OUR CULVERT CAME OUT OF A NOZZLE
“A TRUE STORY”

THOMAS LEFCHIK, ODOT DISTRICT 9
“ONCE UPON A TIME IN DISTRICT 9 THERE WAS A CULVERT CALLED …”
JAC-93-0.15

- BUILT 1960
- 15’ DIAMETER
- 152’ LONG
- 26 DEGREE SKEW
- INVERT PAVED 1985
- APPROXIMATELY 4.5’ WATER
- 13’+ FILL OVER CROWN
OPTIONS

- PLASTIC LINER
OPTIONS

- PLASTIC LINER – MAX 12’ DIAMETER, RAISE HEADWATER 2’
HYDRAULICALLY TAXED
OPTIONS

- PLASTIC LINER – MAX 12’ DIAMETER, RAISE HEADWATER 2’
- CONCRETE ARCH -
OPTIONS

• PLASTIC LINER – MAX 12’ DIAMETER, RAISE HEADWATER 2’

• CONCRETE ARCH - REQUIRES ROAD CLOSURE FOR EXCAVATION
OPTIONS

- PLASTIC LINER – MAX 12’ DIAMETER, RAISE HEADWATER 2’
- CONCRETE ARCH - REQUIRES ROAD CLOSURE FOR EXCAVATION
- BRIDGE PHASE CONSTRUCTED AT GRADE THEN EXCAVATED
OPTIONS

- Plastic Liner – Max 12’ Diameter, Raise Headwater 2’
- Concrete Arch - Requires Road Closure for Excavation
- Bridge Phase Constructed at Grade Then Excavated – High Cost
OPTIONS

• PLASTIC LINER – MAX 12’ DIAMETER, RAISE HEADWATER 2’
• CONCRETE ARCH - REQUIRES ROAD CLOSURE FOR EXCAVATION
• BRIDGE PHASE CONSTRUCTED AT GRADE THEN EXCAVATED – HIGH COST
• STRUCTURAL SPRAY LINER (SS 833)
OPTIONS

• PLASTIC LINER – MAX 12’ DIAMETER, RAISE HEADWATER 2’
• CONCRETE ARCH - REQUIRES ROAD CLOSURE FOR EXCAVATION
• BRIDGE PHASE CONSTRUCTED AT GRADE THEN EXCAVATED – HIGH COST
• STRUCTURAL SPRAY LINER (SS 833) – NO LONG TERM EXPERIENCE
OPTIONS

- **Plastic Liner** – Max 12’ Diameter, Raise Headwater 2’
- **Concrete Arch** – Requires Road Closure for excavation
- **Bridge Phase** Constructed at Grade Then Excavated – High Cost
- **Structural Spray Liner (SS 833)** – No Long Term Experience – Let’s Try It
BIDS

• FIRST BID REJECTED – ONE INSTALLER
• SECOND BID NOT AS HIGH – TWO INSTALLERS
• COMPETITION IS A GOOD THING
  • INCLUDE ALTERNATIVE METHODS IF POSSIBLE
SUPPLEMENTAL SPECIFICATION 833

CEMENTITIOUS OR GEOPOLYMER BASED STRUCTURAL LINER PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Duration</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive Strength</td>
<td>ASTM C 109</td>
<td>1 Day</td>
<td>Min. 2,500 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 Days</td>
<td>Min. 8,000 psi</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>ASTM C 293</td>
<td>7 Days</td>
<td>Min. 600 psi</td>
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<tr>
<td></td>
<td></td>
<td>28 Days</td>
<td>Min. 800 psi</td>
</tr>
<tr>
<td>Modulus of Elasticity</td>
<td>ASTM C 469</td>
<td>28 Days</td>
<td>3,480,000 psi</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM C 496</td>
<td>---</td>
<td>670 psi</td>
</tr>
<tr>
<td>Bond Strength</td>
<td>ASTM C 882</td>
<td>28 Days</td>
<td>1,100 psi</td>
</tr>
</tbody>
</table>
**SUPPLIED MATERIAL**

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Compressive Strength</td>
<td>C-109</td>
<td>4310 PSI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6000 PSI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10000 PSI</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>596</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>28 Day</td>
<td></td>
</tr>
<tr>
<td>Bond Strength</td>
<td>C-882 (modified)</td>
<td>2500 PSI</td>
</tr>
<tr>
<td></td>
<td>28 Day</td>
<td></td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>C-293</td>
<td>720 PSI</td>
</tr>
<tr>
<td></td>
<td>7 Day</td>
<td>850 PSI</td>
</tr>
<tr>
<td></td>
<td>28 Day</td>
<td>1695 PSI</td>
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<tr>
<td>Splitting Tensile</td>
<td>C-496</td>
<td>420 PSI</td>
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<td></td>
<td>28 Days</td>
<td>750 PSI</td>
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<tr>
<td>Chloride Permeability</td>
<td>C-1202</td>
<td>205 Coulombs</td>
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<td></td>
<td>28 Day</td>
<td></td>
</tr>
<tr>
<td>Modulus of Elasticity</td>
<td>469-02</td>
<td>3,433,333</td>
</tr>
<tr>
<td></td>
<td>28 Day</td>
<td>4,533,333</td>
</tr>
<tr>
<td>Freeze/Thaw</td>
<td>C-666</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 cycles – No Damage</td>
</tr>
<tr>
<td>Unit Weight</td>
<td></td>
<td>128.3 PCF</td>
</tr>
</tbody>
</table>
No. 4 Steel Dowel
12" Long at 18" O.C.
Typical, Both Sides

