

TRB Webinar, Sponsored by AFS40
(Subsurface Soil-Structure Interaction), June 20th 2008

Culvert Relining Installation, Design and Hydraulic Considerations

Presented by:

Tim Toliver, P.E.

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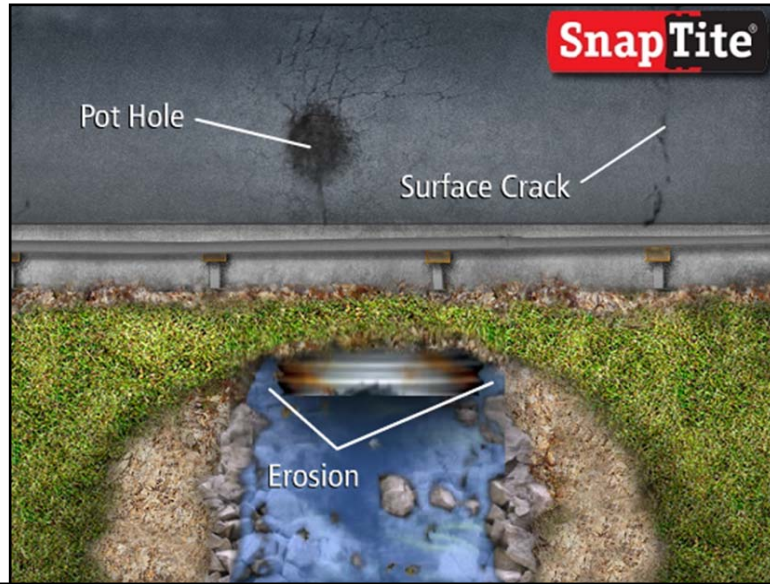
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Introduction

- Repair Methods and Installation
- Structural Design Considerations
- Hydraulic Design Considerations

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Introduction



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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

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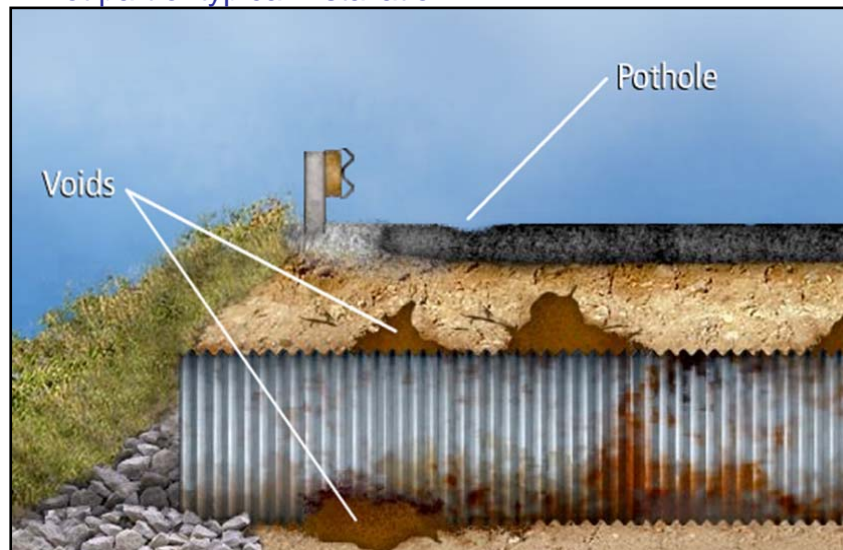
Cured in Place Systems

- 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⁾

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Cured in Place Systems

Grouting of void space between host pipe and backfill is not part of typical installation.



