Wisconsin Department of Transportation
Wisconsin Highway Research Program

Request for Proposal

Performance and Policy Related to Aluminum Box Culverts and Pipe Culverts in Wisconsin

Questions submitted to research@dot.wi.gov regarding the content of this RFP are due no later than 4:30 PM (CST) on December 12, 2016

Responses to questions will be posted to the WisDOT Research and Library website http://wisdotresearch.wi.gov/rfps-and-proposals by 4:30 PM (CST) by December 19, 2016

Researchers must submit a PDF version of their proposal by 4:30 PM (CST) by January 20, 2017 to: research@dot.wi.gov

Researchers will be notified of the proposal review decision by May 1, 2017

For more information regarding this RFP contact the WisDOT Research Program at: research@dot.wi.gov. This RFP is posted to the Internet at: http://wisdotresearch.wi.gov/rfps-and-proposals

Wisconsin Highway Research Program
Request for Proposals
Structures Technical Oversight Committee

Performance and Policy Related to Aluminum Box Culverts and Pipe Culverts in Wisconsin

I. Background and Problem Statement

Wisconsin DOT Bridge Manual Chapter 36 has a restrictive policy on the use of Aluminum Box Culverts that basically prohibits the use on state/federal transportation projects. This policy dates back a number of decades and was heavily influenced by studies conducted in the 1980's, 1990's, and also a 2003 report where aluminum drainage structures were studied by the department. The structures within the studies were primarily round culvert pipes of limited diameter. The primary concern identified was corrosion and deterioration of the aluminum materials. Related to these studies, Wisconsin DOT Facilities Development Manual (FDM) Procedure (15-1-S15.4) provided guidance that limits use of aluminum pipes to side drains and highways with traffic volumes under 1500 Design AADT unless some provision is made to insulate the upper surface of the structure from infiltrating road salt. It may be possible that the findings of these past studies may be based on conditions, materials, or construction details that are no longer used. It may also be possible that modern construction specifications, techniques, and protection systems may address or mitigate concerns identified in the earlier studies. It is also possible that the alloy used in larger aluminum drainage structures (plate, pipe-arches, and box culverts) is a different alloy of aluminum that may have a different performance than what has been studied in these past Wisconsin studies.

Wisconsin DOT has reached out to other DOTs to examine their policy and practices related to the use of aluminum box culverts. We have had a limited number of responses that indicate a great variation in policy and practice. Some DOTs allow the use while other DOTs have very restrictive policies.

Our concern is in obtaining information related to long-term performance as it may relate to deterioration of the aluminum material. The deterioration may be in response to water pH, soil resistivity, soil potential, or the application of roadway deicing chemicals (salts and other).

This synthesis & research would develop information that would be used to update the current department Bridge Manual policy on the use of aluminum box culverts based on contemporary information including literature searches, review of other DOTs' policies, aluminum materials available, construction details and practices, and field review of historic aluminum box culvert performance.

II. Objectives

The objective of this research is to develop recommendations and guidelines for the validation of WisDOT's current Bridge Manual Chapter 36 policy on the use of aluminum box culverts or provide information that would be used as the basis of a revised policy and guidelines for inclusion of aluminum box culverts on WisDOT administered transportation projects.

III. Scope of Work

A. Literature search of current information related to materials, applications, policies, and performance of aluminum box culverts in transportation environments. This should include conducting a national literature review, assessment of current practices at WisDOT and various other state DOTs, FHWA resources, industries and manufacturers resources and interviews. Some reference materials currently available to the researcher include:
    1. An initial WisDOT Literature Search that will be provided to Researchers as part of this RFP.
    2. Select responses from various DOTs related to policy and practice.
    3. Past WisDOT studies on culvert pipe performance, including:
        I. Corrosion Evaluation of Culvert Pipes in Wisconsin, Progress Report V, 1981, Robert Patenaude
        II. Corrosion Evaluation of Experimental Metal Culvert Pipes in Wisconsin, Progress Report V, 1988, Robert Patenaude
        III. Corrosion of Aluminum Drainage Structures, State of Wisconsin Memo, July 26, 1993, Robert Patenaude
        IV. Experimental Culvert Pipe, STH 80, Juneau and Wood Counties, Wisconsin. WisDOT Research Study #80-02, 03, 04, Final Report, 2003, Robert Patenaude

B. Examine the existing inventory data of aluminum box culverts in Wisconsin. WisDOT Bureau of Structures Web Application - Highway Structures Information System (HSIS) can be used for demographic and condition information related to FHWA National Bridge Inventory (NBI) aluminum box culverts in Wisconsin.

