Kanaflex®

Abrasion Resistance of Kanapipe™ Steel Reinforced Polyethylene (SRPE) Pipe

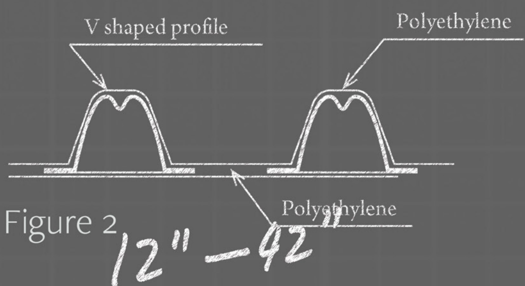


Figure 2

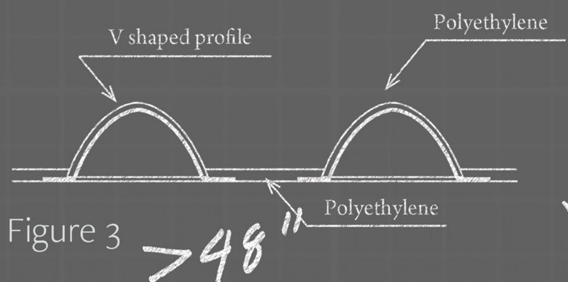


Figure 3

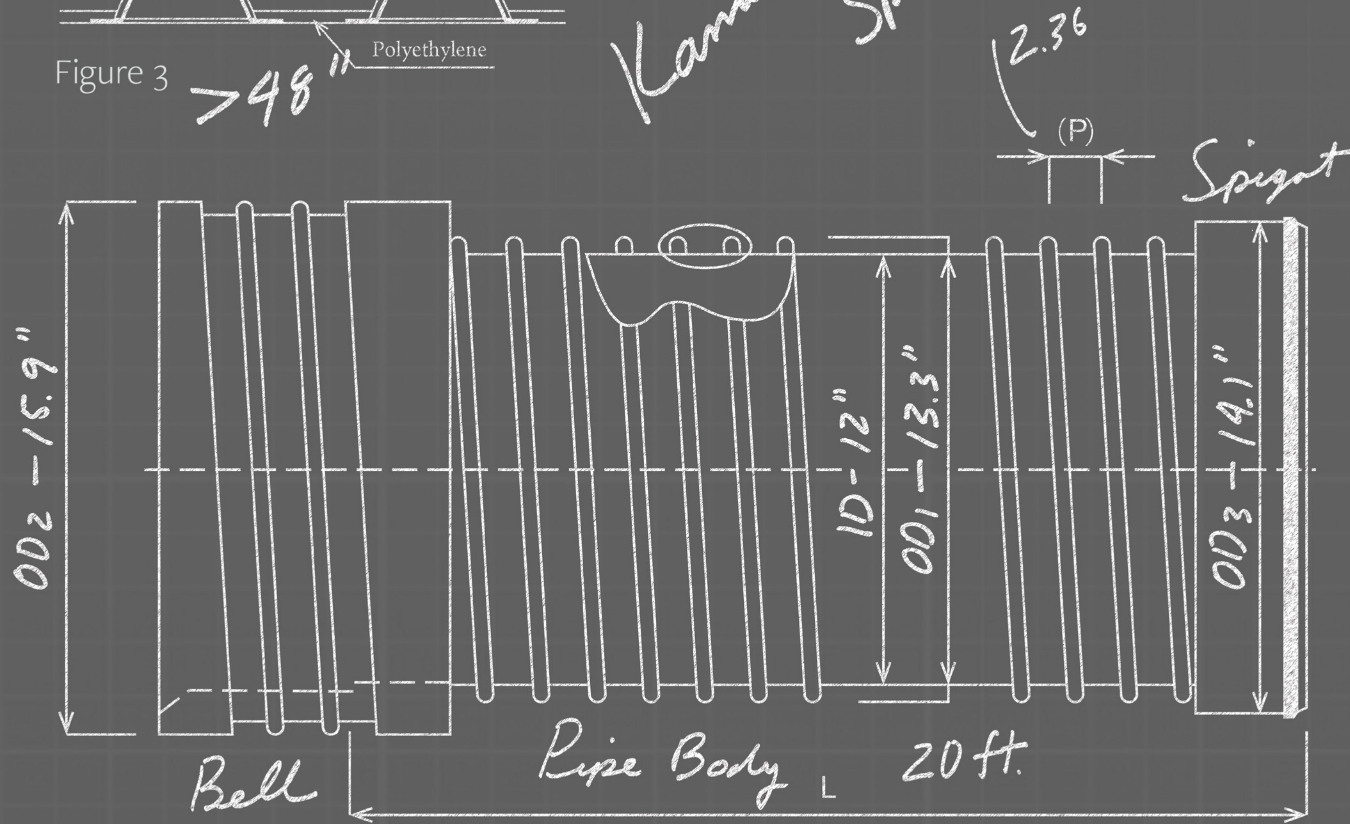


Figure 1

Introduction

Abrasion is the reduction in the thickness of a pipe's inside surface material due to the mechanical action of erosion. Under normal operating circumstances, gravity flow pipes can be subjected to abrasive bed loads containing, sand, gravel, rocks and/or sharp stones. Abrasion rates can be further accelerated when an abrasive bed load is combined with an acidic effluent. The pipe invert is the most common location where abrasion occurs.

Abrasion rate is a function of fluid velocity and particle characteristics of the suspended particulates where it increases with increasing fluid velocity and pipe diameter. In most highway applications such as culverts and surface water drains, flow velocity is less than 20 ft/s (6 m/s) and in sewer pipes, flow velocity is even slower and hence, less abrasive.

Kanapipe™ Steel Reinforced Polyethylene (SRPE) Pipe

