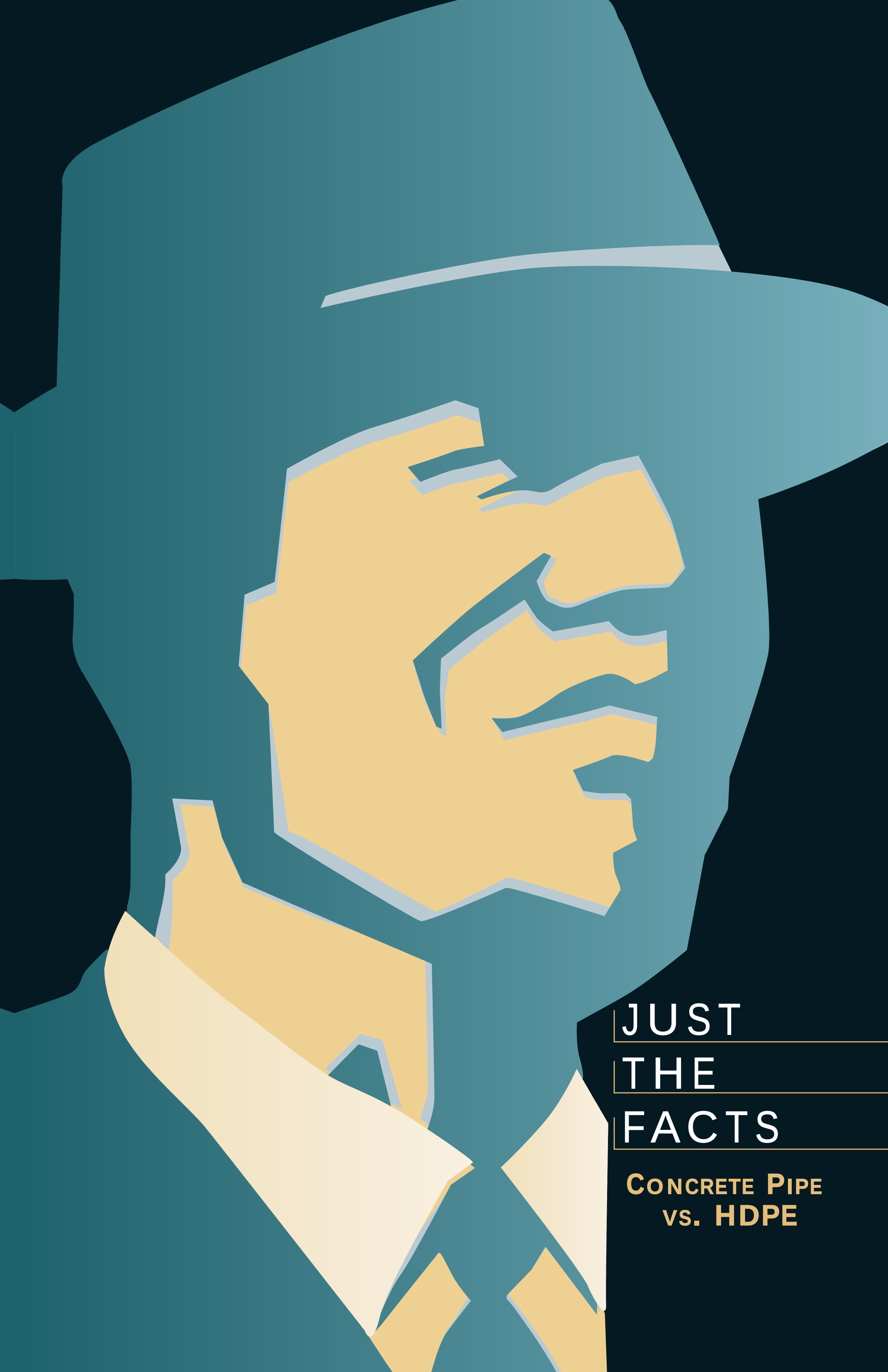


JUST THE FACTS

Concrete Pipe vs. HDPE

Drainage Pipe Performance and Design Comparison

Concrete vs. HDPE

Contents

Current Standards

In the province of Ontario, standards generally used are a combination of the Ontario Provincial Standards (OPS) and Canadian Standards Association (CSA). For HDPE pipe, it is not as simple as referencing documents from these organizations. A review of the current standards related to the materials used in manufacturing, as well as the installation of HDPE pipe, provides designers and specifiers with the need to reference other documents such as ASTM and AASHTO.