C. Contact of other DOTs and collection of relevant DOT policies and practices related to the use of aluminum box culverts. WisDOT will provide some information that has been collected from various state DOTs. Additional information will need to be collected.

D. Systematic evaluation of the FHWA NBI and element level bridge condition data. This should be correlated to state DOT practices and strategies related to the use of aluminum box culverts. It is recommended that the research team request access to the FHWA Long Term Bridge Preservation Bridge Portal for collection of national bridge demographic and condition information. The information obtained on established policy and practice as well as documented aluminum box culvert condition history will be used to identify and support conclusions related to aluminum box culverts.

E. Contact industry members involved with sale and manufacture of aluminum culverts and collect information related to contemporary aluminum box culvert alloys, details, performance, and references.

F. Field review select in-service aluminum box culverts (in Wisconsin or other states as appropriate) for the purpose of condition inspection. It is anticipated that there will be limited field inspection or testing and no laboratory investigation as part of this research.
G. Formulate recommendations and documentation that would serve as the basis for new Policy on the use of Aluminum Box Culverts on State and Local Roads.
H. Develop recommendations and guidelines in a format consistent with WisDOT Bridge Manual and associated presentation materials for WisDOT practitioners.

IV. WisDOT/TOC Contribution

WisDOT will provide the following support through the WHRP Project Oversight Committee and Regional Bridge Maintenance Engineers:

A. Work will be conducted with project oversight by the WisDOT Bureau of Structures and WHRP Structures Technical Oversight Committee (TOC).
B. The research team will not assume the availability of WisDOT staff or equipment in the proposal. If WisDOT or another entity donates equipment, a letter of commitment must be included in the proposal.
C. Expected level by staff/TOC members: Maximum of 40 hours over the duration of the project. Project Oversight Committee (POC) members will consult with research team in the selection of project sites.
D. This project will require travel for a meeting to finalize the work plan with the POC, and travel to Madison is required to report the results of the study to the TOC. Other interim reporting is also expected.
E. WisDOT staff will assist the research team in accessing the WisDOT Bureau of Structures Web Application - HSIS for demographic and condition information related to NBI aluminum box culverts in Wisconsin.
F. WisDOT staff will assist the research team in contacting the FHWA for access to the FHWA Long Term Bridge Preservation Bridge Portal for collection of national bridge demographic and condition information.
G. If field work on or around in-service facilities (bridges) is anticipated by the research, the proposal will need to discuss the nature and extent of needed traffic control and support assistance that will be requested from WisDOT. The researcher will need to closely coordinate with WisDOT regional personnel and possibly the county personnel where project fieldwork is being conducted. For WisDOT planning purposes, the Principal Investigator shall specify in his or her proposal, as practical, what specific traffic control will be required for this project, such as traffic flagging, signage, barricades, etc., as well as the duration needed (hours/day/location). It should not be assumed that WisDOT would fund the traffic control apart from the research project budget.

V. Required Travel

This project may require travel for a meeting to finalize the initial project work plan with the POC and the researcher's data collection efforts. Travel will likely be required for inspection of in

service aluminum box culverts in Wisconsin and other states as appropriate. Travel is also required to deliver the final presentation.

VI. Deliverables

A. Reporting Requirements: Six (6) hard copies and an electronic copy of the final report delivered to WisDOT by the contract end date. This includes the report, special provisions, and structural details. Please refer to the Implementation section for further details.
B. Bridge Manual Chapter 36 Policy recommendations related to the use of aluminum box culverts.
C. Recommendations related to construction details and specifications for aluminum box culverts.
D. Development of PowerPoint presentation to serve as a training tool for WisDOT Bridge designers and Regional Planning/project staff that illustrated the findings of this research project. WisDOT staff will provide the associated training.
E. Presentation Requirements: All projects require the PI to give a closeout presentation to the TOC after submittal of the draft final report.

