Research Brief

Wisconsin Highway Research Program
Project 0092-17-05
August 2019

Performance and Policy Related to Aluminum Culverts in Wisconsin

Research Objectives

- Evaluate the performance of aluminum drainage structures in Wisconsin
- Examine recent changes to materials and specification for use of aluminum drainage structures
- Establish best practices for aluminum culvert use and formulate recommendations for updated aluminum culvert policy in Wisconsin

Research Benefits

- Determined causes and processes of corrosion
- Identified optimal soil and water conditions for aluminum culverts
- Recommended strategies for protecting culverts from chloride-induced corrosion
- Revised contemporary policies on the use of aluminum drainage structures

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Background

Corrosion and abrasion are the two primary factors that affect aluminum culvert durability. Corrosion manifests in two ways: general corrosion and localized pitting corrosion. The failure of an aluminum culvert due to pitting corrosion from deicing salts in 1993 prompted WisDOT to reevaluate its use of aluminum drainage structures, such as pipe and box culverts. Field investigations of other aluminum culverts revealed widespread corrosion at the tops of the structures, likely initiated by soil-side contact with infiltrating deicing salts. The results of this investigation lead WisDOT to severely limit its use of aluminum drainage culverts.

Corroded aluminum pipe removed from WIS 32

The objectives of this research were to evaluate WisDOT's current policies restricting the use of aluminum culverts and provide guidelines for how to best administer culverts in transportation projects.

Methodology

The research team identified 53 aluminum culverts, most five feet or greater in diameter, in WisDOT's Highway Structures Information System (HSIS) database. Photos from each culvert's most recent inspection were used to assign it one of three corrosion grades: no corrosion, minor corrosion and significant corrosion. The team inspected three in-service aluminum culverts (one corrugated pipe and two corrugated structural plate pipe arches) in accordance with the National Cooperative Highway Research Program's Culvert and Storm Drain System Inspection Manual. Each culvert was evaluated for signs of distress, such as general and localized pitting corrosion and abrasion. Soil, water and aluminum culvert samples were taken from each site and subjected to laboratory testing to determine environmental conditions and material properties.

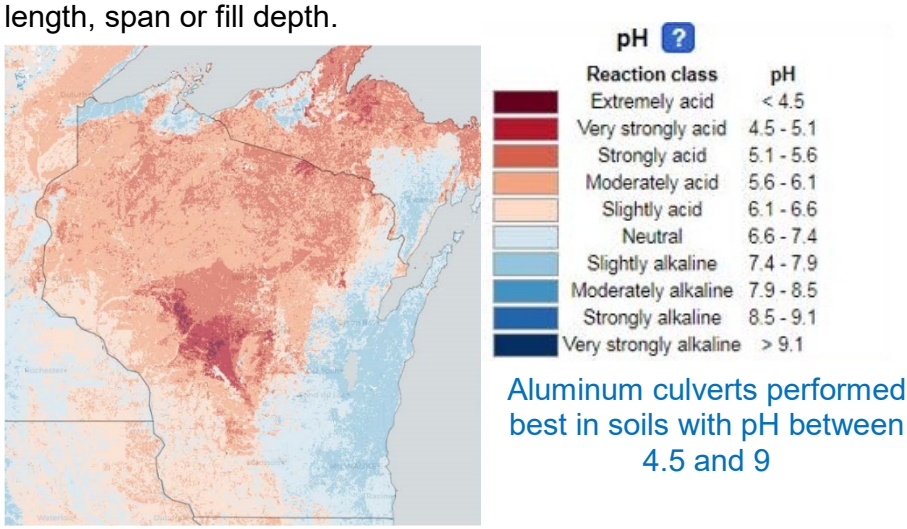
"This research identified potential pathways for aluminum culvert corrosion and methodology to prevent its occurrence. The results will be used to guide future WisDOT culvert policy."
– Steve Neary, WisDOT

Interested in finding out more?

Final report is available at:
WisDOT Research website

Results

No corrosion was noted in 39 of the 53 culverts; minor corrosion appeared in eight; and significant corrosion in two, which had the lowest National Bridge Inventory (NBI) ratings. Aluminum culverts proved to be very resistant to general corrosion when installed at sites with soil and water pH between 4.5 and 9 and resistivity of more than 500 Ω-cm. Corrosion levels correlated with culvert age, pavement cracking and heavy road salt usage; they did not correlate significantly with average daily traffic, geographic location, culvert length, span or fill depth.



Aluminum culverts performed best in soils with pH between 4.5 and 9

Recommendations for implementation

Laboratory testing of soil and water samples from sites of potential culverts should be performed prior to design to determine suitability of environmental conditions. To ensure corrosion does not initiate on culverts in regions that use deicing chemicals, aluminum should be isolated from contact with chloride-containing salts that can migrate vertically from the roadway surface through cracked pavement and soil fill and through unpaved shoulders and embankments. Abrasion classifications should be made for each new culvert to determine if any additional protective measures should be taken.

The research team recommended the following updates to WisDOT's manuals and specifications regarding aluminum culverts:

- Allow use of aluminum culverts (pipe, structural plate structures, box culverts) at sites where soil and water pH ranges from 4.5 to 9 and resistivity is greater than 500 Ω-cm
- Specify use of an impermeable isolation membrane in the backfill envelope extending at least 10 feet from edges of pavement or to the end of the culvert
- Specify free-draining backfill with limited chloride ion content (< 100 ppm) below the isolation membrane

This brief summarizes Project 0092-17-05,
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