Innovative Culvert Inspection

Developing an Effective Small-Pipe Culvert Inspection System

Exploratory Advanced Research . . . Next Generation Transportation Solutions

Thousands of culvert pipes are damaged every year in large rain events or in floods, costing millions in repair or replacement costs and causing widespread impacts. Developing an effective culvert inspection technology for small pipes, less than 1.2 m (4 ft) diameter, to minimize these costs, disruptions, and impacts was the goal of the Exploratory Advanced Research (EAR) Program project "Buoyant Sensors for Mapping, Monitoring, Diagnosis, and Repair of Culverts." Southwest Research Institute (SwRI) conducted this research, which was funded by the Federal Highway Administration (FHWA) in 2010.

Importance of Culverts

Culverts allow water to flow under a road, railroad, trail, or similar obstruction and are typically buried in soil. There are an estimated 2 million culverts supporting the Nation's highway infrastructure.[1] While an inspector can go into a larger culvert to assess conditions, smaller culverts require specialized equipment. The cost to repair or replace culverts can be in the millions of dollars because of the expenses involved in detouring traffic, providing mitigation for environmental impacts, habitat or stream restoration, and additional right-of-way and engineering costs. Malfunctioning culverts also pose a significant public safety risk: they could result in flooding of roads and highways and the creation of subsurface voids, ultimately leading to roadway collapse.

The investigators of this research focused on the development of an inexpensive and easy-to-deploy inspection system for use in both water-filled and dry culverts. Applications for an effective small-pipe culvert inspection technology could be far-reaching as a practical and inexpensive tool for Federal, State, and local agencies in their efforts to monitor, maintain, and catch repairable damage early. There are many scenarios in which such a culvert inspection system could be put to use, including post-flooding, as part of routine inspections, following a pipe installation, or to check pipe repairs.

Inspection Requirements

Critical requirements for an effective culvert inspection system include the ability to measure:

- The hydraulic capacity of a culvert—this determines how much of the original design flow can still pass through. Restricted capacity, for example from debris, can cause high velocities and low pressure zones leading to perforated inverts, seams, and joints in the piping.
- Flattening or wall buckling because of vertical earth pressure—this could indicate a potential for failure.
- Alignment and settlement issues—detecting issues can prevent water pooling in the pipe.
- Dislocated joints or seams—these may allow water to flow and create voids, potentially leading to roadway washout or collapse.

Other items for inspection include durability issues related to corrosion or abrasion and a scenario known as *piping*. Piping is the erosion of the soil that results from flowing groundwater and may also lead to voids, sinkholes, and the collapse of the culverts.

Inspection System

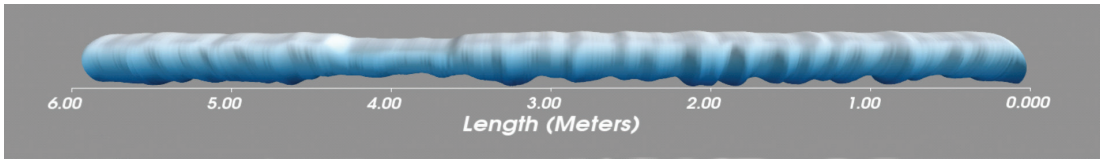
The Turner–Fairbank Highway Research Center (TFHRC) Hydraulics Laboratory worked with SwRI to develop an ultrasonic culvert mapping system to image and inspect small, inaccessible culvert interiors in three dimensions (3D), both

1 Transportation Research Board. (2013). *Culvert and Storm Drain Management System: A Transportation Research Board Research Needs Statement*. Washington, DC. Retrieved July 28, 2014, from http://rns.trb.org/dproject.asp?n=33808.

U.S. Department of Transportation
Federal Highway Administration

Innovative Culvert Inspection

Developing an Effective Small-Pipe Culvert Inspection System



Ultrasonic image of a partially-filled culvert with engineered defects.

in air and water. The project was broken into two phases, consisting of an initial laboratory prototype phase and a field prototype development phase. Three generations of system prototypes were tested at TFHRC before moving into field development.

The current prototype system housing is approximately 11.5 cm (4.5 inches) in diameter and 38–46 cm (15–18 inches) in length and contains the ultrasonic transmitters and receivers, system electronics, Wi-Fi antenna, camera, 360-degree mirror, and battery. At approximately $4,000 for the probe, the system represents significant cost savings over the traditional rover-based closed-circuit television units used in current inspections. In 2013, researchers tested the first-generation field prototype at the TFHRC Hydraulics Laboratory in a full-size corrugated metal culvert pipe. The culvert inspection probe is not currently combined with a transport mechanism and must therefore be pushed, mechanically transported, or floated through a flooded, dry, or partially filled culvert pipe. Following a storm event, or as part of an in-service inspection, the probe can pass through a pipe and combine ultrasonic images with video to produce a 3-D view of the culvert interior.

The prototype culvert inspection probe.

Importance to FHWA

"Culverts and drainage structures represent an integral portion of highway infrastructure that routinely require inspection, maintenance, repair, and renewal," says FHWA's Frank Jalinoos. "Much of the Nation's existing culvert and storm drainage infrastructure has reached, or will soon be reaching, the end of its initial projected service life." Jalinoos continues, "Loss of structural and hydraulic integrity of this infrastructure system can result in roadway closures, costly rehabilitation and replacement, and increased risk to the traveling public."

EXPLORATORY ADVANCED **RESEARCH**

What Is the Exploratory Advanced Research Program?

FHWA's Exploratory Advanced Research (EAR) Program focuses on longer-term, higher-risk research with a high payoff potential. The program addresses underlying gaps faced by applied highway research programs, anticipates emerging issues with national implications, and reflects broad transportation industry goals and objectives. To learn more about the EAR Program, visit the Exploratory Advanced Research Web site at www.fhwa.dot.gov/advancedresearch. The site features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events. For additional information, contact David Kuehn at FHWA, 202-493-3414 (email: david.kuehn@dot.gov), or Terry Halkyard at FHWA, 202-493-3467 (email: terry.halkyard@dot.gov).

Prototype testing results have been encouraging, and the next step is for field validation. FHWA is in the process of discussing next phase advancements with SwRI, including the incorporation of a transport mechanism for dry culvert applications and a commercialization plan for the culvert inspection probe.

Learn More

For more information on this project, contact Frank Jalinoos, FHWA Office of Infrastructure Research and Development, at 202-493-3082 (email: frank.jalinoos@dot.gov).

Image other side:
Culvert under a railroad bridge.

Credit: © Tom Gill

Publication No.
FHWA-HRT-14-095
HRTM-30/10-14(1M)E