VII. Budget and Schedule

A. Project Budget shall not exceed **$100,000.**
B. Proposed project duration is **18 months** starting around **June 1, 2017.**
   - Deadline for submittal of draft final report is three months prior to contract end date to allow for report review activities.
   - Deadline for research close out presentation is 4-6 weeks prior to contract end date.
   - Deadline for submittal of the Final Report is the contract end date.

VIII. Implementation

Successful implementation of this research will be achieved through the development of the following items:

A. Summary of a significant number of DOTs and their policies related to the use of aluminum box culverts.
B. Recommendations related to the use of aluminum box culverts in Wisconsin that are supported by well-documented conclusions drawn from research findings.
C. Development of updates to Bridge Manuals chapter 36 related to culverts.
D. Development of PowerPoint presentation to serve as a training tool for WisDOT Bridge Designers, Maintenance, and Regional Planning staff.

WisDOT Office of Finance, Policy and Improvement
Research & Library Services

4802 Sheboygan Avenue, Room 104
PO Box 7910, Madison, WI 53707

research@dot.wi.gov
http://wisconsindot.gov/Pages/about-wisdot/research

Literature Search -

Aluminum Box Culverts

To: Bill Oliva, DTSD, WHRP Structures Technical Oversight Committee
From: John Cherney, OPFI, Research and Library Services
Date: July 25, 2016
Topic: WisDOT has a restrictive policy on the use of Aluminum Box Culverts that dates to the 1980s and may be based on conditions and materials that are no longer common or used. This literature search could inform an update of the policy. The literature search should relate to materials, applications, policies and performance of Aluminum Box Culverts in transportation environments. Any information on other state DOT policies, practices, and performance histories with Aluminum Box Culverts would also be helpful.

Keywords/Keyphrases:

Transportation Research Thesaurus (TRT) Terms:

- Aluminum
- Aluminum culverts
- Bridges and culverts
- Box culverts
- Corrugated metal culverts
- Corrugated pipe culverts
- Culverts
- Pipe culverts
- Types of culverts

Other database terms (ASCE Library, natural language, etc.)

- ABC (Aluminum Box Culverts)

The literature search identifies completed research and other authoritative information in an area of interest. The citations below are representative, rather than exhaustive, of available English-language studies on the topic.
The listing below provides links to online copies of cited literature when available. Contact the WisDOT Library to obtain print versions of any citations or electronic full-text copies of an item not freely accessible.

Findings

Projects

Experimental Project Construction Report and Annual Evaluation: Contech Ribbed Aluminum Box Culvert (ABC)
Principal Investigator: Craig Abernathy
Montana Department of Transportation Research Programs
January 2016
http://www.mdt.mt.gov/other/webdata/external/research/docs/epsl/abc/eval_jan16.pdf

Abstract:
The objective of this research project is to document all phases of the installation practice of the aluminum box culvert (ABC) unit. Issues such as special backfill required, installation of reinforcing ribs, equipment required, and construction loading will supplement the report. This project will provide a comparison with the current use of steel structural plate pipe. The project will monitor and report on long-term performance. The research will monitor performance for a minimum period of five years annually, with every year up to *ten years (informally). This is in accordance with the Department's "Experimental Project Procedures". Delivery of a construction/installation report, interim, annual or semi-annual reports is required as well as a final project report. A web page will be dedicated to display all reporting from the project.

Note: original 2012 workplan for the project is here:
http://www.mdt.mt.gov/other/webdata/external/research/docs/epsl/abc/workplan.pdf

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Reports

Aluminum Box Culverts with Bottoms Review
Transportation Permitting Unit, Division of Water Quality, North Carolina Department of Environment and Natural Resources
February 2012
http://ncdenr.s3.amazonaws.com/s3fs-public/Water%20Quality/Surface%20Water%20Protection/TPU/DWQ%20Aluminum%20Culvert%20Study.pdf

Introduction:
The North Carolina Division of Water Quality (NCDWQ), Transportation Permitting Unit staff, has seen requests from the North Carolina Department of Transportation (NCDOT) to install aluminum box culverts. Traditionally, these requests have been associated with efforts to replace old timber-pile bridges that have reached or exceeded their useful life or to replace failed culvert pipes (often multiple pipes) which are usually much smaller than aluminum box culverts which replace them.

