Ohio Department of Transportation Research Project Fact Sheet

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits

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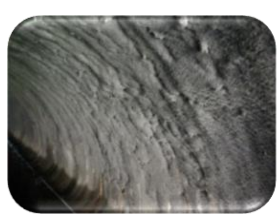
Agency	The Ohio Department of Transportation, Office of Statewide Planning & Research
Report Date	April 2021
Project Number	103453

The Problem

Culverts and drainage structures are an integral part of roadway assets that deteriorate overtime and require maintenance and renewal. Failure of these conduits is costly for DOTs directly due to emergency cost of replacement of the failed conduit and indirectly due to social costs of traffic interruptions and inconvenience to commuters. Further challenges are the variety in host conduit material types, level of deterioration, shapes, embedment materials, types of roads, depth of cover from road surface, size (diameter or span), length, condition of substrate, accessibility, wide geospatial distribution, groundwater, and environmental exposures that makes every single culvert unique. There are several trenchless technology methods available to renew and replace these deteriorated culverts with different degrees of installation experiences, costs, advantages, limitations and applicability. These methods, as described in this report, include Cured-in-Place Pipe (CIPP), Sliplining (SL), Modified Sliplining (MSL), In-line Replacement (ILR) or Pipe Bursting (PB), and Spray Applied Pipe Linings (SAPLs). Among these methods, SAPLs provide more flexibility of installation, specifically for tight to reach areas, higher speed of mobilization and installation, and adaptability to different shapes. While CIPP and sliplining (two common methods of culvert renewal) have a long history of use and can be utilized for structural applications, they may decrease pipe cross sectional area and may not be applicable due to limited access, size, shape and other features of host culvert. In addition, SAPLs can improve or maintain hydraulic capacity of host culverts and inhibit further deterioration and corrosion. However, there has been some recent installation quality issues with SAPL and there are no SAPL standard specifications and design guidelines. Therefore, the objectives of this research were to address quality and structural applications of SAPLs by developing design equations and performance specifications for both cementitious and resin-based materials for circular and arch shapes.


Heavy SAPL Material at the Crown


Heavy SAPL Material Sagging off


Efflorescence

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This research was sponsored by the Ohio Department of Transportation and the Federal Highway Administration.

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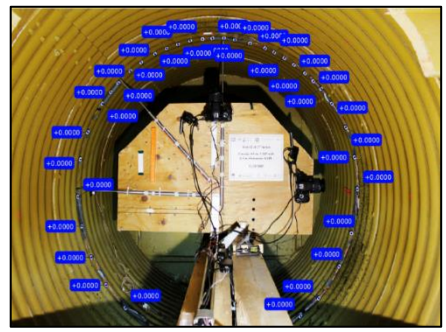
Research Approach

The methodology for this research included:

- Survey of U.S. DOTs and Canadian agencies,
- A database of all the previous SAPL projects and experiences,
- Literature search to minimize amount of laboratory testing and field inspections,
- Review of needs for additional reinforcement,
- Evaluation of needs to fill valleys of corrugated metal pipes (CMPs) before SAPL application,
- Comparison of construction and environmental costs of SAPL, CIPP and sliplining,
- Field data collections of SAPL installations for participating DOTs,
- Review of CIPP design equations,
- Development of SAPL structural design equations,
- Development of performance construction specifications,
- Finite element modeling of SAPL renewed CMPs tested at the soil box, and
- Laboratory and soil box testing to develop and validate structural design equations with circular and arch shapes for various thicknesses.



Findings

Findings of this research show that SAPL can be a used for semi-structural and structural applications of deteriorated circular- and arch-shape corrugated metal culverts. The survey of U.S. DOTs showed that many of them have interest in this method, however, they had concerns about its application for structural purposes and its design methodology. During inspections and data collection of recent SAPL projects, several installation quality issues were found. The review of CIPP design equations indicated that these equations were developed for lining of rigid pipes in gravity flow conditions, and even for their intended purpose, they have flaws. The CIPP equations cannot be used for SAPLs as they are applied over a flexible pipe with cementitious (rigid material) and polymeric (semi-rigid). For cementitious SAPL, it was recommended to fill corrugations of host conduit, but there is no need to fill corrugations for polymeric SAPLs. Additional reinforcement was found to be unnecessary for cementitious SAPL applications and may in fact be impractical for the spray nozzle. Using soil box testing results for different thicknesses and with aid of finite element modeling as well as AASHTO's Load and Resistance Factor Design (LRFD) – Bridge Design Specifications (BDS) loading conditions, the design equations for polymeric and cementitious SAPLs were developed. The performance specifications for both SAPLs were provided.

Recommendations

This research was limited to soil box testing of one type of polymeric material as well as one type of cementitious material. It is recommended that additional soil box testing is conducted with other products from additional vendors. The finite element modeling of cementitious SAPL was not completed due to delays in testing for Covid-19 pandemic. Since laboratory installations are different with installations in the field, it is recommended field monitoring, evaluation and testing of aged SAPLs be conducted, such as testing physical properties of SAPL coupons after 5- and 6-year periods. Additionally, laboratory testing is recommended for other host culvert shapes and materials, such as concrete box culverts. Impact of different environmental conditions on the host culverts and SAPLs must be investigated. Finally, results of this research with performance specifications and design equations should be implemented and monitored in the field.

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