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VERMONT AGENCY OF TRANSPORTATION

Materials & Research Section
Research Report

EVALUATION OF ULTRALINER PVC ALLOY PIPELINER

Report 2013 – 13

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Evaluation of Ultraliner PVC Alloy™ Pipeliner

Final Report 2013 – 13

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Follow Up to Research Update U2004 – 01

Reporting on Work Plan 2001-R-08

STATE OF VERMONT
AGENCY OF TRANSPORTATION

MATERIALS & RESEARCH SECTION

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16. Abstract

In an effort to evaluate promising pipe lining techniques, the Agency installed two Ultraliner PVC Alloy Pipeliners in the town of Barton, Vermont in May of 2003; one in an 18-inch (450 mm nominal) reinforced concrete pipe (RCP) and one in a 24-inch (600 mm nominal) asphalt coated corrugated metal pipe. The liners were a folded continuously extruded polyvinyl chloride (PVC) pipeliner and are designed to return to their extruded shape upon the application of heat and to be formed tightly against the host pipe by “blow molding” with steam.

In ten years of service life to the publishing of this report, the liners and the culverts have no visible damage. The liners have halted the degradation of the culverts and extended the serviceable lives considerably. Due to these findings, the Agency is in support of continued use of the Ultraliner product, as well as continued evaluations and usage of similar culvert lining materials to extend the lives of our culverts and to reduce maintenance costs going forward.

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ABSTRACT

In an effort to evaluate promising pipe lining techniques, the Agency installed two Ultraliner PVC Alloy Pipeliners in the town of Barton, Vermont in May of 2003; one in an 18-inch (450 mm nominal) reinforced concrete pipe (RCP) and one in a 24-inch (600 mm nominal) asphalt coated corrugated metal pipe. The liners were a folded continuously extruded polyvinyl chloride (PVC) pipeliner and are designed to return to their extruded shape upon the application of heat and to be formed tightly against the host pipe by "blow molding" with steam.

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INTRODUCTION

State Departments of Transportation are continually looking for cost effective products and processes to extend the life of any number of transportation related products. One such item that has garnered significant interest in recent years is the use of pipeliners for existing culverts.

Culverts, defined as a closed conduit for the conveyance of stream flow and surface waters, serve an important purpose by providing roadway drainage and allowing existing waterways to pass underneath roadways, railroads or other impediments. The Agency typically constructs culverts of corrugated metal, concrete, or plastic pipe and provide a service life of approximately 50 years. According to the "2013 VTrans Fact Book," the VTrans maintains approximately 40,000 small culverts. A small culvert has a diameter of less than 72 inches. According to the Agencies culvert database, roughly 91% of the small culverts are at least 4 inches in diameter or are at most 24 inches in diameter. According to the database, roughly, 66% of these culverts are comprised of corrugated metal pipe (CMP), which represents approximately 24,000 culverts.

The widespread use of CMPs is due to its reduced material costs, ease of transport, and ease of construction in comparison to other types of culverts such as concrete. However, corrugated metal pipes are subject to deterioration resulting from soil and water chemistry containing a low PH, anaerobic biological systems, which exhibit reduced oxidation potential, otherwise known as acidic conditions, and low resistivity, or low resistance to the movement of an electrical charge, in addition to abrasion generated by infiltrating sediments. The Agency has determined that deicing salts accelerates the process of corrosion as they increase the ability of water to carry electrons.

As the metal culverts corrode, they suffer from section loss and associated reduction in structural integrity warranting replacement or repair. Conventional culvert replacement entails trench excavation to remove and replace the preexisting pipe. This causes a significant disruption to traffic flows as well as contributes to high replacement costs. With an increasing number of culverts in need of replacement, VTrans is seeking alternative methods that minimize traffic delays and incurred costs while maximizing service life. A promising method of trenchless technology, commonly referred to as "Cured-In-Place-Pipe," or CIPP, allows for the rehabilitation of the preexisting pipe with little to no excavation. The preexisting pipe is left in place and circumferentially confines the felt-like material to the inside diameter of the culvert. Through the curing process, the experimental material hardens and forms into a rigid structure.

