Ultimate strength three-edge bearing test of Class III, 300 mm reinforced concrete pipe. Photo by Inland Pipe

INITIAL COST SHOULDN'T BE THE PRIMARY FACTOR IN CHOOSING GRAVITY PIPE SYSTEMS

By **Gerry Mulhern**

Municipal and consulting engineers can sometimes lose sight of project life and serviceability expectations when it comes to gravity pipe storm drainage systems and sanitary sewers. Too often, decisions are based on the initial cost of the pipe and not enough consideration is given to the cost of proper installation, maintenance or rehabilitation costs, and service life.

It is important to distinguish between the terms "pipeline systems" and "pipe materials."

Pipeline systems include the pipe material, couplings or joints, fittings, connections to maintenance holes, and embedment materials. A thorough pipeline assessment examines technical, financial, and risk considerations.

TECHNICAL ASSESSMENT

A technical assessment examines the specifications and standards referenced in the contract documents. In Ontario, typical standards and specifications are produced by agencies such as Canadian Standards Association, Ontario Provincial Standards, and American Society for Testing and Materials. A manufacturing standard often references a standard for a test method or an installation standard.

For example, *ASTM D3034 – 15 Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings* references *ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications*.

ASTM D2321 references the engineer or their authorized representative on site at least 25 times. Therefore, they need to understand fully the ramifications of the entire referenced standard and that they are responsible for issues such as trench widths, embedment densities, unstable trench bottoms, minimum cover for construction loads, field monitoring, establishing methods for controlling and monitoring distortions of pipe, and connections to manholes.

QUALITY CONTROL

Engineers should establish what quality control programs are in place by an industry to ensure that the quality of the pipe product produced and shipped to the site is what they expected. In Ontario, all concrete pipe is produced at plants that are prequalified under the Plant Prequalification Program for precast concrete drainage products. This covers all concrete pipe, concrete maintenance holes, catch basins and fittings.

Ontario Provincial Standard Specification (OPSS) 1820 Material Specification for Circular Concrete Pipe requires manufacturers of circular concrete pipe to possess a current Prequalification Certificate issued under the Plant Prequalification Program.

STRUCTURAL DESIGN

Structural failure of a culvert may result in a collapse of the highway pavement. Structural failures are usually sudden, with no warning to drivers. It is imperative that engineers understand how a rigid pipeline system (concrete) and how a flexible pipeline system (CSP, PVC, HDPE, PP) function.

Furthermore, engineers must understand the differences between the two systems. Without a proper understanding of gravity pipeline systems, engineers may prepare inadequate material, installation and testing specifications that ultimately result in premature maintenance, or failure of the systems.

It is critical to the success of a pipeline project that engineers understand proper installation practices for rigid and flexible systems. OPSS 410 states: "Flexible Pipe means pipe that can deflect 2% or more without cracking, such as polyvinyl chloride or polyethylene or steel pipe." A lot depends on a properly installed and compacted soil embedment to achieve the required design strength. Loss of the embedment due to washout or infiltration into the pipe (due to leaky joints or corroded pipe walls) can cause the pipe to collapse.

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OPSS 401 Construction Specification for Trenching, Backfilling, and Compacting states: "Bedding material placed in the haunches must be compacted prior to continued placement of cover material. Bedding requiring compacting shall be placed in layers not exceeding 200 mm in thickness, loose measurement, and compacted to 95% of the maximum dry density before a subsequent layer is placed. Bedding on each side of the pipe shall be completed simultaneously.

"At no time, shall the levels on each side differ by more than the 200 mm uncompacted layer."

OPSS 410.07.16.05 states: "Ring deflection testing shall be performed on all pipe sewers constructed using plastic pipe."

Engineers should always insist on deflection testing of the flexible pipe systems after installation. This is usually done by manually pulling a deflection gauge or mandrel through the pipe. Deflection testing should be carried out no sooner than 30 days after the soil over the pipe has been installed to final grade. Some municipalities, such as the City of

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Hamilton and the Regional Municipality of Niagara, require a second test prior to final acceptance.

Rigid pipes, with inherent pipe strength, will crack before they are deflected 2%. Rigid pipes receive additional support from the bedding cradle underneath the pipe when they are installed. Reinforced concrete pipe design is conservative and pipes are regularly overdesigned.

A concrete pipe will usually provide more than 60% of the required structural strength, with the remainder provided by the soil embedment. All, or almost all, of the design strength is built into the pipe itself. Strength of a 50D pipe would be acceptable for a particular design, but the engineer may specify 100D or 140D.

WATER-TIGHTNESS AND JOINTS

The type of joints available and the water-tightness of the system can have a major impact on the structural stability of the system.

HYDRAULICS

The technical assessment should include the Manning's n roughness coefficient of the pipe, actual inside diameter, deflection of a flexible pipe and corrugation growth in externally corrugated thermoplastic pipe products. If a culvert fails to perform as a conduit due to deflection, clogging, or other factors, catastrophic failures can occur. Failures include a complete washout of the culvert, or washout of the embedment soils around the culverts. Washouts in turn cause a collapse of the culvert pipe and the pavement above.

FINANCIAL ASSESSMENT

Initial pipe cost should be considered in a financial assessment but the engineer is cautioned not to limit his/her decision solely to initial costs.

Proper installation is essential, especially with regards to flexible pipeline systems since they require approved embedment materials, appropriate trench widths, and the correct level of compaction completely around and over the pipe.

What maintenance costs, if any, are anticipated over the design life of the project? How do maintenance costs affect the initial pipe material choice?

The engineer needs to decide what the expected life of the project is and then assess the available pipe materials to determine which products have a service life that equals or exceeds the project design life.

RISK ASSESSMENT

A risk assessment should look at the different modes of failures of the available pipe products that include: buckling due to poor installation; corrosion; combustion; disjointing; flotation; washout; abrasion; post installation connections; and chemical attack.

The best risk analysis is to examine the historical performance of a product and evaluate how well it has performed in similar applications with similar heights of cover and traffic loads. Installing gravity pipe in trenches where the use of a trench box, or sheet piling is required by the Department of Labour, poses challenges for the engineer and the contractor, especially considering the proper installation of flexible pipes.

CONCLUSIONS

Municipalities can protect themselves from litigation due to failures of gravity pipeline drainage systems by conducting comprehensive assessments of the pipeline systems that they are using. Engineers can and should reduce their liability and protect the public by: understanding rigid and flexible pipe design; requiring quality control programs for the manufacturing and testing of pipe and raw materials; writing thorough installation specifications; requiring post-installation inspections, and, addressing trenching and safety requirements. ■

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