Kanapipe™ is a composite Steel Reinforced Polyethylene (SRPE) pipe comprised of a smooth interior High Density Polyethylene (HDPE) liner that is reinforced with a helically wrapped V shaped external galvanized steel profile (Fig. 1 & Fig 2). The galvanized steel profile is enclosed within the polyethylene profile. The fluids transported through the pipe come in contact with the HDPE liner only, therefore its abrasion resistance is considered the same as that of regular dual-wall smooth interior corrugated HDPE pipe (Fig. 3).

Abrasion Resistance of HDPE

Available scientific literature overwhelmingly confirms the superiority of polyethylene pipe's abrasion resistance when compared to that of other pipe materials. The Ministry of Transportation of Ontario (MTO) in Canada states the following in its MTO Gravity Pipe Design Guidelines (Ref. 1): "The long-chain molecules that make up the polymer chain are able to resist the impact of heavy bed loads", or abrasive fluids. Combined with its high resistance to aggressive chemicals and acidic conditions, polyethylene provides continuous performance compared to other pipe materials and ensures a longer product life in most hostile environments.

Figure 1
Rib Profile for Diameters 12- to 42-inch

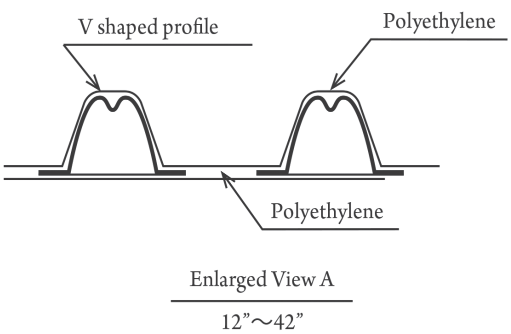


Figure 2
Rib Profile for Diameters 48-inch and Larger

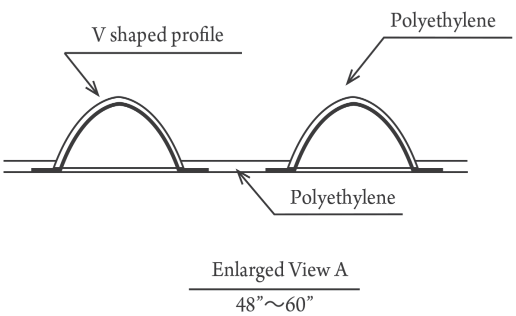
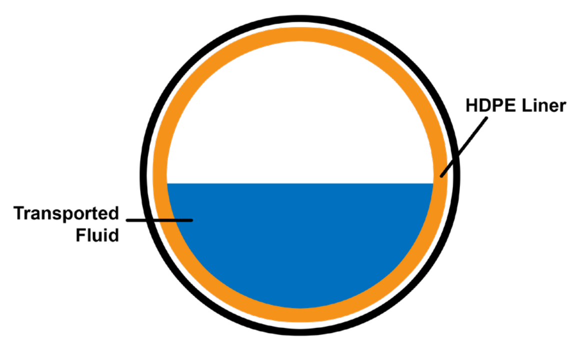