Strip-wound Lining

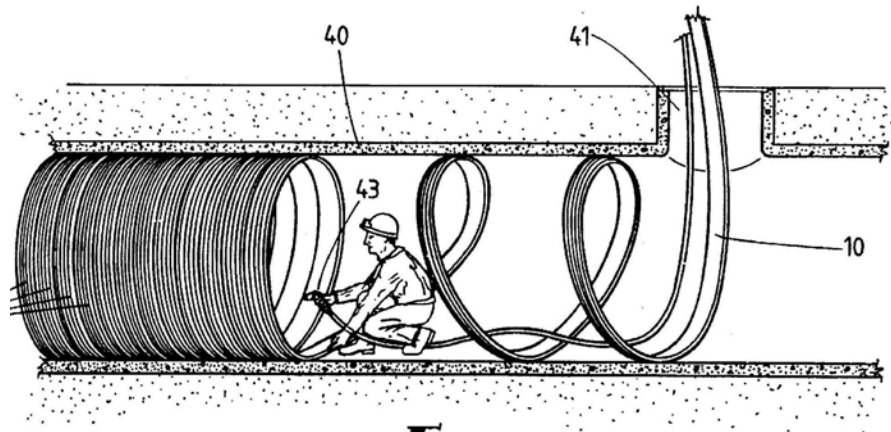


FIG 5

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Strip-wound Lining

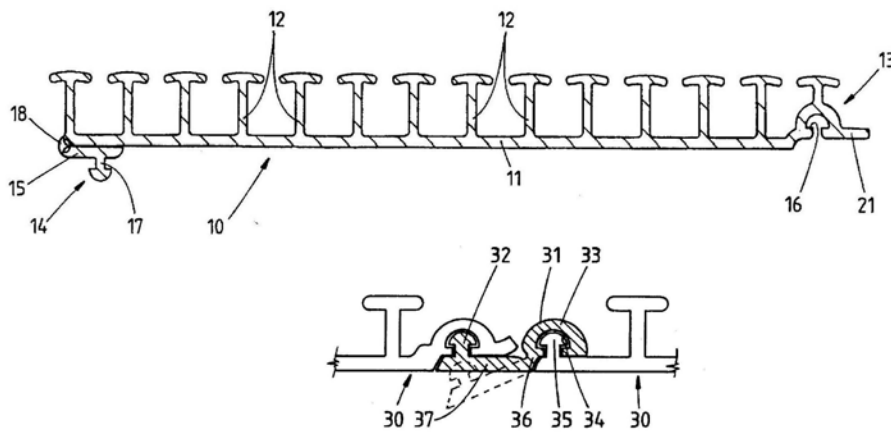


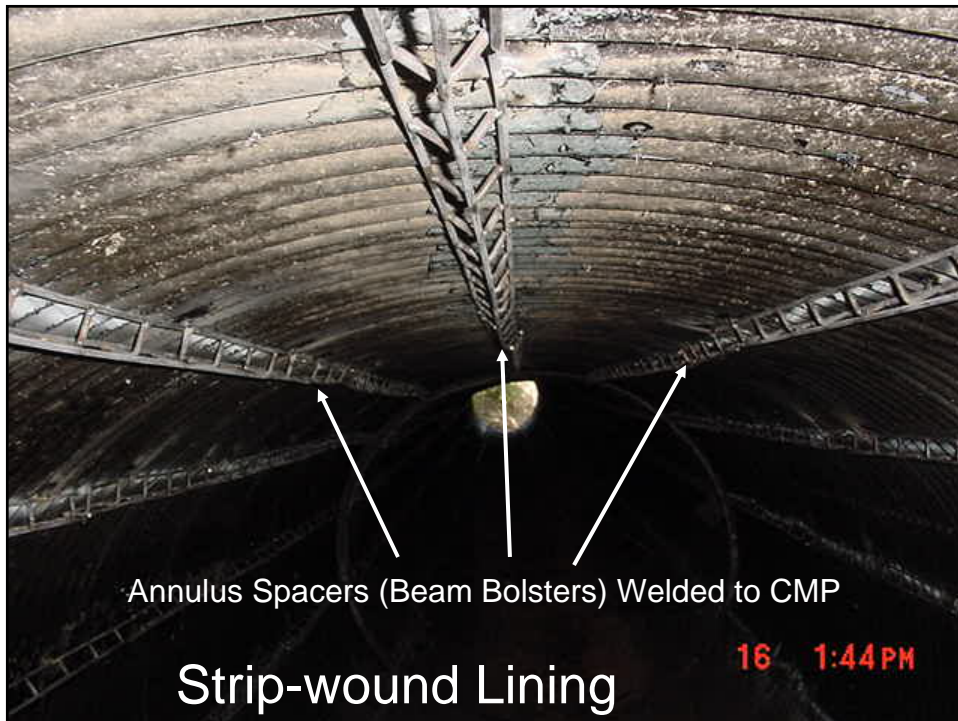
FIG 4

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Strip-wound Lining



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Strip-wound Lining



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Slip-lining Pipe

12" to 63" diameter
meets AASHTO M
326 requirements

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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



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Slip-lining Pipe (HDPE)
INDOT



Slip-lining Pipe (Grouting Operation)



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

Volume	26.47 cy
UW	68.32 lbs/ft ³
Sand	
Other	
Design Air	40
Cement	1000 lbs
Fly Ash	250 lbs
Water	563 lbs (67 gals)

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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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Condition of Host Pipe

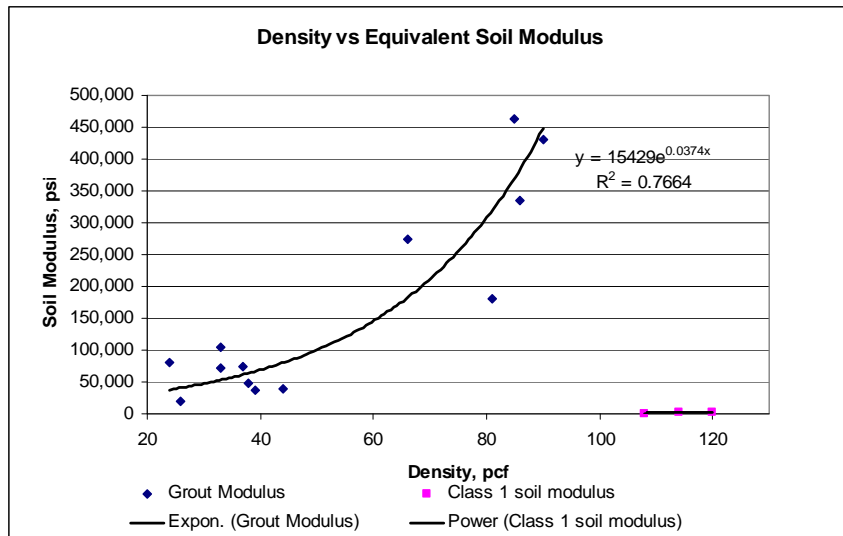


Existing Culvert Evaluation

- 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⁾