A compilation of the current standards, for HDPE non-pressure pipe products includes:

OPSS 1840: Material Specification for Non-Pressure Polyethylene Plastic Pipe Products – this standard provides general guidance appropriate standards for materials and quality assurance.

CAN/CSA-B182.6: Profile Polyethylene Sewer Pipe and Fittings – this standard covers open profile, 100 mm to 1200 mm, and closed profile, 450 mm to 1200 mm, diameter sewer pipe

ASTM F894: Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe – this standard covers requirements and test methods for materials, dimensions, workmanship, ring stiffeners, flatteners, joint systems and a form of marking for large diameter, 10 to 120 in. (250 to 3050 mm) profile wall polyethylene pipe for use in low pressure and gravity flow applications

ASTM F405: Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings – this standard covers requirements and test methods for corrugated polyethylene (PE) pipe and fittings for nominal sizes 3 to 6 in. (75 to 150 mm)

ASTM F667: Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings – this standard covers requirements and test methods for materials, etc. for nominal sizes 8 to 24 in. (200 to 600 mm)

AASHTO M252: Standard Specifications for Corrugated Polyethylene Drainage Pipe – this specification covers the requirements and methods for testing of corrugated polyethylene (PE) pipe, etc. for 75 mm to 250 mm diameter

AASHTO M294: Standard Specification for Corrugated Polyethylene Pipe, 300 to 1200 mm diameter – this specification covers the requirements and methods for testing of corrugated polyethylene (PE) pipe, etc. for 300 mm to 1200 mm diameter

A COMPILATION OF THE CURRENT STANDARDS, BY CONCRETE PIPE PRODUCT INCLUDES:

OPSS 1820: Material Specification for Circular Concrete Pipe – this standard provides general guidance appropriate standards for materials and quality assurance

CAN/CSA-A257.1: Circular Concrete Culvert, Storm Drain, Sewer Pipe and Fittings – this specification covers nonreinforced circular concrete pipe and fittings 100 mm to 900 mm in diameter

CAN/CSA-A257.2: Reinforced Circular Concrete Culvert, Storm Drain, Sewer Pipe, and Fittings – this specification covers reinforced circular concrete pipe and fittings 300 mm to 3600 mm in diameter

CAN/CSA-A257.3: Joints for Circular Concrete Sewer and Culvert Pipe, Manhole Sections, and Fittings Using Rubber Gaskets – this standard specifies the design and performance requirements for flexible watertight joints


RCP - Smooth Wall

CORRUGATION GROWTH AND ITS EFFECT ON MANNING'S "N"

Selection of the proper value for the coefficient of roughness of a pipe is essential in evaluating the flow through culverts and sewers. An excessive value is uneconomical and results in over sizing of pipe, while on the other hand a low value can result in hydraulically inadequate pipe.

Numerous laboratory studies have been conducted in an effort to determine Manning's n. Results of these laboratory studies including work at Utah State University confirm Mannings "n" laboratory values of 0.009 to 0.010 for concrete pipe and 0.009 to 0.015 for smooth inside wall polyethylene pipe.

"Smooth inside wall HDPE pipe develops ridges in the liner when installed. This deformation of the liner is caused by backfill loads that force the corrugated outer portions of the pipe to deform the liner."

Generally accepted recommendations for design include a safety factor of 20% to 30%, to account for differences between laboratory and actual installed conditions.
Misalignment of joints, debris in the line, maintenance hole transition losses and other obstructions account for the necessary safety factor. These recommended safety factors are independent of the type of pipe being used. In Ontario, the MOE guidelines suggest a Manning's "n" of 0.013 for all smooth walled pipe.


HDPE - Smooth Wall

Smooth inside wall HDPE pipe develops ridges in the liner when installed. This deformation of the liner is caused by backfill loads that force the corrugated outer portions of the pipe to deform the liner. This well-known and documented phenomenon is known as corrugation growth. Unfortunately, no laboratory testing which has been endorsed by the standards applicable in Ontario has been conducted to assess the effects of increased roughness of the pipe liner. The depth of the liner corrugations has been measured up to 19 mm, which is comparable to corrugated metal pipe. Designers need to account for this increased roughness when sizing drainage pipe. The true installed value of Manning's "n" should be closer to that of corrugated metal pipe.

900mm HDPE - Smooth Wall.

