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TECHNICAL SUMMARY

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PROJECT COST:
$118,470

Laser ring profilers offer precise readings of how much culverts have reshaped under environmental conditions.

Guidebook Reviews Available Inspection Technologies for Improving Culvert Repair

MnDOT developed a guide that describes traditional and enhanced culvert inspection methods and tools, their limitations and costs. The guide also includes best practices for identifying when conventional inspection methods work best and when enhanced technologies may offer good value.

What Was the Need?

MnDOT manages more than 100,000 culverts in the state's highway culvert system. Culverts are inspected routinely to monitor corrosion and other damage that could lead to expensive repairs and highway closures.

New culverts are inspected to confirm that construction measures up to specification. Centerline culverts, which run from one side of the road to the other under pavement, must be inspected every two to six years. MnDOT also inspects culverts in emergencies or when the public notifies the agency of potential damage or blockage.

Inspection typically begins with an end-of-pipe visual investigation, usually aided by flashlight or occasionally by a camera placed in the pipe. If pipes are large enough, inspectors enter the pipe to examine the walls and measure corrosion or other damage, take photos and conduct hands-on examinations.

But not all culverts are large enough for human access, and inspecting damaged or failing culverts can be dangerous. New, enhanced technologies may offer valuable, safer inspection options.

What Was Our Goal?

This project aimed to review common inspection technologies available for culvert and pipe inspection. The results of this review would then be used to develop guidance for choosing a cost-effective inspection strategy that was appropriate for the site and would provide the required data.

What Did We Do?

The research team began by reviewing literature related to culvert inspection best practices. The team then interviewed inspectors from various Minnesota counties and MnDOT districts, and from five other state transportation agencies to gather additional information on best practices.

Next, investigators reviewed 12 videos of MnDOT inspections performed from 2011 through 2016 and then contracted with a robotics inspection firm to conduct end-of-pipe, laser ring and video inspections of 10 MnDOT culverts that represented a range of sizes, pipe materials and on-site conditions. The results from the three inspection methods were compared to identify best practices, which were incorporated along with the best practices from the literature review and interviews in the Enhanced Culvert Inspections—Best Practices Guidebook.

What Did We Learn?

The guide describes traditional and enhanced inspection technologies and methods, their limitations, costs and best uses for specific situations. Each method offers distinct advantages and disadvantages. End-of-pipe inspection costs about 7 cents per foot, and

continued

"We wanted to document how far you can see into the pipe to get a good inspection and when more than an end-of-pipe inspection was needed. We found that there are some cost-effective options for doing more than end-of-pipe inspections."

—Andrea Hendrickson,
State Hydraulic Engineer,
MnDOT Office of Bridges and Structures

"Inspection crews need to understand what type of data they want to gather for each situation, and then balance the quality of data required with the cost of the inspection method."

—Doug Youngblood,
Environmental Engineer,
CDM Smith

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MnDOT inspectors constructed this HIVE inspection robot from off-the-shelf electronics, developing an inexpensive and effective imaging tool for culvert inspection.

enhanced inspections cost from 23 cents to $6.50 per foot. Before using enhanced methods, inspectors should have a firm grasp on the quality of data and detail required to best optimize their choices and budget limitations.

End-of-pipe inspections are the fastest and least costly of the methods, but provide the least data. Typically, an inspector with a flashlight can investigate from 5 to 30 feet inside the culvert from the end of the pipe. These inspections work well for determining work conditions and data needs.

Measurement-based inspections include traditional and enhanced methods, including person-entry inspections, hammer sound testing and coring, mandrels and multiple-sensor units such as laser and sonar profilometers. Laser ring scanning offers precise measurement and excellent quantitative data on culvert alignment and geometry. Multiple-sensor units are the most expensive inspection method based on cost per foot and time to process the data, which often takes weeks.

Video inspection typically entails the use of closed-circuit television (CCTV) cameras or consumer-level video from a Hydraulic Inspection Vehicle Explorer (HIVE). MnDOT owns several of both units, which incur labor costs of about 23 cents per foot. CCTV is a national standard for inspection. It offers permanent records with familiar technology; however, lighting, image centering, lens clarity, cumbersome data volumes, and operator training and experience present challenges.

The HIVE is a remotely operated crawler equipped with off-the-shelf cameras and accessories. Developed by MnDOT District 6, the HIVE takes lights and a video camera that is capable of panning and tilting inside a culvert and transmits data wirelessly to a tablet computer. While CCTV offers better measurement ability, a HIVE is lighter, easier to transport and easier to operate. Given that contractor-run CCTV typically costs $2 per foot, the cost of using 750 feet of CCTV would pay for a HIVE.

What's Next?

In addition to the guidebook, researchers have developed a webinar (see youtube.com/mndotresearch) on culvert inspection options for Minnesota inspectors and crews.

MnDOT will monitor developments among local contractors, as no Minnesota firms currently offer multiple-sensor inspection capability. MnDOT owns a sonar scanner for use on tripods and floatable platforms, and also owns a laser ring inspection unit. Pilot testing and training may make these options cost-effective. Researchers recommend further development of the MnDOT-developed HIVE, including a foam floating platform and a snap-on laser ring scanner for the camera.

This Technical Summary pertains to Report 2017-16, "Enhanced Culvert Inspections—Best Practices Guidebook," published June 2017. The full report can be accessed at mndot.gov/research/reports/2017/201716.pdf.