In an effort to maintain stream crossings such that they are safe to the traveling public, existing culverts and small bridges are replaced as they reach the end of their design or useful life, if not before. Most bridges and culverts being replaced have been in service for many decades. Older bridges may be constructed of concrete on wooden or steel piles. The vast majority of box culverts in the state are constructed of concrete. However, since the early 1980s, NCDOT has used box culverts constructed of aluminum to replace some of these older structures (personal communication, Jerry Lindsey, NCDOT).

Aluminum box culverts are available in two different styles. One style is bottomless and is built on concrete footers which in turn typically sit upon a solid bedrock foundation. The foundation and footers support the weight of the culvert as well as the weight of the fill, roadbed, and traffic. The second style has a bottom, and is usually a compressed oval shape, much like a "D", with the bottom area being nearly flat. This type is often used when a suitable bedrock foundation is not available. The NCDWQ requires these culverts to be buried, unless a factor is present that would prevent sufficient burial. If the structure is not backfilled during construction then it is expected that when these culverts are buried sediment will settle in the bottom of the culvert through natural events. When this occurs it presents a more natural setting, more closely mimicking the pre-installation condition of the stream. This in turn allows for acceptable flow and aquatic life passage during low and extreme low flow conditions.

Currently, there are at least seventy-five aluminum box culverts installed throughout the state (personal communication, Jerry Lindsey, NCDOT). At present, it is unclear how many of those installed are bottomless and how many are bottomed. When aluminum box culverts are used, the NCDWQ generally prefers the bottomless type, as it allows for the natural stream bed, location, and function to remain in a more natural state. The installation process for bottomed culverts is more intrusive to the stream than that of bottomless culverts. While both types may require dewatering, the whole stream bed must be excavated down in order to properly set a bottomed culvert. Excavation several feet below the natural stream bed is often required as a bed of gravel, stone, or other supporting material must be laid to support the weight of the culvert and provide a level substrate for the bottom to rest on. Generally, the installation of a bottomless culvert involves excavation for the footers to be installed, leaving much of the natural stream bed undisturbed.

While there may or may not be financial savings for the use of aluminum box culverts over other traditional methods or structures, the NCDOT reports that there are other benefits which are considered when deciding on replacement construction. For example, aluminum box culverts parts can be, depending on the overall size, delivered to the site and assembled on nearby land. Once the culvert is assembled, it can be lowered into place very quickly once the site has been prepped for installation. This shortens the overall construction time and allows the road to be closed for a shorter length of time. In extreme cases however, the structure must be assembled in place, although thus far these appear to be rather rare cases. The width of aluminum box culvert openings can be much wider than that of a poured concrete box culvert, which can reduce maintenance by allowing larger debris to pass through the opening rather than getting trapped in smaller openings and requiring time and effort to remove.

Condition Assessment of Utah Highway Culverts and Determination of Culvert Performance Measures
Jesse L. Beaver1; Timothy J. McGrath; and Blaine Leonard
Utah Department of Transportation
In Critical Transitions in Water and Environmental Resources Management: pp. 1-10
2004, pp. 1-10
Contact library staff for copy

Abstract:
The Utah Department of Transportation installed and manages over 47,000 culverts but has no comprehensive, quantitative method for evaluating the performance of these culverts. UDOT initiated a study to assess culverts throughout the state, develop performance measures to evaluate these installed culverts, and determine performance ratings for their structural and hydraulic performance. UDOT contracted with Simpson Gumpertz & Heger Inc. for this work. Culvert inspections included primarily metal, concrete, and plastic culverts up to five feet in diameter. Numeric performance ratings were determined and used to make recommendations for culvert maintenance and inspection. Inspected culverts are performing well. Average ratings for, all pipe materials are approximately equal. The problems unique to each type of culvert pipe material are discussed.

Experimental Culvert Pipe, STH 80, Juneau and Wood Counties, Wisconsin
R. Patenaude
Wisconsin Department of Transportation
November 2003
Contact library staff for copy

Abstract:
Culvert pipes of aluminum, aluminized steel, polymeric coated galvanized steel and epoxy bonded steel were placed at three sites in central Wisconsin in 1981 and monitored for their corrosion resistance. Galvanized steel apron end walls were attached to the pipes as a means of comparison of corrosion rates with zinc galvanized steel. The three sites selected were in areas where strong corrosiveness to zinc galvanized steel pipe was highly likely. Field tests of soil and water at the sites were made annually including pH, electrical resistivity and oxidation-reduction potential of the soil and water, dissolved oxygen content of the water and sulfide content of the soil. The pipes experienced corrosion originating from a variety of conditions including low pH of the soil and water, anaerobic sulfate reducing bacteria in the soil and water, and road salt. In comparing the performance of the four culvert types, the polymeric coated galvanized steel pipes appeared to best resist corrosion.