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Grout Density⁽⁵⁾



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Design Guidance



Snap-Tite®
Manual

SNAP-TITE











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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 1/2 Profile, 14 gauge pipe wall thickness, 50% section loss, 5% deflection.
 - Grout densities: 40 lbs/ft³ and 75 lbs/ft³
 - 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.

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CANDE – 2007 Analysis

Maximum Burial Depth Based on CANDE – 2007 Analysis ⁽⁶⁾					
Case # 1	Case # 2	Case # 3	Case # 4	Case # 5	Case # 6
15.3 ft	30.8 ft	20.4 ft	12.3 ft	29.6 ft	19.3 ft

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/ft³; Good Soil

Case # 3 – Host + Liner; Grout=40 lb/ft³; Good Soil

Case # 4 – Host only; Poor Soil

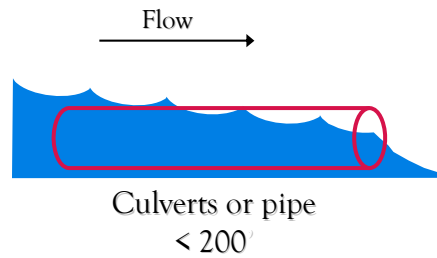
Case # 5 – Host + Liner; Grout=75 lb/ft³; Poor Soil

6/19/2008 Case # 6 – Host + Liner; Grout=40 lb/ft³; 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



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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⁾

