Comparative Properties and Service Life of Jacking Pipes Used as Sanitary Sewers

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Sanitary sewers carry corrosive effluents which result in the additional generation of a corrosive atmosphere within the pipe. Hydrogen sulfide generation and condensation on the pipe wall results formation of sulfuric acid. Industrial waste and chemicals adds indeterminate additional corrosive potential to the natural corrosive sanitary sewerage. Furthermore as water becomes more precious and valuable, the concentrations of the effluent will rise and the historical performance expectations of many pipe materials will be challenged by the higher chemical concentrations. Stresses from external loading and resulting deflection of some materials accelerated the effects of corrosion. Some pipe materials are even deleteriously affected by the presence of water.

Installation of jacking pipes by microtunneling and more traditional pipe jacking methods are well established trenchless methods. These methods have the advantage of minimizing surface disruption, economically advantageous in deep installations, long term green foot print where pump stations and the operating energy are eliminated and where ground water is above the pipe grade. Trenchless installation of new pipes is accepted and its use is accelerating.

Microtunneling pipes requires adequate strength to transfer jacking loads from the shaft to the face of the machine. The loads are a combination of face pressure, cutter engagement force and friction between the exterior of the pipe and the soil. These forces can total in hundreds of tons with longer drives and larger diameters resulting in higher loads.

Materials used for jacking pipes have varying advantages and disadvantage. The owner and the installer may have differing perspectives and criteria for selection of pipes. For instance pipe longevity is essential for an owner to amortize long term return on investment and to build residual asset value. An installer is primarily concerned of installation cost over the short term. The installer and owner may often result in the same selection of ideal material but sometimes the selections would not be equal. The owner has the burden for selecting long term performance, financial responsibility and building residual wealth from assets that long exceed amortization requirements of financing.

It is essential for the designer and owner to understand the selection of pipes for ease of installation, maintenance costs and long term life. It is of major economic significance. The selection process is more complicated than in the past. New materials are developed or used in new ways to make pipes. There have been many pipes introduced over the years that are no longer available due to poor performance. Poor longevity has frequently been the demise of pipes.

Impact to the public when pipes are installed in new or less developed areas in preparation for future growth and expansion are often low. Utilities are expensive to install and repair, but even more so after growth has occurred. A street that may have been moderately traveled grows to be an essential corridor. Replacement/repair at a later date can still be accomplished, but at a higher impact to the public/social cost than during the original construction and/or with techniques that are less disruptive but more expensive. The desire for less impact to the public is translated through public expression and even voter dissatisfaction. It has become a larger driver in installation/rehabilitation repair method selection. Installations that use designs and requiring materials that have long term cost advantages should be selected. The oft repeated adage, “If you can’t afford to do it correctly the first time, can you afford to do it twice?”comes to mind.

The following table is generated from assembly of information in manufacturing standards, papers and manufacturer’s product literature:

Sewer Pipe Material for Microtunneling	**Strength of Pipe Material at 50 yrs**	**Initial Internal Corrosion resistance**	**Initial External Corrosion resistance**	**Jacking strength** [1]	**Design Basis**	**Typical Seal Pressure Rating**	**Longevity, Greater than 100 Years**
GRP, glass fibers, sand, polyester	50% of initial, loss of cross linking naturally occurs – accelerated by stress and corrosion elements. Water damage.[2 3 4]	Good, 1 pH – 10 pH (based upon 1.15 yr. extrapolation at 22 deg C. deteriorates with temperature increase	Good, 1 pH – 10 pH (based upon 1.15 yr. extrapolation at 22 deg C. deteriorates with temperature increase[5]	Low	Flexible	>2bar	Poor, extrapolated from 50% strength deterioration at 50 years, corrosion acceleration with stress and molecule linking failures with age.[6]
GRP, glass fibers, sand, polyester, vinyl ester interior coating	50% of initial, loss of cross linking naturally occurs – accelerated by stress and corrosion elements.[2 3 4]	Very good, 1 pH – 10 pH (based upon 1.15 yr. extrapolation at 22 deg C. deteriorates with temperature increase	Very Good, 1 pH – 10 pH (based upon 1.15 yr. extrapolation at 22 deg C. deteriorates with temperature increase	Low	Flexible	>2 bar	Poor, extrapolated from 50% strength deterioration at 50 years, corrosion acceleration with stress and molecule linking failures with age.[6]
Polymer Concrete, graded sand and gravel, polyester	50% of initial, loss of cross linking naturally occurs – accelerated by stress and corrosion elements.[2 3 4 7]	Good, 1 pH – 10 pH (based upon 1.15 yr. extrapolation at 22 deg C. deteriorates with temperature increase [7]	Good, 1 pH – 10 pH (based upon 1.15 yr. extrapolation at 22 deg C. deteriorates with temperature increase	High	Rigid	>2 bar	Poor, extrapolated from 50% strength deterioration at 50 years, corrosion acceleration with stress and molecule linking failures with age. [6 8]
Reinforced Concrete, sand, aggregates and cement	100%, less corrosion of concrete & rebar	Poor, in corrosive conditions [9 10 11]	Poor, in corrosive conditions [11]	High	Rigid	>1 bar	Poor, in applications with internal or external corrosion environment [9]
Reinforced Concrete with Plastic Liner, concrete, sand, aggregates and cement with a cast plastic liner	100%, less corrosion of concrete & rebar	Moderate, liners have shown short and moderate life <50 years.[12]	Poor, in corrosive conditions [11 13]	High	Rigid	>1 bar	Poor, in applications with internal or external corrosion environment
Steel	100% where there are no corrosion effects	Very poor	Very poor	High to Low, depending upon wall thickness		Welded	Poor, if corrosion possible Good, if no corrosion present [13]
Vitrified Clay, high temperature fired structural ceramic	100% [14 15 16]	Excellent, ph 0 to pH 14 [15]	Excellent, 0 pH to 14 pH [15]	High	Rigid	>2 bar [17 18]	Excellent, demonstrated long life [19]