To assess the ease of construction, durability, and performance of one of these liners, the Agency undertook an evaluation project using the Ultraliner PVC Alloy Pipe liner.

MATERIAL DESCRIPTION

The Ultraliner PVC Alloy Pipeliner is a continuously extruded polyvinyl chloride pipeliner tube with a specified nominal wall thickness to dimension ratio of 35. The pipeliner is folded into an 'H' shape and rolled onto a spool as a final step in the fabrication process. See Figure 1. The pipeliner is designed to return to its extruded round tubular shape upon the application of heat and to be formed tightly against the host pipe by "blow molding" with steam. The result is a permanent tight-fitting liner that conforms to the irregularities and corrugations of the inner surface of the culvert. Upon cooling, the liner will not shrink away from the wall of the culvert, thereby locking it in place. It can be supplied in diameters from three to thirty inches. The liner conforms to three industry standards, including:

- ASTM D1784-08 "Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds" (1)
- ASTM F1871-02e1 "Standard Specification for Folded/Formed Poly (Vinyl Chloride) Pipe Type A for Existing Sewer and Conduit Rehabilitation" (2)
- ASTM F1867-06 "Standard Practice for Installation of Folded/Formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation" (3)

Figure 1 Spooled Ultraliner on the project site.

According to the manufacturer documentation, Ultraliner's advantages of this higher-compliance PVC alloy material include:

- More favorable thermal properties which provide a wider window of installation forgiveness and which enable lining larger diameter pipes due to the ability to heat a thicker wall, sufficiently.
- According to the industry standard buckling design methodology, the material has a higher hydrostatic compression resistance at 'equivalent' structural load bearing capacity.
- The material attracts less soil load at 'equivalent' hydrostatic compression resistance.
- The material develops less localized stress at 'equivalent' structural load bearing capacity.
- Superior at avoiding and/or reducing stress concentrations in the pipeliner wall, resulting in reduced long-term creep and equates to greater long-term stability.

Table 1 below highlights some of the material properties of the Ultraliner PVC alloy, as provided by the company, and the applicable ASTM test method utilized to obtain the results.

Table 1 Summary of the material properties of the Ultraliner, from manufacturer.

Material Property	Value	ASTM Method
Base Resin	Poly(vinyl chloride) homopolymer	--
Izod Impact Resistance	15 ft-lb/in	D 256
Tensile Modulus	155,000 psi	D 638
Tensile Strength	3,600 psi	D 638
Flexural Modulus	145,000 psi	D 790
Rec. Long Term Modulus Reduction	25% Reduction, 75% Retention	--
Flexural Strength	4,100 psi	D 790
Heat Deflection Temperature	115ºF	D 648
Chemical Resistance	General sanitary sewer conditions	--

According to the product literature, the Ultraliner Pipeliner can accommodate culvert sizes from 4 to 24-inch diameters.

PROJECT LOCATION AND SUMMARY

The Ultraliners were installed in two pipes with an intermittent water flow within the Barton STP 0113(58) S project on US Route 5 in Barton, Vermont, which began 1 mile from the Barton Village line and continued towards Barton for 0.29 miles. The first culvert was an 18-inch diameter pipe located at approximately 80 feet before mile marker 3.90 and the second a 24-

inch pipe located at approximately 160 feet after mile marker 3.90. The pipes run under US Route 5, under the southern approach of Bridge 00161, and under the adjacent access road and discharge eastward into Crystal Lake. The 18-inch pipe was a reinforced concrete pipe (RCP) as originally constructed, while the 24-inch pipe was an asphalt coated corrugated metal pipe (ACCGMP). Winterset Inc. was the prime contractor on the project, with Eastern Pipe Service Inc. the subcontractor performing the linings.

