Improving the Selection and Testing of Culvert Pipe Materials

What Was the Need?
To allow water to pass beneath roads and other structures, engineers have traditionally used culverts consisting of concrete or metal pipes. Alternative culvert pipe materials have become available, including coated metal and plastic. In certain environments, these materials may be more resistant to corrosion, a common maintenance issue for culverts that can lead to failure and serious road damage, endangering public safety and requiring costly emergency repairs.

MnDOT’s current Drainage Manual has limited guidance on the selection and inspection of pipe materials. The manual focuses on the selection of concrete and metal pipes, but does not cover alternative pipe materials or have enough information about the effects of environmental conditions on pipe durability. Research was needed to synthesize the districts’ experiences and national culvert research for inclusion in the Drainage Manual.

What Was Our Goal?
The objective of this study was to evaluate factors affecting the service lives of culvert pipe materials and to use the evaluation as guidance for selecting materials and inspecting pipes.

What Did We Do?
Researchers began by conducting a literature review on factors influencing pipe material selection and durability. Then they investigated current state and national practices by:

- Interviewing MnDOT staff about pipe design, materials, methods and maintenance.
- Conducting a site visit to MnDOT District 6 to inspect pipes exhibiting typical failure modes and to spend time with maintenance personnel and construction inspectors.
- Holding discussions with several pipe distributors and contacting the Florida Department of Transportation about its use of plastic pipe.

Researchers then analyzed databases with information related to watersheds flowing into MnDOT culverts to determine how typical Minnesota site conditions affect the expected service lives of steel pipes. In doing so, they used the California Method, which estimates how the acidity and electrical resistivity of soils affect pipe corrosion. They also examined MnDOT’s HydInfra database for trends in pipes made from all materials. This database is used to manage inventory for storm drainage features and includes information about pipe location, materials, design, conditions, and inspection and maintenance activities.

Analyzing this data, researchers evaluated pipes in Minnesota for their failure rates, modes of failure and factors contributing to failure.

What Did We Learn?
Researchers found that the separation of joints between pipe segments was a significant problem for concrete pipes; medium pipes with diameters of 24 to 36 inches were most...
susceptible. More than half of pipes with joint separation had problems with a loss of backfill material. Researchers also found significant corrosion problems for galvanized metal pipes.

The report summarizing this study includes the following recommendations:

• Projecting a design service life of 100 years for culverts under mainline highways and a design service life of 50 to 75 years for culverts under lower volume roads.

• Removing dry pipe conditions from Chapter 2 of the Drainage Manual since pipes are often subjected to wet conditions for much longer than initially expected during design.

• To improve compaction, adding third-party nuclear density testing to construction projects for all culverts of 18 inches or larger.

• For concrete pipes, using gasketed joints, which are sealed with rubber, to reduce the incidence of culvert failure due to joint separation.

• For steel pipes, making the default material 16-gage corrugated steel with an aluminumized coating, since it has a service life of three to eight times longer than galvanized corrugated steel pipe.

• For plastic pipes, using HDPE but rarely PVC, which becomes brittle at low temperatures. If installed correctly, HDPE can have a service life of more than 100 years and is not significantly susceptible to freeze/thaw damage.

What’s Next?

Researchers developed recommendations for several future projects to evaluate and update MnDOT guidelines for pipe material selection and inspection. One project, “Steel Pipe Service Life Map,” recently received funding and involves creating a statewide map of expected steel pipe service lives based on soil pH and resistivity. A second project, “Pipe Inspection and Testing Methods,” is in the planning stages. Further research is also needed into plastic pipe installation, concrete pipe joint separation, modeling pipe abrasion from groundwater sediments and establishing the ages of pipes in the HydInfra database.