Conclusion:

The considered selection of pipe materials is an essential element in project design and development of specifications. Pipe selection is essential to long life cycle installations that build asset value and provide economical service.

References:

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[3] *Buried Pipe Pipe Life Prediction in Sewage Type Environments,* Jean-Matthieu Bodin page 78, Time to Failure Chart

[4] *Long Term (50 year)Tensile Strength and Modulus of Elasticity of Structural Plastics for Piping*, Bureau of Engineering, City of Los Angeles Department of Public Works, see page number 4 of this document

[5] *AWWA C950*, page 18

[6] *The Advantages of Epoxy Resin versus Polyester in Marine Composite Structures,* www.c-cyachts.com/images/.../16cf4_Adv_of_Epoxy_v_Poly.pdf, Degradation from Water Penetration, page 2

[7] *Polymer Concrete Pipe Product Guide*, Meyer Polycrete, Amiantit, page 16

[8] *ASTM D 6783*, Section 6.6.1, page 3

[9] *Concrete Pipe Vulnerable to Corrosion, U.S. EPA,* http://www.epa.gov/nrmrl/news/032010/news032010.html

[10] *URS*, Letter of May 15, 2011 to City of Phoenix, AZ, URS

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[14] *Sustainability and Vitrified Clay Pipe*, NCPI, reference U.S. Army Corp of Engineers, http://www.ncpi.org/GreenStandards.asp

[15] *Why Vitrified Clay,* Steinzeug Keramo, http://www.steinzeug-keramo.com/CMS/upload/Why_vitrified_clay_def_3992.pdf

[16] *European Standard – EN 295-3*, Section 10 Chemical Resistance and Section 12 Abrasion Resistance

[17] *Denlok Jacking Pipe*, Can Clay Corporation, page 1, http://www.canclay.com/htdocs/Denlok%20Flyer%202011.pdf

[18] Denlok Product Range and Specifications, Naylor Drainage Ltd., http://www.naylor.co.uk/drainage/clay-products/denlok/products-specs.php

[19] *Sustainability of Vitrified Clay Pipe*, page 3, 2500 year old clay pipe in Ephesus, http://www.ncpi.org/files/WhitePapers/Sustainability%20White%20Paper%2006102009.pdf

CITY OF LOS ANGELES - DEPARTMENT OF PUBLIC WORKS
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Figure H 211.41 A - Long Term (50 year) Tensile Strength & Modulus of Elasticity of Structural Plastics for Piping