None of the pipes were perforated and removal of the coating was localized to the vicinity of exposed rivet heads and section ends. The epoxy bonded steel pipes did not perforate but lost considerable coating at the two sites of flowing water and experienced advanced corrosion at joints at the site of equalizer pipes. This type of coating is no longer used. The aluminized steel pipe experienced localized perforation and localized pitting of the steel cores and inverts at localities of organic material. The protective cover of aluminum is ascribed to the development of an aluminum oxide coating on the metal and this coating appears to be degraded in more strongly reducing environments.

The aluminum pipe evidenced the most severe distress and resulted in several instances of failure due to corrosion in forms of thinning of the metal roofs, perforations in the roofs, and coatings of white precipitate on the inner roofs of the pipes. This type of corrosion appears to be attributable to the presence of NaCl in chemical deicers (road salt). The aluminum pipes have, however, proved to be immune to corrosion in the natural environment. There has not been a reported case of perforation of an invert of an aluminum pipe from the water side in Wisconsin, but there were several aluminum pipes perforated from the soil side in areas of wet organic sandy soil.

These pipes had replaced the zinc galvanized steel pipe that had been corroded by the actions of anaerobic sulfate reducing bacteria in the water. At this time, some aluminum culvert pipes with protective covering laid over the top are being installed in Wisconsin. The galvanized steel apron end walls unexpectedly experienced advanced corrosion at all three sites, and some perforation at one site. It appears that the type of pipe least susceptible to corrosion caused by moist organic soil, at sites where tests for anaerobic sulfate reducing bacteria in the soil are frequently positive, is a pipe with an organic barrier coating, such as polymeric coated steel.

Durability Study of Various Culvert Materials: Guidelines for Selection of Pipe Culverts
Bradley R. Boyd, et al.
Arkansas Highway and Transportation Department
April 1999
http://www.arkansastrc.com/TRC%20REPORTS/TRC%209601.pdf

Abstract:
The Arkansas State Highway and Transportation Department (AHTD) funded a study to determine if the durability of culvert pipes could be correlated with certain variables. Fifty-one sites in 9 of the 10 AHTD districts were investigated. Culvert materials included galvanized corrugated metal pipe (CMP), 19 sites; bituminous-coated CMP, 13 sites; concrete, 6 sites; aluminum CMP, 4 sites; aluminized CMP, 2 sites; and plastic, 3 sites.
The measured variables (culvert material type, water pH, soil resistivity, soil potential, and culvert age) were selected to describe the both soil-side and the aqueous corrosion that can affect the culvert. Atmospheric corrosion was assumed to be negligible. In no cases were unusually aggressive pH values found in the waters flowing through these culverts. A statistical analysis showed a weak correlation involving the culvert age and the water pH for the bituminous-coated CMP. This test was significant at the 0.05 level. Correlations were not found for galvanized CMP, and for other types of culverts no statistical analysis was possible because of the limited number of data points. Although no statistical correlations were possible, "engineering" conclusions include:
(1) concrete culvert pipes hold up well under all conditions observed; (2) galvanized CMP seems suitable for "dry stream" application, but in a "wet stream" extensive damage may take place in fewer than 10 years; (3) bituminous or polymeric coatings add from 5 to 20 years to the life of galvanized CMP; (4) plastic, aluminum, and aluminized CMP stand up well in all environments observed.

