

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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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 both 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), length, condition of substrate, accessibility, wide geospatial distribution, water table, 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), 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 less costs. While CIPP and sliplining have a long history of use and can be utilized for structural applications, they may decrease hydraulic capacity and may not be applicable due to limited access, size, shape and other features of host culvert, while SAPLs can be used in those conditions. In addition, SAPLs can improve or maintain hydraulic capacity of culverts and possibly inhibit further deterioration and corrosion of host culvert, however, currently there is not much history of use for SAPL structural application and there are no SAPL standard specifications and design guidelines. Therefore, objectives of this research were to address structural applications of SAPLs and to develop design equations and performance specifications for both cementitious and resin-based materials for circular and non-circular (arch) shapes. The developed design equations considered loading conditions as detailed in the AASHTO's Load and Resistance Factor Design (LRFD) Bridge Design Specifications.



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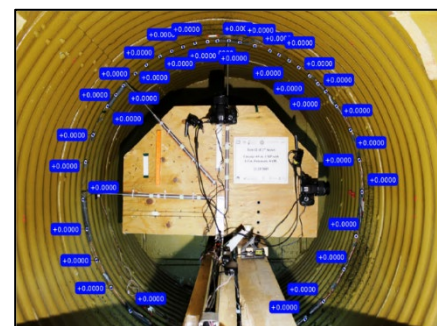
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Research Approach

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 and various thicknesses.



Findings

Findings of this research show that SAPL can be 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 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 CIPP lining of rigid pipes in gravity flow conditions, and even for their intended purpose, they have flaws. These equations cannot be used for SAPLs as 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 for there is no need filling corrugations for polymeric SAPL. 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 for different thicknesses and with aid of finite element modeling, the design equations for polymeric SAPL were developed, however, the equations for cementitious SAPL were derived by regression of soil box test results. The performance specifications for both polymeric and cementitious SAPLs were developed.

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 additional soil box testing be conducted with other products from additional vendors. The finite element modeling of cementitious SAPL was not completed due to delays in testing for Covid19 pandemic. The equations in this report require further evaluation with additional laboratory testing and FEM. Additionally, laboratory testing is required for other host culvert shapes and materials, such as host concrete box culvert. Different environmental conditions, such as freeze/thaw, impact of groundwater infiltration and inhibition of CMP corrosion must be investigated. SAPL performance during flooding is another category that can be examined in the field as well as in the soil box. Finally, results of this research with performance specifications and design equations should be implemented in actual roadway conditions and further investigated.

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