Culvert pipe materials and durability: Making the right selection for Minnesota

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May 22, 2013
Project objectives and goals

Project Goals:
Evaluate current practice and develop a research roadmap that will update design, construction, and monitoring practices for culvert installations in Minnesota.

Ø Phase I Project
Ø Develop recommendations for improving practice
Ø Develop Research Needs
Project Motivation

Three issues motivate this work:

1. The actual service life of infrastructure is less than expected
2. Advances in pipe materials & federal requirement to consider alternative materials
3. MnDOT seeks to improve/update guidelines - MnDOT Drainage Manual (Chapter 2)
What causes pipes to deteriorate?

- Acidity/alkalinity of water and soil (pH)
- Soil resistivity
- Chlorides & Sulfates
- Abrasion
- Loading (structural, freeze/thaw, bedding)
Overview of material types

• Reinforced Concrete Pipe
  – Most common in the state. Durable pipe
  – Service life can exceed 100 years

!Tie bars are structural elements!
Overview of material types

• **Galvanized Corrugated Metal Pipe**
  – Commonly used, inexpensive, lightweight, available
  – Design service life from 25-50 years.
Overview of material types

- **Aluminized Corrugated Metal Pipe**
  - Less-commonly used but positive feedback on use
  - Service life *3-8 times longer* than galvanized
Overview of material types

- Polymeric coated corrugated metal pipe
  - Less common, lightweight
  - Optimum service life 100 years
  - Extremely Difficult to install!
Overview of material types

• HDPE
  – Lightweight
  – Good service life 50-100 years

Databases Investigation

- NRCS Web Soil Survey (WSS)
  - Some Soil Chemistry
- District 3 pH map
  - Collected by MnDOT
- MNDOT HYDINFRA
  - Continual Culvert Inspection Effort
Databases Investigation

- USGS Database - (surface water, pH)
  - Larger Streams & Rivers
- Minnesota Pollution Control Agency (MPCA)
  - Shallow groundwater

Summary: Many databases were insufficient for this study.
HYDINFRA database

- **HYDraulic INFRAstructure inspection program**
- Records
  - Location
  - Size
  - Condition
  - Other “Red Flags”
- **Over 95,000 pipes identified**
Major Findings

Usage Statistics for Concrete, Steel, & Plastic Pipe

District

- Plastic
- Steel
- Concrete

Metro State Wide
Major Findings

Average Pipe Condition by District

- Concrete
- Plastic
- Steel

District

1 2 3 4 6 7 8 Metro State Wide
Major Findings

• Concrete pipe is correlated with most of road damage – Is this perception or truth?

• Joint separation is a major issue
  – ~18% of RCP have joint separation issues

• For joint separation pipes, ~14% results in road damage

<table>
<thead>
<tr>
<th>District</th>
<th>% RCP w/Joint Separation</th>
<th>No Damage</th>
<th>Distress Only</th>
<th>Void Only</th>
<th>Both</th>
<th>Any Damage</th>
<th>% Road Damage</th>
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<tr>
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<td>649</td>
<td>123</td>
<td>165</td>
<td>937</td>
<td>14.4%</td>
</tr>
</tbody>
</table>
Recommendations

• MnDOT may or may not incorporate recommendations

• Project did not consider all factors
  – Economics
  – Logistics
  – Safety
Recommendations

- 100 year design service life for centerline and mainline T.H. culverts
- 50-75 years design service life for entrance culverts
  - MnDOT District Interviews
**Recommendations**

- Gasketed joints should become the default concrete pipe joint for all sizes of CP.
  - Joint separation most common failure (HydInfra)

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![Diagram showing JOINTS IN NON-GASKETED PIPE STD. PLATE 3000 and JOINTS IN GASKETED PIPE STD. PLATE 3006]
Recommendations

- Aluminized Corrugated 16g pipe should replace galvanized as the default steel pipe
  - ~Cost equivalent
  - Better service life
Recommendations

• Split HDPE pipe into two classes
  – Class I: 50-year material service life
  – Class II: 100-year material service life

• Adopt Florida DOT testing methods for determining HDPE material service life
Recommendations

• MnDOT should review the supplemental pipe inspection methodologies.
• Examples include:
  – 1) Consider video inspection for special or high risk pipe installations
  – 2) consider pressure/vacuum tests for critical pipes.
  – 3) Laser ring inspection for flexible pipe
Recommendations

• Adopt CalTrans abrasive conditions design methods
  – Abrasive conditions determined by previous installation
  – Found in NCHRP Project Report 20-07

Photo from: FHWA/CA/TL – CA01-0173
Research Needs

Research implementation priorities are as follows:

• Supplemental Inspection and Testing Methods
• Concrete Pipe Joint Separation Evaluation
  – Required joint strength
• Processed Based Abrasion Model
• Steel Pipe Service Life Map
  – Expected to start in July 2013
Acknowledgements

• Funding provided by Minnesota Department of Transportation (Contract #89261; Work Order No. 244)
• Funding provided by St. Anthony Falls Laboratory – University of MN.

• MnDOT Technical Advisory Panel Members:
  – Andrea Hendrickson,
  – Bonnie Peterson,
  – Joe Nietfeld,
  – Jim Kochsieck,
  – James Michael,
  – Ruth Betcher,
  – David Johnston,
  – Jon Bergstrand, and
  – Shirlee Sherkow.

• Center for Transportation Studies, UMN
• District and industrial contacts who made the interviews possible.
Thank you!

Questions?

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