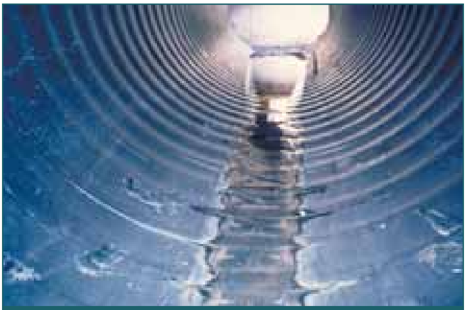
DEFLECTIONS, DEFORMATIONS, LINE AND GRADE PROBLEMS

The difficulty of installing HDPE pipe is often evidenced by the many types of deformations that show up in the finished installations. Vertical deflections are primarily a result of the pipe being installed without adequate side support to withstand the loads from overburden, which can be enhanced when moving trench boxes. A general lack of pipe stiffness is the biggest contributor to deflection and deformation problems. Line and grade irregularities are due to a lack of longitudinal stiffness in the pipe. The longer lengths of pipe, approximately 6 m, require close control of bedding material, grade and compaction during installation, or high and low spots or deflection may occur.

In contrast, the 2.44 m concrete pipe lengths allow close control of line and grade, which fits easily into a standard trench box. The weight of concrete pipe resists lateral movement during backfill operations and the wall thickness prevents deformation.

"A general lack of pipe stiffness is the biggest contributor to deflection and deformation problems. Line and grade irregularities are due to a lack of longitudinal stiffness in the pipe."

Vertical Deflection.



Cracked HDPE Liner.

Long Term Pipe Durability

A recent NCHRP Study indicated stress cracks and liner tears occur in HDPE pipe with time. The cracks generally occur at the junction where the liner is welded to the outer corrugations. The main cause of the cracks is a combination of residual stresses built into the pipe from the manufacturing process and stresses induced by poor installation and changing soil conditions. This research has shown that the lack of stress crack resistance of the polyethylene resin used to manufacture HDPE pipe leads to this long term problem. The raw materials used to manufacture HDPE pipe can be tested for Environmental Stress Crack Resistance (ESCR), but many HDPE pipe manufacturers do not choose to do so. There is no established method of repairing a torn or cracked HDPE pipe.

"...research has shown that the lack of stress crack resistance of the polyethylene resin used to manufacture HDPE pipe leads to this long term problem."

Concrete pipe is designed to the 0.3mm crack, in accordance with CSA. Cracking of concrete pipe to this standard indicates the design is appropriate and the steel is working as designed to maintain the shape of the pipe.

Cracked HDPE Liner.

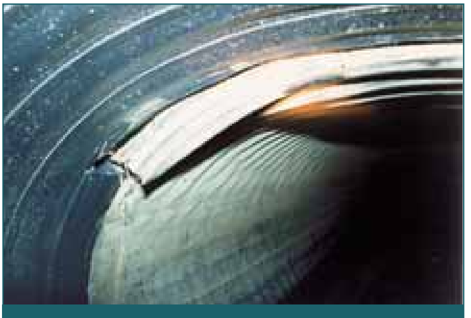
Joints and Maintenance Hole Connections

If HDPE pipe joints are torn during installation, leaks are a likely result. There is no established repair method for torn joints. Compaction of pipe at maintenance holes can be difficult. Due to the nature of maintenance hole installation, proper compaction around the pipe can be difficult and vertical deflections are likely to result. The use of flexible boots are suggested as the most appropriate method of connection between a rigid maintenance holes and flexible pipe. Grouting of this connection will not work.

Concrete pipe joints that are damaged during installation can be repaired in accordance with established methods. There is little differential deflection when a properly installed concrete pipe enters a rigid maintenance hole. The maintenance hole and the pipe should be subjected to the same bedding characteristics.

Joint Failure. Bedding Material Washed In.

"If HDPE pipe joints are torn during installation, leaks are a likely result. There is not an established repair method for torn joints."



Failed HDPE Joint.

Floating 1050mm Pipe.

Flotation

Flotation needs to be addressed during the design of buried pipelines. The lack of weight and stiffness of HDPE pipe makes this an important design consideration in areas with a high water table. If HDPE pipe cannot be restrained with overburden, anchoring devices should be used.

Because of the heavy weight and stiffness of concrete pipe, flotation is generally not an issue.

"Fire can ruin the structural integrity of the HDPE pipe and, in some cases, there is nothing left except the soil around the pipe."