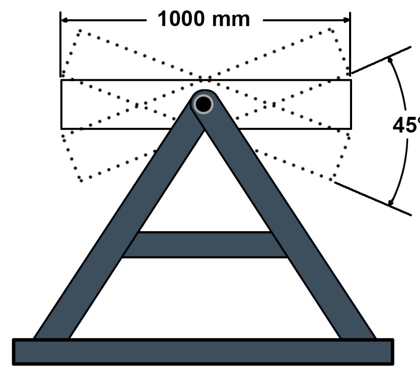
Figure 3
Kanapipe™



Laboratory Testing

Laboratory tests are very useful in comparing how different pipe materials behave in aggressive environments. Several documented studies have been conducted to determine the wear rates of pipe materials in controlled laboratory settings. One of the most famous studies is the Darmstadt Test (Ref. 2) developed by Dr. Kirschmer of the Institute of Technology in Darmstadt, Germany. In this study, a test section of 1 meter of pipe was tilted back and forth with a frequency of 21.6 cycles/min while containing an abrasive slurry of 46% by volume of quartz sand (particle size 0-30 mm) in water (Fig. 4). The resultant velocity of the surface of the pipe was 0.36 m/s. Results from the testing showed that the pipe with a smooth HDPE liner outperformed clay and concrete pipes (Fig. 5).

Figure 4
Darmstadt Test Apparatus



Another well documented laboratory experiment is the Erosion Study conducted by the Saskatchewan Research Council (Ref. 3). The abrasion performance of plastic pipe with smooth HDPE liner (similar to Kanapipe™) was compared to that of steel and aluminum pipes. Tests were performed on a sample of 2-inch (50 mm) pipe using a 40% by weight mix of coarse sand (particle size 0.55 mm) and fine sand (particle size 0.30 mm) in a water slurry in a closed loop system at a controlled temperature. Tests were conducted for 3 weeks at 4 m/s and 6 weeks at 2.1 m/s. Results were extrapolated to obtain annual wear rates, shown in Table 1.

Results show that wear rates for the HDPE liner were significantly less than that of other materials tested.

Figure 5
Abrasion Loss of Various Pipe Material

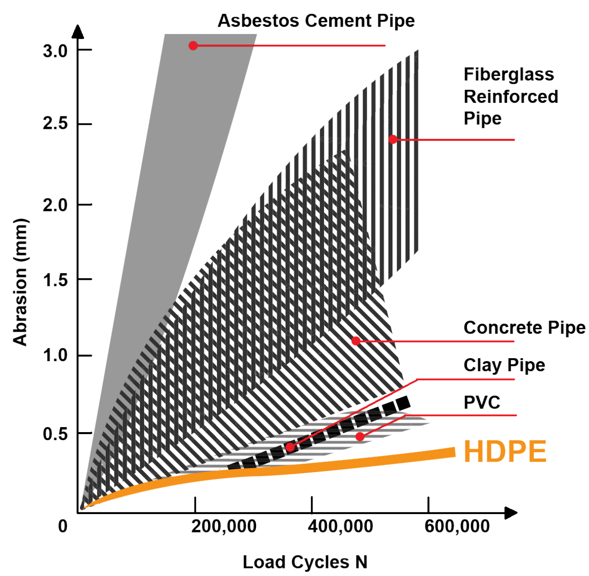


Table 1
Extrapolated Annual Wear Rates of Smooth HDPE Liner and Uncoated Metal Liners Under Abrasive Slurries

Material	Wear Rates (mm/year)			
	Coarse Sand		Fine Sand	
	2.1 m/s (7 ft/s)	4.6 m/s (15 ft/s)	2.1 m/s (7 ft/s)	4.6 m/s (15 ft/s)
Steel	0.65	1.81	0.04	0.02
Aluminum	1.81	7.48	0.14	0.86
Polyethylene	0.06	0.46	Nil	0.06