The existing pipes were in poor condition with deformations, tree root infiltrations, and extensive areas of corrosion. The Ultraliners were installed in 2003: the 18-inch liner on May7 and the 24-inch on May 8. Liner installation consists for unfurling a folded liner into the culvert and supplying low-pressure steam (5 to 12 psi) for up to two hours for processing. The installers then applied compressed air to cool the liner and ultimately harden it. Refer to the Research Update U2003-06 for complete installation details. (*4*)

Following installation of the liners, the project Resident Engineer noted in a project daily report that "I am very impressed with the finished product; the liner completely takes the shape of the host pipe showing all the corrugation. I feel this is a viable product that could be used at other failing pipes within the state." (*5*)

PERFORMANCE

Periodic site visits were performed to the two culverts after installation to assess the condition of the liners. Visits were made on November 23, 2004 and again on July 5, 2007 with a final visit on October 19, 2010. Side-by-side photographs of the inlet of the 24-inch liner and the outlet of the 18-inch liner at each of the site visit dates can be seen in the Figures 2 through 7. These photographs show little, if any, change between the year of installation (2003) and seven years of age (2010).

Figure 8 shows the outlet of the 24-inch liner in 2010 while Figure 9 shows the inlet of the 18-inch liner in 2004.

COST ANALYSIS

A significant motivation for utilizing this product was cost savings. The cost of replacing failed culverts can be significant depending on the depth and length of the culvert. It is estimated that replacing these two culverts would require approximately $110,000 (in 2003) worth of installed materials along with a full or partial road closure of two to three weeks, which would cause a significant amount of inconvenience to the traveling public.

In 2003, the total cost of the 24-inch lining was $27,300 and $13,000 for the 18-inch lining. These were bid as lump-sum items. Additional labor and minimal materials were used in erosion control and preparation. Those costs would have also been incurred with a normal replacement.

Figure 2: Inlet of 24-inch pipe, 2004

Figure 3: Inlet of 24-inch pipe, 2007

Figure 4: Inlet of 24-inch pipe, 2010

Figure 5: 18-inch pipe outlet, 2004

Figure 6: 18-inch pipe outlet, 2007

Figure 7: 18-inch pipe outlet, 2010

Figure 8: Photograph of the outlet of the 24-inch liner in 2010.

Figure 9: Photograph of the inlet of the 18-inch liner in 2004.

Since the product has been in production since 1991, the life span of the culvert liner is unknown at the time of publication of this report. The average annual inflation rate since 2003 has been 2.4% (*6*). Based on this, the annualized construction and materials cost becomes $4,580 over the 10 years in service. A nine-year service life would have an equivalent annual cost of $5,030. Assuming a reliable lifespan for the typical full replacement is 30 years, the annualized construction and materials cost of the replacing the two culverts would be $5,180 over the 30 years of service life. As a permanent 30-year repair, the annualized cost of the liner would be $1,900.

The construction and materials cost comparison does show that there are considerable cost savings using the Ultraliner Pipeliner system if the product remains in service for 10 or more years. This comparison does not consider the costs associated with traffic control and the economic impacts to the local economy that a road closure would have caused.

SUMMARY AND RECOMMENDATIONS

Two Ultraliner PVC Alloy Pipeliners were installed in the town of Barton, Vermont in May of 2003; one in a 18-inch reinforced concrete pipe (RCP) and one in a 24-inch asphalt coated corrugated metal pipe. The liners are continuously extruded polyvinyl chloride tubes that are folded and coiled. During installation, they are designed to return to their extruded tubular shape upon the application of heat and to be formed tightly against the host pipe by "blow molding" with steam.

Through the ten years of service life of the liners to this point, no visible damage can be seen to the liner or the culverts themselves. Any degradation of the culverts has been halted and their serviceable lives extended considerably. Due to these findings, the Agency is in support of continued use of the Ultraliner product, as well as continued evaluations and usage of similar culvert lining materials to extend the lives of our culverts and to reduce maintenance costs going forward.