Note: The diagrams are not to a scale.
PLAN NOTE

• CLARIFY THAT STRUCTURAL DESIGN DOES NOT CONSIDER EXISTING PIPE
• MANUFACTURER REPRESENTATIVE ON-SITE AT ALL TIMES
• FABRICATE TWO TEST PANELS
• TESTING
• QUALITY OF FINISH
STRUCTURAL DESIGN

• ALL CALCULATIONS PERFORMED AND STAMPED BY A REGISTERED PROFESSIONAL ENGINEER. DESIGN THE STRUCTURAL SPRAY LINER REHABILITATION SYSTEM TO SUPPORT THE DEAD LOAD, LIVE LOAD AND PROVIDE A MINIMUM 50 YEAR SERVICE LIFE FOR DURABILITY.

• WHAT ARE THE LOADS?
  • THE CMP IS FLEXIBLE
  • THE LINER IS RIGID

• WHAT IS THE DESIGN METHOD?

• DESIGN VARIABLES ARE IN SS 833

• A DESIGN WAS PROVIDED AND APPROVED.

• 3” THICKNESS ABOVE THE TOP OF THE CORRUGATIONS.
### Cementitious or Geopolymer Based Structural Liner Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Water Height</td>
<td>At the top of the pipe unless site conditions indicate higher</td>
<td>ft</td>
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<tr>
<td>Poisson’s Ratio</td>
<td>0.3</td>
<td>n/a</td>
</tr>
<tr>
<td>Lateral Earth Pressure Ratio</td>
<td>0.45</td>
<td>n/a</td>
</tr>
<tr>
<td>Soil Density</td>
<td>120 minimum</td>
<td>lb/cf</td>
</tr>
<tr>
<td>Soil Modulus of Reaction</td>
<td>2,000 maximum</td>
<td>psi</td>
</tr>
<tr>
<td>Long Term Material Modulus</td>
<td>100% of short term material modulus</td>
<td>psi</td>
</tr>
<tr>
<td>Factor of Safety</td>
<td>2.0 minimum</td>
<td>n/a</td>
</tr>
<tr>
<td>Crack Width</td>
<td>0.01 maximum</td>
<td>inches</td>
</tr>
<tr>
<td>Live Loading</td>
<td>HL-93 Vehicle</td>
<td>psi</td>
</tr>
<tr>
<td>Thickness</td>
<td>1.5 min; increase calculated value to nearest 0.5 intervals</td>
<td>inches</td>
</tr>
</tbody>
</table>
MANUFACTURER REPRESENTATIVE

- RECEIVED REQUIRED DOCUMENTATION
- WAS ON THE PROJECT AS REQUIRED
- DISAPPOINTING
THICKNESS MEASUREMENTS

From Inlet 2 8.9 feet

70' R 3.3, 3.7, 3.6, 3.5, 3.6
L 2.7, 2.5, 2.5, 2.5, 2.7

85' R 1.4, 1.4, 1.4, 1.6, 1.7
L 2.7, 2.5, 2.5, 2.5, 2.7

48' R 1.6, 1.8, 2.0, 2.3, 2.2
L 1.6, 1.6, 1.6, 1.7, 1.8

65' R 1.5, 1.5, 1.7, 1.9, 2.3
L 1.9, 1.9, 1.8, 2.3, 2.2

76' R 2.0, 1.8, 1.8, 1.7, 1.7
L 1.9, 1.9, 1.9, 2.1, 2.3

90' R 3.3, 3.0, 3.0, 2.9, 2.9
L 2.3, 2.4, 2.2, 2.3

125' L 2.9, 2.4, 2.3, 2.5, 2.7
THE HERO
ONE YEAR LATER
LESSONS LEARNED

• MORE RESEARCH IS NEEDED FOR STRUCTURAL DESIGN

• REQUIRE A CERTIFIED NOZZLEMAN

• MANUFACTURER REPRESENTATIVE IS NOT WORTHWHILE

• ONLY SPECIFY NON-CORROSIVE STUDS FOR THICKNESS VERIFICATION

• (TRUST BUT VERIFY) A GOOD QUALITY PACHOMETER CAN CHECK THE THICKNESS. TAKE CORES.

• COMPETITION IS A GOOD THING. ALTERNATE METHODS SUCH AS STEEL CASING SHOULD BE ALLOWED.

• LONG TERM PERFORMANCE IS UNKNOWN
THE END