Storm drainage systems often carry both acidic and abrasive effluent. A study performed by California State University (Ref. 4) investigated the effects of abrasive and acidic flow on pipe wear of various materials. Tests were conducted using both neutral (pH = 7) and acidic (pH = 4) mediums. Sections of 12-inch (300 mm) diameter pipe were filled with an abrasive slurry consisting of ½ - ¾ inch (13-19 mm) crushed quartz and 2-inch (51 mm) minimum river run quartz gravel. Two thirds of the abrasives were crushed quartz with the remainder being river run gravel in order to best simulate working site conditions. The pipe ends were capped and the pipe was attached to a rocking apparatus and rotated through an 83 degree arc, constituting one cycle. A total of 50,000 complete cycles (100,000 half cycles) were used in the tests. An average fluid velocity of 0.9 m/s was maintained. Conditions were monitored in order to maintain consistent pH and aggregate levels throughout the experiment. Tests were completed after a specified number of rotations.

The study compared the durability of a 12-inch (300 mm) smooth liner HDPE pipe and that of a plain concrete pipe of the same size. The loss of wall thickness was measured for both pipes. Results are summarized in Tables 2 and 3.

Table 2
California State University Abrasion Resistance Test – Neutral Conditions (pH = 7)

	Initial wall thickness (mm)	Expandable Wall Thickness[1] (mm)	Max. Loss of Wall Thickness (mm)	Remaining Wall Thickness[2] (%)	Visual results
Smooth HDPE liner Pipe 300 mm	2.8	0.89	0.53	40	Liner showed some evidence of wear. Liner perforation did not occur
Plain Concrete Pipe 300 mm	54.6	13	20	< 0	Steel reinforcement would have been exposed[3]

Notes
1. The thickness of the wall that can abrade before reaching failure
2. Presented as a percentage of the expendable wall thickness and is an indication of the amount of service life remaining
3. Tests intended to use reinforced concrete pipe as per construction applications, however non-reinforced was used

Table 3
California State University Abrasion Resistance Test – Acidic Conditions (pH = 4)

	Initial wall thickness (mm)	Expandable Wall Thickness[1] (mm)	Max. Loss of Wall Thickness (mm)	Remaining Wall Thickness[2] (%)	Visual results
Smooth HDPE liner Pipe 300 mm	2.8	0.89	0.61	31	Liner showed some evidence of wear. Liner perforation did not occur
Plain Concrete Pipe 300 mm	54.6	13	30.5	< 0	Loss of wall thickness was much higher than in neutral conditions. Significant amount of reinforcement would have been exposed[3]

Notes
1. The thickness of the wall that can abrade before reaching failure
2. Presented as a percentage of the expendable wall thickness and is an indication of the amount of service life remaining
3. Tests intended to use reinforced concrete pipe as per construction applications, however non-reinforced was used.

Tests indicated that even under harsh acidic conditions, the smooth HDPE liner did not suffer any perforations and the wear rate increased by only 15% leaving over 30% remaining of the liner thickness. The concrete pipe showed significant wear. In acidic environments the wear increased by 50%. If tests had been performed using reinforced concrete pipe, the reinforcement would have also been exposed and the pipe would have failed sooner than in a neutral environment.

Kanapipe™ has an HDPE liner with a minimum thickness ranging from 1.5 to 4.0 mm depending on the nominal diameter. According to the results shown in Tables 1, 2 and 3, the highest wear rate is about 0.61 mm (Table 3) which is significantly less then the minimum thickness of the Kanapipe™ HDPE liner for any diameter of pipe. This confirms that a sizable thickness reduction, let alone perforations, in the Kanapipe™ liner will not occur due to abrasion even under harsh acidic conditions.

Any material loss is undesirable in a pipe system. However, the structural integrity of Kanapipe™ depends solely on the encapsulated steel profile, therefore, minor loss of the HDPE liner due to abrasion will not adversely affect the structural integrity of the pipe.

References

1. Ontario Ministry of Transportation “Gravity Pipe Design Guidelines”, April 2014

2. Kirschmer, O., “Problems of Abrasion in Pipes”, Steinzeugin Formationen, 1966, No. 1, pp 3-13

3. Hass, D.B. and Smith, L.G., “Erosion Studies – A Report to Dupont of Canada Ltd.”, Saskatchewan Research Council, E75-7, September 1975

4. Gabriel, Lester. “Abrasion Resistance of Polyethylene and Other Pipes.” California State University, Sacramento, California, 1990

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