RESIN/BRAND	INTENDED USE	CELL CLASSIF.	F_t INITIAL TENS. STR.	CREEP RED. FACT.	F_t 50-YEAR STRENGTH	E_S, INITIAL MODULUS	CREEP RED. FACT.	E, 50-YEAR MODULUS
EPOXY (Shell Epon 9215/ Insituform)	Sewer/Storm Dr.	NA	4,000(27.6)	75%*	1,000(6.9)*	300,000(2068)	75%*	75,000F(517)*
EPOXY VINYLESTER (Dow Derakane 411/ Inliner)	Sewer/Storm Dr.	NA	4,000(27.6)	50%	2,000(13.8)	300,000(2068)	50%	150,000F(1034)F
EPOXY VINYLESTER (*****Chemtron B9220/Generic)	Sewer/Storm Dr.	NA	0	0	0	0	0	0
HDPE	Storm Drain Only	335434C	3,000(20.7)	52%	1,440(9.9)	110,000(758)	80%	22,000(152)T
HDPE	Storm Drain Only	315412C	3,000(20.7)	70%	900(6.2)	110,000(758)	80%	22,000(152)T
HDPE	Storm Drain Only	334433C	3,000(20.7)	62.5%	1,125(7.8)	80,000(552)	75%	20,000(138)T
HDPE (Driscopipe, Plexco & Spirolite)	Sewer/Storm Dr.	345434C	3,200(22.1)	70%	960(6.6)	120,000(827)	70%	36,000(248)T
HDPE (*****Nova HD-2007H/U-Liner)	Sewer/Storm Dr.	345434D	3,100(21.4)	70%	885(6.1)	90,000(621)	70%	27,000(186)T
POLYESTER (Hobas)	Sewer/Storm Dr.	NA	2,500(17.2)	65%	490(3.4)	1,000,000(6895)	65%	350,000(2413)F
POLYESTER (*****Chemtron B-3005/ Insituform)	Storm Drain Only	NA	3,000(20.7)	80%*	600(4.1)*	250,000(1723)	80%*	50,000(345)*
POLYESTER (*****Polycrete)	Sewer/Storm Dr.	NA	NA	75%*	NA	NA	75%*	NA
PVC (AmLiner)	Sewer/Storm Dr.	12111C	3,500(24.1)	80%*	700(4.8)*	155,000(1069)	80%*	31,000T(214)*
PVC (Contech or PW - DIRECT BURIAL)	Sewer/Storm Dr.	12454C	7,000(48.3)	47%	3,700(25.5)	400,000(2758)	65%	140,000(963)T
PVC (Danby & *****PVC-500)	Sewer/Storm Dr.	13354B	6,000(41.4)	80%*	1,200(8.3)*	400,000(2758)	80%*	80,000(552)*
PVC (Danby Wound)	Sewer/Storm Dr.	12344C	6,000(41.4)	80%*	1,200(8.3)*	360,000(2482)	80%*	72,000(497)*
PVC (*****EX Pipe)	Sewer/Storm Dr.	12334B	6,000(41.4)	80%*	1,200(8.3)	340,000(2344)	80%*	68,000(462)*
PVC (NuPipe)	Sewer/Storm Dr.	13223B	5,000(34.5)	80%*	1,000(6.9)*	280,000(1931)	80%*	56,000(386)*
PVC (*****RibLoc)	Sewer/Storm Dr.	13454C	7,000(48.3)	80%*	1,400(9.7)*	400,000(2758)	80%*	80,000T(552)*
PVC (*****Ultraliner)	Sewer/Storm Dr.	16223B	6,000(41.4)	80%*	1,200(8.3)*	280,000(1931)	80%*	56,000(386)*
PVC (*****Uponor- DIRECT BURIAL)	Sewer/Storm Dr.	12454B	0	0	0	0	0	0
PVC (Vylon)	Sewer/Storm Dr.	12364B	6,000(41.4)	57%	2,600(17.9)	440,000(3034)	64%	158,400(1092)T
VINYLESTER (*****Interplastic VE8319/ Insituform)	Sewer/Storm Dr.	NA	4,000(27.6)	75%*	1,000(6.9)*	250,000(1723)	75%*	62,500(431)*
HDPE (ULiner - Discontinued 1998)	Sewer/Storm Dr.	345434C	3,200(22.1)	70%	960(6.6)	120,000(827)	70%	36,000(248)T
PVC (Danby - Discontinued 1995)	Sewer/Storm Dr.	12454C	7,000(48.3)	47%	3,700(25.5)	400,000(2758)	65%	140,000(963)T
PVC (NuPipe - Discontinued 1996)	Sewer/Storm Dr.	12344B	6,000(41.4)	80%*	1,200(8.3)*	360,000(2482)	80%*	72,000(496)*

Legend:

- E : Long Term (50-year) Elastic Modulus [psi/ (MPa)]
  F: Flexural Modulus; T: Tensile Modulus
- E_S : Initial Elastic Modulus [psi/(MPa)]
- F_t : Tensile Strength [psi/(MPa)]
- NA : Not applicable
- *****: Trial Demonstration Product - Restricted Use

Notes:

1. (*) If this value is inadequately justified by the manufacturer, the arbitrary creep correction factor will be at least 75% for thermosetting resins and 80% for PVC. Many materials are unsuitable for long-term, load-carrying use and will require concrete encasement (Standard Plan S-251 Case 5).
2. This figure is periodically updated by the Engineer of Design.