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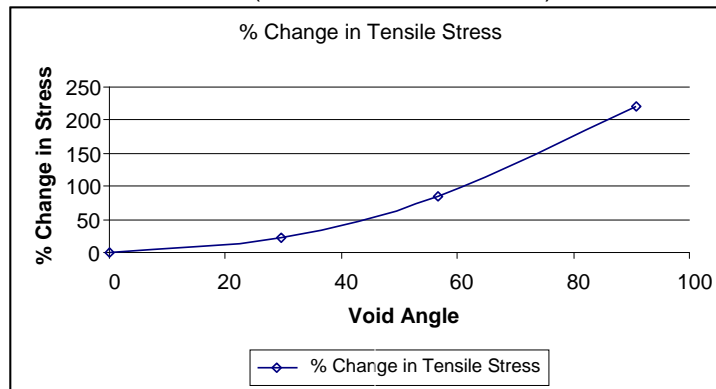
Erosion parallel to pipe



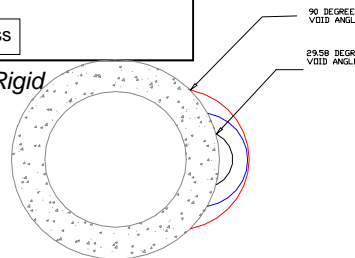
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Voids near host pipe

(Load factor due to voids)



"Effect of Backfill Erosion on Moments in Buried Rigid Pipes" (8)



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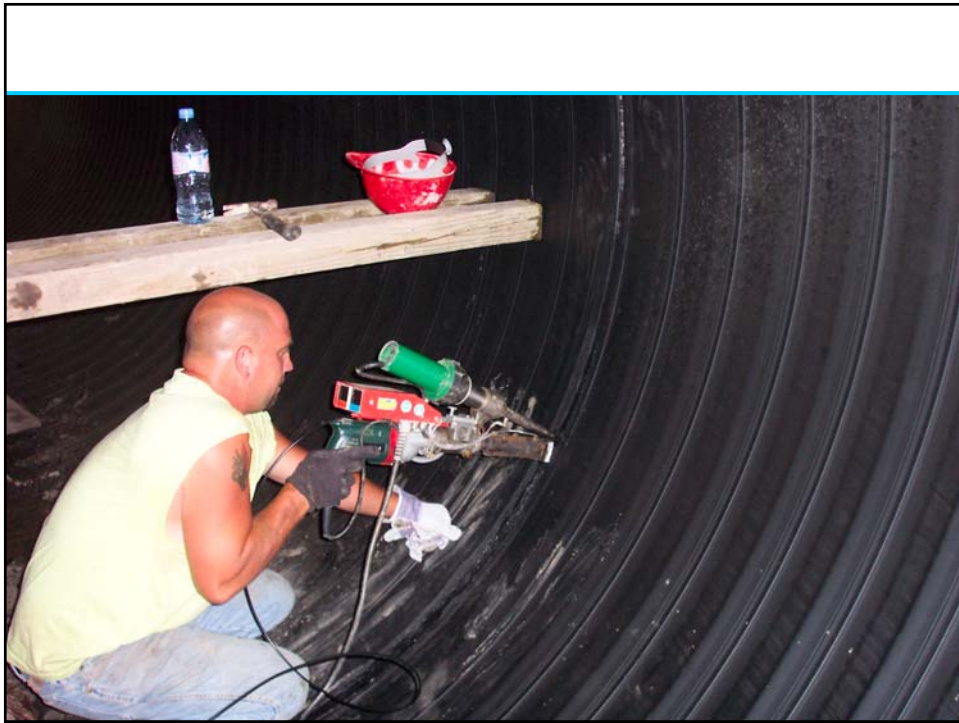
Joint infiltration and exfiltration



Profile wall
joints
Exterior sealing
and Interior
welding



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4. National Association of Sewer Service Companies – Pipeline Assessment and Certification Program
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6. Katona M. and Toliver, 2008. CANDE Structural Evaluation of Slip-lined CMP.
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