Fire

HDPE pipe is a petroleum based product. It is flammable and is not required to contain a fire retardant. Fire can ruin the structural integrity of the pipe. In some cases, the pipe material is consumed by fire leaving nothing except the soil around the pipe. There are documented cases of fire in storm sewers and culverts caused by burning debris.

Concrete is not flammable. There have been cases of burning items such as leaves, grass in a concrete pipe, with no damage to the pipe or inconvenience to the public.

Culvert Fire.

Conflicts with Underground Utilities

Utility trenching and boring machines will damage most plastic pipe, including HDPE. There is no indication to the operator of the machine that a pipeline has been compromised. Even activity in the easement that doesn't damage the pipe outright, can cause long term problems by disturbing the backfill envelope that is integral to a flexible pipes strength.

Concrete pipe can also be damaged by utility trenching and boring equipment, but the operator knows something has been hit. The damage can be fixed and/or the route altered. Concrete pipe is much less likely to be affected by a disturbed soil envelope because the strength of a concrete pipe is engineered into the product.

Trenched Power Cable.

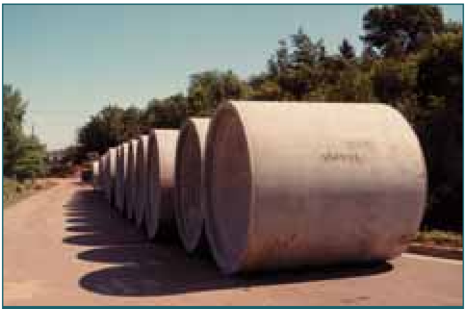
"Concrete pipe is not affected by a disturbed soil envelope because the strength of a concrete pipe is engineered into the product."

Wall Buckling and Crushing

Wall buckling most often occurs at the spring line of the installed HDPE pipe, although localized wall buckling can occur elsewhere. In deep fill situations, wall buckling can progress to the point where the wall actually crushes or tears. A general collapse of the pipe may eventually occur when wall crushing is present.

Concrete pipe is not affected by this failure mechanism.

Failed Pipe Wall Buckling.



Concrete Pipe.

Design Flexibility

HDPE pipe does not have design flexibility because it is not a custom engineered structure in the same way as concrete. A polyethylene pipe installation is determined to be appropriate when deflection, buckling and bending calculations are within acceptable limits. The success of the installation is almost totally dependent on the care taken by the installer, the quality of the bedding materials and the insitu soil.

Concrete pipe can be custom designed for each installation, accounting for differences in loads, supporting soils, and traffic over the pipe. Concrete pipe can be designed to utilize a very good backfill or even an uncompacted backfill. Special wyes, tees, bends, and transition pieces can be produced to the same strength as the pipe.

"Concrete pipe can be custom designed for each installation, accounting for differences in loads, supporting soils, and traffic over the pipe."

Concrete Pipe Installation.

Handling and Storage

The transport of HDPE pipe to the job site is generally done using flat bed trucks, delivered in a loose or palletized form, depending on the type and quantity of pipe. HDPE pipe has little structural strength and is therefore subject to damage if handled improperly. Nylon slings or cushioned cables are recommended. The pipe should be set aside on the job site, in a flat area free of large rocks, rough surfaces and debris. Damaged pipe cannot be repaired. The pipe should also be located away from construction traffic. The pipe is subject to degradation by the sun's ultra violet rays and should not be stored on site for an extended period of time.

Concrete pipe is a very durable product. The pipe is generally delivered to site on flat bed trucks and unloaded using a boom or hydraulic lift. Concrete pipe resists gouging and if chipped, can be repaired using well-known procedures. The pipe can be stored on site for extended periods of time, with no deterioration as it is not susceptible to degradation by ultra violet rays.

Handling Concrete Pipe

"HDPE pipe has little structural strength and is therefore subject to damage if handled improperly. Nylon slings or cushioned cables are recommended."

