2014. Although inspection procedures have become more rigorous through these efforts, inspectors face many challenges in determining the actual condition of culverts, which can vary substantially in material type, form, length, depth of cover, accessibility, and age. This study was performed to understand and synthesize alternative culvert inspection methods, with a focus on identifying and prioritizing readily available solutions.

Findings

This study revealed that no standard inspection guidelines exist for small culverts and that inspection practices vary significantly across states. DOT survey results confirmed that most DOTs do not have a specific technical solution for small to medium culvert inspections and instead rely primarily on visual examination conducted by field personnel, often from the open ends of the culvert, which limits the range of flaws and failure modes that

can be identified and the desired early warning benefits of inspection. The synthesis of available technical solutions demonstrates that a broad range of technologies are available to facilitate culvert inspection. However, many methods can only be employed for a limited set of culvert materials and operating conditions. As a result, more broadly applicable inspection methods such as visual camera-based and multi-sensing techniques stand out for their high potential to provide significant insight into the condition of a variety of culvert types at low to moderate cost.

Thus, the focus for DOTs such as INDOT should be developing and deploying a low-cost multi-sensing solution founded on visual techniques, with the added ability to navigate within a culvert via deployment on a remote-controlled mobile platform (e.g., a radio controlled (RC) vehicle)—a method broadly termed a visual-camera-on-crawler solution. Inspiration for this type of system can be derived by combining devices such as the Ultrasonic Culvert Inspection System developed by the Southwest Research Institute (SwRI) and FHWA, with additional capability to be mounted on a crawler for use in dry culvert conditions. Additionally, for visual-camera-on-crawler techniques, improvements such as the use of a side-scanning camera could greatly enhance efficiency and effectiveness by eliminating the need for stopping, panning, tilting, and zooming, thereby reducing the in-field time and effort of the system operator. Aside from adopting technology to facilitate inspection, a long-term goal should be developing a systematized phase-wise approach for issue detection and maintenance of culverts. Such a system would be particularly valuable when used in combination with the Esri Collector Application database that INDOT has commissioned for infrastructure maintenance. Furthermore, as data is collected via these systems, stochastic predictive models could be developed to provide INDOT asset managers



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with an informed rationale to schedule inspections and enhance overall resource utilization and efficiency in the inspection and maintenance of culvert infrastructure.

Implementation

The results of this synthesis study provide a ranked recommendation of readily available culvert inspection solutions. The recommendations are segmented according to their applicability to varying culvert conditions and inspection needs, including culvert material, flow condition, deployment constraints, and inspection time. Model numbers, vendor-related information, and, to the extent possible, general cost estimates are provided to assist in technology acquisition and development decision-making.

Recommended Citation for Report

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