Introduction

• Repair Methods and Installation
• Structural Design Considerations
• Hydraulic Design Considerations
Introduction

Culvert failure kills five
Culvert failure kills five

Repair Methods

- Cured in Place Systems
- Strip-wound Lining
  - Size restriction to Man-Entry Applications
- Slip-lining Pipe (HDPE)
  - 12” to 120” diameter
Cured in Place Systems

- Lining tube saturated with thermosetting resin installed into damaged culvert and cured with a heat source to form a pipe-within-a-pipe.
  - Environmental impact of CIP: “Three to four gallons of uncured resin were released during a CIP installation (the location of which was not disclosed in the report) on a stormwater drain. The residual uncured resins were carried to a creek, resulting in the death of more than 5,500 fish of various species.”(1)
Strip-wound Lining

Fig 5

Strip-wound Lining

Fig 4
Strip-wound Lining

Annulus Spacers (Beam Bolsters) Welded to CMP

Strip-wound Lining
Strip-wound Lining

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Slip-lining Pipe

12” to 63” diameter meets AASHTO M 326 requirements

Standard Specification for
Polyethylene (PE) Liner Pipe, 300-
to 1600-mm Diameter, Based on
Controlled Outside Diameter
AASHTO Designation: M 326-08

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Slip-lining Pipe

Pipe joint

Slip-lining Pipe (HDPE)
INDOT
Slip-lining Pipe
INDOT

Slip-lining Pipe
Concrete Headwalls

Low slump concrete used for headwall
Slip-lining Pipe (Grouting Operation)

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Slip-lining Pipe

TxDOT Rehabilitation Project
Grout Design

Project Parameters

- Two 3’ x 3’ Concrete Box Culverts, 48 LF
- Slip Lined with 32” Snap-Tite Pipe
- 20 cu. yds. of Grout Estimated
- Completed September, 2007
- Compressive Strength (6 days) = 1,400 psi

Submitted Design

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<th>UW</th>
<th>Sand</th>
<th>Other</th>
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<th>Cement</th>
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Structural Design Considerations

- Highway or traffic loads
- Hydraulic pressure
- Dead loads
- Condition of Host Pipe
  - Voids near host pipe
- Grout density
- CANDE – 2007 Analysis

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Existing Culvert Evaluation

- Culvert Rating Systems:
  - Ohio DOT – “New Inspection and Risk Assessment Methods for Highway Metal Culverts in Ohio” (2)
  - Utah DOT – “Management of Utah Highway Culverts” (3)
  - NASSCO – Pipeline Assessment and Certification Program (4)
Grout Density(5)

Density vs Equivalent Soil Modulus

\[ y = 15429e^{0.0374x} \]

\[ R^2 = 0.7664 \]

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Design Guidance

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CANDE – 2007 Analysis

• Structural analysis of slip-lined CMP with a HDPE relining pipe meeting AASHTO M326
  – Host pipe: 36" diameter CMP, 2 2/3 X ½ Profile, 14 gauge pipe wall thickness, 50% section loss, 5% deflection.
  – Grout densities: 40 lbs/ft^3 and 75 lbs/ft^3
  – Relining pipe: Solid wall HDPE meeting AASHTO M326, SDR 32.5.
  – Soil Type:
    • Good soil, Constrained modulus = 3,000 psi;
    • Poor soil, Constrained modulus = 1,000 psi
  – CANDE: Interface elements between host pipe and grout and between grout and liner pipe.

Maximum Burial Depth Based on CANDE – 2007 Analysis (6)

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<th>Case #3</th>
<th>Case #4</th>
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Notes:

All failure modes are CMP plastic hinging at springline except case #6 which exceeded the grout’s trust capacity at the spring line.

Case #1 - Host only; Good Soil
Case #2 – Host + Liner; Grout=75 lb/ft^3; Good Soil
Case #3 – Host + Liner; Grout=40 lb/ft^3; Good Soil
Case #4 – Host only; Poor Soil
Case #5 – Host + Liner; Grout=75 lb/ft^3; Poor Soil
Case #6 – Host + Liner; Grout=40 lb/ft^3; Poor Soil
Hydraulic consideration

(LOAD factor due to voids)

• Inlet Control
  – Inlet coefficients (J. Hurd Presentation)
  – Manning Coefficient of Deteriorated pipe
  – Channeling of water parallel to pipe for inlet control condition
  – Joint infiltration and exfiltration

Hydraulic Considerations

• Deterioration of host pipe (CMP)

“Based upon the experimentally determined values, the full-flow capacity of each pipe ... corresponds to a 14% reduction of capacity due to the combined effects produced by their innate physical differences and those that accompany deterioration after 30 years of service. Based on the section loss the old culvert was determined to be at condition state 3 and a survival probability of 74.5% with an average section loss of between 10% and 30%.” (7)
Erosion parallel to pipe

Voids near host pipe

(Load factor due to voids)

"Effect of Backfill Erosion on Moments in Buried Rigid Pipes" (8)
Joint infiltration and exfiltration

Profile wall joints
Exterior sealing and Interior welding
References

4. National Association of Sewer Service Companies – Pipeline Assessment and Certification Program