IMPLEMENTATION STRATEGY

Pipeliners similar to the Ultraliner PVC Alloy Pipeliner should be considered in extending the life of existing culverts that are suffering from moderate deterioration where the overall integrity of the culvert is intact. When in service for 10 years or more, the pipeliner will provide a substantial cost benefit when compared to reconstruction for long-term solutions. For highways that are scheduled for reconstruction well within a 10 years period, and depending on the degree of deterioration, it may prove to be more cost effective to include the culvert replacement in the highway reconstruction rather than use a pipeliner. When deterioration is reaching critical levels where the integrity of the culvert becomes a concern for the near future, a pipeliner should always be considered.

REFERENCES

1. ASTM D1784-08 "Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds", ASTM International, West Conshohocken, PA, www.astm.org

2. ASTM F1871-02e1 "Standard Specification for Folded/Formed Poly (Vinyl Chloride) Pipe Type A for Existing Sewer and Conduit Rehabilitation", ASTM International, West Conshohocken, PA, www.astm.org

3. ASTM F1867-06 "Standard Practice for Installation of Folded/Formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation", ASTM International, West Conshohocken, PA, www.astm.org

4. Ashworth, Lindsay, "Installation of the Ultraliner PVC Alloy Pipe Liner - Barton, Vermont" Vermont Agency of Transportation, Research Update U 2003 - 06, September 15, 2003.

5. McClure, Kevin, Project Notes, Vermont Agency of Transportation, 2003.

6. U.S. Bureau of Labor Statistics, U.S. Price Inflation (CPI-U, Annual Average), U.S. government's Consumer Price Index (CPI), 1913 to present.

TA-565 Rev4/79 Prepared by: William E. Ahearn P.E.
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October 30, 2001

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH SECTION

CATEGORY II WORK PLAN FOR
Ultraliner PVC Alloy™ Pipeliner

Work Plan No. WP 2001-R-8

OBJECTIVE OF STUDY: To evaluate the performance of a pipe lining system for the purpose of extending the service life of in-place pipes. The study will obtain information on the initial condition of a 450mm reinforced concrete pipe (RCP) and a 600mm asphalt coated corrugated metal pipe (ACCGMP), and the condition immediately after placement of the lining materials. Results of a final evaluation will be published after 2 years. This study will provide early information about the performance of pipe lining systems in Vermont's climatic conditions.

LOCATION: US Route 5 in Barton Vermont, beginning 1.61 km from Barton Village line and continuing toward Barton for 0.46 km. The subject pipes are located at stations 1+063.000 and 1+142.000 on the Barton STP 0113(58) S project.

MATERIAL: The lining system is a folded continuously extruded polyvinyl chloride pipe liner with a specified minimum dimension ratio (DR) of 35. The pipe liner is designed to return to its pre-folded round "memory" shape upon the application of heat and to be formed tightly against the host pipe by "blow molding" with steam.

COST: The cost of materials and installation of the liner for the 18-inch RCP is estimated to be $13,000. Alternatively, costs for complete replacement of the RCP are estimated to be $40,000.

The cost of materials and installation of the liner for the 600 mm ACCGMP is estimated to be $25,000. Alternately, costs for complete replacement of the ACCGMP are $70,000.

SURVEILLANCE AND TESTING: The condition of the pipes selected for lining will be established in their baseline condition. Observations will be made regarding pipe thickness, coating condition and pipe deformation prior to installation. The liner installation will be documented with field observations, photographs, and internal video inspection of the completed installation of the pipe liner. Observations of the pipe deformation, liner alignment and liner integrity will be made after installation. Final observations will be made approximately two years after installation and will include findings on all previous observation criteria including extraction of a sample of liner and pipe for evaluation.

DURATION OF THE STUDY: The length of the study shall be 24 months.

REPORTS: A report will be prepared after the initial installation of the product for distribution within the Agency. A second report that defines the condition found at twenty-four months will be prepared and distributed according to the original distribution.

Reviewed By:

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Date:

Approved by Material and Research (RFC)
Approved by Federal Highway Administration (CPJ)