Field Performance Evaluation of Precast Concrete Box Culverts, Aluminum Culverts, and Galvanized Metal Arches and Pipe Arches
Fleckenstein, L. J.; Allen, D. L.; Graves, R. C.
University of Kentucky, Lexington and the Kentucky Transportation Cabinet
1993
http://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1589&context=ktc_researchreports

Abstract:
Reported herein are the field performances of three different classes of culverts. The study included precast concrete boxes, precast arch culvert, aluminum boxes and pipe culverts, and several shapes of galvanized metal culverts. A total of 82 culverts were inspected throughout the state of Kentucky. Culverts were inspected in all 12 highway districts. A total of 15 precast concrete structures, 11 aluminum structures, and 56 galvanized metal structures were evaluated. This report discusses the

distress observed in the three different classes of culverts. Recommendations for future installations and possible maintenance schema for the existing culverts are included.

Behavior of a Corrugated-Metal Box Culvert. Final Report
Beal, D. B.
New York Department of Transportation
1986
Contact library staff for copy

Abstract:
Strain and deflection were determined for a 22-ft 3-in aluminum box culvert during backfilling and under static live load. The structure was instrumented at the crown and haunches with electrical-resistance strain gages on the structural plates and stiffening ribs, and curvature meters on the plates. This instrumentation permitted determination of average bending on five corrugations (each 9-in. wide) across a 54-in. wide structural plate. In addition, crown displacement was monitored at five locations with potentiometers. The structure was assembled and loaded in the laboratory to permit calibration of measured response with bending moment and thrust. The laboratory testing showed that the structural plates and stiffening ribs were not fully composite in resisting applied loads, with the amount of composite action being less at the haunches than the crown. The structure's response was determined at 18 increments of backfill from the footing to 22 in. over the crown. Response under the final asphalt paving was also measured. For the live-load test, a 32-kip dual-tire truck axle was statically positioned at a number of locations over the crown. These tests were performed on the subgrade and with the finished paving in place. Measured response of the structure is compared with estimates from finite-element analysis and design equations.

Journal articles

Structural Performance of an Aluminum Box Culvert
J.O. Hurd, et al.
In *Transportation Research Record*
1991, no. 1315, pp. 46-52
http://onlinepubs.trb.org/Onlinepubs/trr/1991/1315/1315-007.pdf

Abstract:
Corrugated metal box-type culverts are increasingly used as replacements for short-span bridges. Their lightness, relatively easy and quick transportation and construction procedures, and lower cost make them attractive in many instances for short-span bridges. Because they are flexible, the flexural stiffness and moment capacity of the structural plates are increased with stiffeners placed along the length of the culvert. A corrugated box culvert carries most of its load through interaction between the culvert and the surrounding backfill. Results of field tests performed on an aluminum low-profile, box culvert during the construction sequence and live load application are evaluated, experimental results are compared with results obtained from the CANDE finite element computer program solutions, stress disruption at bolts is evaluated, and the composite action between rib and plate is determined.

Old Bridge Replaced by Aluminum Box Culvert
In Public Works
May 1990, vol. 21, no. 6, p. 116
Contact library staff for copy

Abstract:
A one-lane, 18-ft bridge on County Road 1000 South in Jonesville, Indiana, was replaced by an aluminum box culvert in less than a day. The bridge is located on a no-outlet road that is the only way in and out for the land-locked residents of the area. The county sized the 38-ft long by 10-ft, 11-in. span by 6-ft, 4-in. rise aluminum box culvert earlier in the year. It was pre-assembled by the side of the old bridge and then lifted into place when weather conditions allowed. Backfilling was the most time-consuming part of the job.

Field Performance of Corrugated Metal Box Culverts
Hurd, John O.; Sargand, Shad
In *Transportation Research Record*
1988, no. 1191, pp. 39-45
Contact library staff for copy

Abstract:
Thirty-nine corrugated aluminum and 10 corrugated steel rib stiffened box culverts were evaluated. In situ chord and chord-ordinate dimensions were measured and compared to design dimensions. In addition, durability information was obtained. Eight of the box culverts had not been manufactured in conformance with the design shape. The most common deviation was a larger crown width and shorter leg length. There was a significant difference between the constructed crown shapes of steel and aluminum box culverts. The steel box culverts were in general crowned, whereas the aluminum box culverts had mid-chord-ordinate dimensions less than the design dimension. The amount of crowning in the steel box culverts decreased with increased crown widths. A potential crown corrosion problem exists on metal box culverts caused by seepage of groundwater containing road salt through bolted seams. The problem is of greater concern on steel boxes because the plate as well as the bolts have corroded. Finite element analyses of the structure capacity of erected shapes different from the design shape of the structures were performed. Slight variation in the culvert geometry has a noticeable but not severe effect on deflections and moments.