Shipping Concrete Pipe

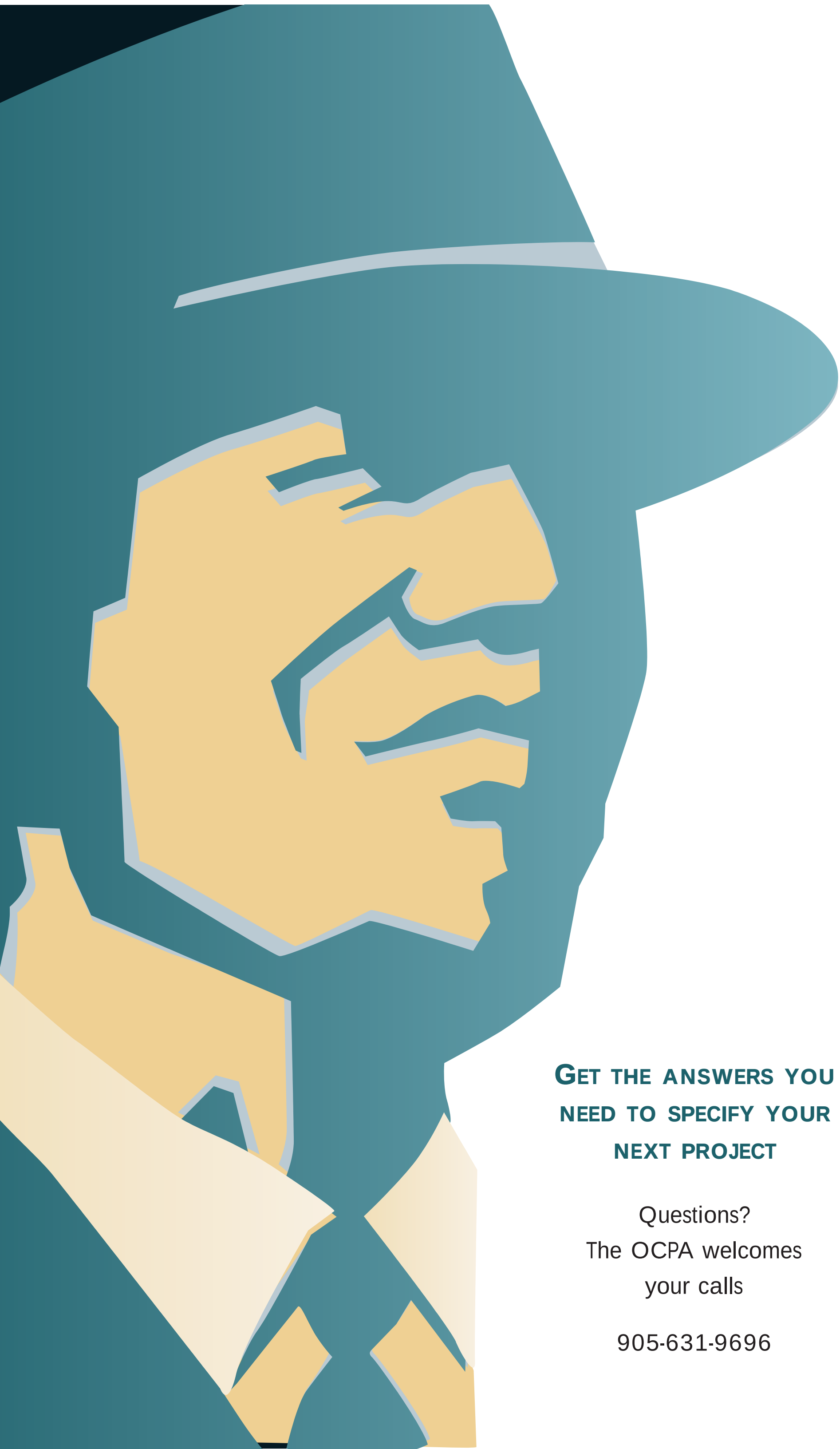
Aggregates, cement and reinforcing steel are the basic raw materials used in reinforced concrete pipe

"Reinforced concrete pipe utilizes conventional materials with known and understood properties. Aggregates, cement and reinforcing steel are the basic raw materials used in reinforced concrete pipe."

Material

Reinforced concrete pipe utilizes conventional materials with known and understood properties. Aggregates, cement and steel are the basic raw materials used in reinforced concrete pipe. There are variations within these basic materials, but the engineering properties of each are well known and may be easily measured.

Polyethylene, as a material component, is less familiar and more difficult to evaluate. There are many formulations of polyethylene and the physical properties can be manipulated to achieve the desired result. Unfortunately, some of the properties have opposing effects. For example, a formulation with a high modulus of elasticity is desirable to give the pipe greater stiffness. But, high modulus of elasticity materials can be susceptible to stress cracking. Selecting a lower modulus that is crack resistant will require more wall area to achieve suitable section properties. This would require additional resin to be used in the manufacture of the pipe, which, it appears, the industry is unwilling to do.



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