Metal-loss Rates of Uncoated Steel and Aluminum Culverts in New York
Bellair, Peter J; Ewing, James P.
In *Transportation Research Record*
1984, No. 1001, pp. 60-66
Contact library staff for copy

Abstract:
In this paper a laboratory evaluation is described of three techniques to determine metal loss on 1-in. coupons extracted from corrugated metal pipe, a field evaluation of 30 pipes to determine the sample size (number of coupons) and sampling location necessary to characterize metal loss, and a statewide survey of steel and aluminum culverts in New York. It is concluded that a pin micrometer can be used to

measure metal loss and that eight coupons extracted randomly along the "worst straight line" of a pipe will provide the accuracy needed for large-scale field surveys. Results of a field survey of 190 galvanized steel culverts and 35 aluminum culverts are presented, and implementation of these results in New York is discussed.

State DOT resources

Aluminum Structural Plate Box Culvert (approved product)
Pennsylvania Department of Transportation
September 25, 2012 (approval date)
https://www.dot.state.pa.us/public/Bureaus/BOPD/Bridge/NewProducts/text/NP53-text.pdf

Use:
Aluminum Structural Plate Box Culvert manufactured by Lane Enterprises, Inc. of Camp Hill, PA has been approved for use as an “As-designed” or “Alternate” metal plate box culvert. The use as an “As-designed” or “Alternate” metal plate box culvert is at the discretion of the District Executive.

Special Note for Aluminum and Steel Structural Plate Box Culverts
Kentucky Transportation Cabinet
June 2012
http://tinyurl.com/juuk3ve

Description:
This Special Note will apply when indicated on the plans or in the proposal. Section references herein are to the Department's 2012 Standard Specifications for Road and Bridge Construction. Contains sections on materials and measurement of aluminum plate box culverts.

Guidance for Modeling Aluminum Box Culvert (ABC) in HEC-RAS
North Carolina Department of Transportation
April 2012
https://connect.ncdot.gov/resources/hydro/Hydraulics%20Memos%20Guidelines/20120424_Guidance%20for%20Modeling%20Aluminum%20Box%20Culvert%20in%20HEC-RAS.pdf

Note:
HEC-RAS is the Hydrologic Engineering Center's (U.S. Army) River Analysis System, a computer program that models the hydraulics of water flow through natural rivers and other channels.

Corrugated Aluminum Box Culverts
2005 and 2010 Specifications
Ohio Department of Transportation
http://www.dot.state.oh.us/Divisions/ConstructionMgt/Materials/2005STM/Documents/707.25.PDF
(2005)

http://www.dot.state.oh.us/Divisions/ConstructionMgt/Materials/2010STM/2010STM/sapp/707.25.html (2010)

Culvert Management Manual
Ohio Department of Transportation
2003
https://www.dot.state.oh.us/Divisions/Engineering/Structures/standard/Maintenance/Documents/CMM_12-2003.pdf

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Standards and Specifications

Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
ASTM Designation B745-15
2015
Contact library staff for copy

Scope:
This specification covers corrugated aluminum pipe intended for use for storm water drainage, underdrains, the construction of culverts, and similar uses. Pipe covered by this specification is not normally used for the conveyance of sanitary or industrial wastes.

Standard Specification for Corrugated Aluminum Box Culverts
ASTM Designation B864-13
2013
Contact library staff for copy

Scope:
This specification covers material, geometric, and wall section properties of aluminum box culverts manufactured from corrugated plate or sheet, with attached rib stiffeners, for field assembly. Appropriate fasteners and optional materials, such as aluminum invert plates and headwalls, are also described. Applications for aluminum box culverts include conduits for gravity flow drainage of surface water, such as culverts and storm drains, as well as for small bridges and grade separation structures such as pedestrian or vehicular underpasses, and utility tunnels.

Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
AASHTO Designation M196-92(2012)
2012
Contact library staff for copy

Scope:
This specification covers corrugated aluminum pipe intended for use for storm water drainage, underdrains, the construction of culverts, and similar uses. Pipe covered by this specification is not normally used for the conveyance of sanitary or industrial wastes. This specification does not include

requirements for bedding, backfill, or the relationship between earth cover load and sheet thickness of the pipe. Experience has shown that the successful performance of this product depends upon the proper selection of sheet thickness, type of bedding and backfill, controlled manufacture in the plant, and care in the installation. The purchaser must correlate the above factors and also the corrosion and abrasion requirements of the field installation with the sheet thickness.

Theses

Service Life of Concrete and Metal Culverts Located in Ohio Department of Transportation Districts 9 and 10

Gabriel J. Colorado Urrea
Ohio University Thesis
December 2014
https://etd.ohiolink.edu/!etd.send_file?accession=ohiou1408279810&disposition=inline

Abstract:
In this study, in-service conditions were evaluated to estimate the service life of concrete and metal culverts. The Ohio Research Institute for Transportation and the Environment (ORITE) and a private consulting company proposed new inspection methods and rating procedures for concrete, metal and thermoplastic pipes; concrete and metal culverts are addressed in this study. The inspection activities were developed in culverts located in Ohio Department of Transportation (ODOT) Districts 9 and 10 since the aggressive environmental conditions found in these portions of the state of Ohio. Before each field trip, culverts were selected to meet requirements of location, material, and dimensions. For dimensions, screening criteria were than 42 inch span and rise dimensions, and a maximum length of 150 feet.
From each culvert, basic information was gathered from the inventory data provided by ODOT and in the field. The data gathered from the inventory and the field work was statistically analyzed to identify significant factors that contribute to material deterioration. The rating scales proposed by the ORITE and ODOT were employed in the statistical regressions as outcome variables, to measure the effectiveness and accuracy in predicting the remaining service life. Multivariable linear and nonlinear regression 4 models were proposed to estimate the remaining service life of existing metal and concrete structures with similar conditions in the state of Ohio.

Results for concrete culverts show that the multivariable linear regression results showed that pH and resistivity of water were significant for the ODOT and ORITE rating scale but the linear model is not since the age is not included in the regression. While, the multivariable non-linear regression results indicated that pH of water, age and span were significant based on the ODOT rating scale.

For metal culverts, the multivariable linear regression results showed that rise, span, age, level of abrasion, thickness of the plate, slope, velocity, and depth of the flow were significant based on the ODOT rating scale. And, age, soil cover, level of abrasion, pH of water, thickness of the plate, slope, flow velocity, and depth of flow were all significant for the ORITE rating scale, both models are not practical in estimating the deterioration of metal pipes. Non-linear regression did not generate more reliable results in predicting the service life of metal culverts.

Analysis of a Corrugated Aluminum Box Culvert
St. Roesyanto Suhuhardjo
Ohio University thesis
June 1989
https://etd.ohiolink.edu/rws_etd/document/get/ohiou1182522042/inline

Abstract:
A corrugated aluminum box culvert with rib stiffeners on the outside was instrumented for strain and deflection measurements that occurred during the backfill and live load. Measured strains were converted to stress, moments and thrusts. Deflections were calculated from bench mark measurements. Soil displacement were measured using four rod extensometers placed around the culvert

Calculated moments, thrusts and deflections are compared to results obtained from the finite element computer program CANDE. Hyperbolic models are employed for the backfill material and the instruction sequence is simulated as closely as possible. Symmetrical and unsymmetrical live load are examined. Soil elements are assumed to be fully bonded to the culvert-beam elements as no interface element was utilized.

Analysis and Design of Box Culverts
Ali H. Abdel-Haq
Ohio University thesis
August 1987
https://etd.ohiolink.edu/rws_etd/document/get/ohiou1183037846/inline

Abstract:
Box culvert problems are a complicated example of soil structure interaction where the relative stiffness between the backfill soil and the culvert materials is a critical factor in the load carrying capacity of culverts.
Duncan et al., proposed an equation for the design of this class of structures. This equation doesn't take into consideration the soil structure interaction phenomena. A modified form of the above equation, which is presented here, with an allowance for the soil properties and culvert stiffness provides a better agreement with the finite element solution. Furthermore, the presence of PCC relieving slabs and their action in transferring live loads is analyzed and another better agreement with the finite element method is obtained.
A sophisticated computer program called SEQCON is used to verify the results obtained from CANDE. The results of both programs are compared with an experimental data on a Lane Steel Culvert.
