LARGE DIAMETER STORM OUTFALL REHABILITATION WITH GEOPOLYMER LINING IN HOUSTON

Justin Mouton, Inland Pipe Rehab – jmouton@teamipr.com
Joe Royer, GeoTree Solutions – jroyer@cs-nri.com

IPR®

GEOTREE®

Spotts Park Outfall – Overhead View

Project Options

- Originally released WO as CIPP
- Cost savings of roughly $250,000 just for the rehab (this does Not include the additional bypass costs)
- With CIPP, we would have to mitigate release of water into Buffalo Bayou (styrene & water temp could have adverse effect on ecosystem) This is not a concern for geopolymer linings

History of Geopolymer Use in COH

First Project(s):

Dairy Ashford Storm Outfall – Q3 2011

COH Contract #4258-46 – Q4 2011

Total Projects:

At Least 20 additional projects over the last decade

Sewer and Storm

Ranging from 30” to at least 120”

Approvals and Testing

TXDOT, LADOT and OKDOT Formal Approvals Since 2012

Texas Department of Transportation

RESEARCH AND TECHNOLOGY IMPLEMENTATI
P.O. BOX 5080 • AUSTIN, TEXAS 78763-5080 •

August 29, 2012

Benjamin Cook
Executive Vice President
GeoTree Technologies, Inc.
1733 Majestic Drive, Suite 101
Lafayette, CO 80026

Re: Product Evaluation 12-2772
"GeoSpray Geopolymer Mortar"

Dear Mr. Cook:

The product information you submitted has been reviewed by te
Division. They note that we have Statewide Special Provision
to products such as "GeoSpray." They further note that your pr
the Special Provision.

If you have questions, please contact me at 512-416-4739.

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Cc: Adriana Geiger
Andy Naranjo

STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
P.O. Box 94245
Baton Rouge, Louisiana 70804-9245
www.dotd.la.gov
225-248-4131

BOBBY JINDAL
GOVERNOR

May 24, 2012

OFFER NO. 05.069
GEO SPRAY GEOPOLYMER NANO-CERAMIC MORTAR

Mr. Jerry Shelsta
GeoTree Technologies, Inc.
1733 Majestic Drive, #101
Lafayette, CO 80026

Dear Mr. Shelsta:

The New Product Evaluation Committee has designed a new Website for products
submitted for evaluation and have been found by the Committee to have some mer
some basic product information and manufacturer contact information to enable in
what's "out there" with respect to new and innovative ways to build a highway.

Your product, Geo Spray Geopolymer Nano-Ceramic Mortar, is a specialty produc
approved product list in place at the current time. Your product will be listed on th
a recommendation to allow its use on a project by project basis, with the understan
use will have to be obtained prior to use. Please keep the Committee informed wh
used on a DOTD project, in order to keep our database up to date. Also, it will be i
notify us of any changes in contact information or product availability in a timely m
validity of the information posted on our web site. You can view your product at t
www.dotd.la.gov/highways/construction/lab/.

This is a new way for the Department of Transportation NPE Committee to showc
possible interested parties. Please return the attached release at your earliest conve
any questions, please feel free to contact me at 225-248-4131.

Sincerely,

J. BERTIN WINTZ, P.E.
NEW PRODUCT EVALUATION C

JBW:tkt
Attachment
Cc: Ms. Mitra Hashemieh

OKLAHOMA DEPARTMENT OF TRANSPORTATION
200 N. E. 21st Street
Oklahoma City, OK 73102-3204

February 21, 2012

Mr. Jerry Shelsta
GeoTree Technologies, Inc.
1733 Majestic Drive, Suite 101
Lafayette, CO 80026

Subject: Review of GeoSpray Geopolymer Nano-Ceramic Mortar

Dear Mr. Shelsta,

The ODOT Roadway Design division has reviewed your product evaluation submittal package for the geopolymer mortar to be used to re-line deteriorating pipes by centrifugally spraying the mortar to the inside of the pipe.

The ODOT does not have a specification or pay item specific to this product; however, we will allow its use as long as no future problems occur related to this product.

We would like to encourage you to reach out to the contracting community, who will likely review the costs and benefits of using this product. Feel free to show this letter to ODOT contractors as proof of acceptance of your product.

If you have any questions or comments, please contact me at (405) 522-6299 or dslattery@odot.org.

Sincerely,

Denise Slattery, P.E.
Standards and Specifications Engineer
Roadway Design Division

cc: Maintenance Division

Only Spray Applied System Evaluated & Approved by WRC

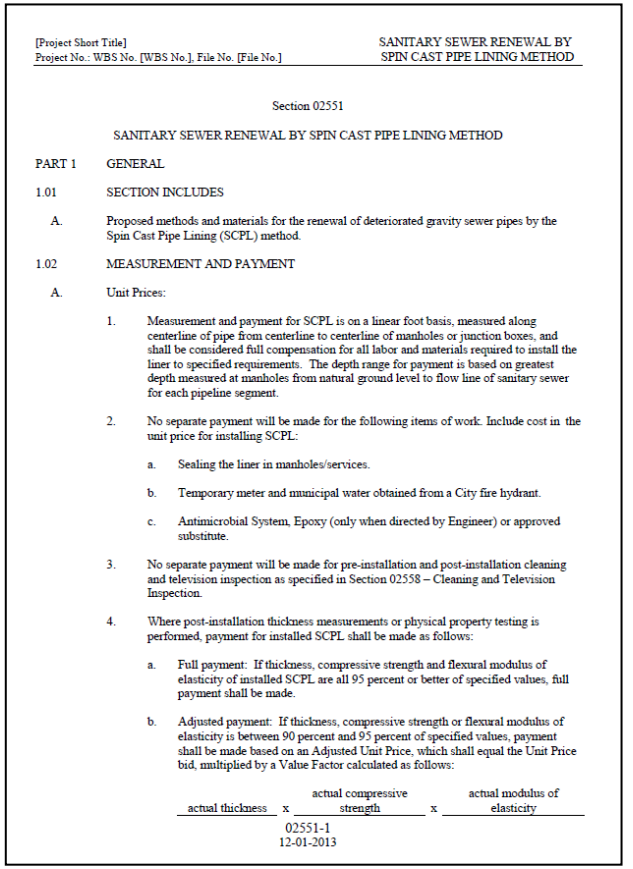
Project Specification

Critical Sections:

Minimum Geopolymer Liner Thickness:

Sewer Pipe Diameter	Maximum Invert Depth 0 to 10 feet	Maximum Invert Depth 10-15 feet	Maximum Invert Depth 15-20 feet	Maximum Invert Depth 20 - 25 feet
30"	1.5 "	1.5"	1.5"	1.5"
36"	1.5"	1.5"	1.5"	1.5"
48"	1.5"	1.5"	1.5"	1.6"
54"	1.5"	1.5"	1.6"	1.7"
60"	1.5"	1.5"	1.7"	1.8"
72"	1.5"	1.6"	1.9"	2.0"
84"	1.6"	1.8"	2.0"	2.2"
96"	1.8"	1.9"	2.1"	2.4"
108"	2.4"	2.0"	2.3"	2.5"
120"	***	2.1"	2.4"	2.6"

Physical Properties	ASTM Reference	Requirements
Compressive Strength	ASTM C 39	Minimum 8,000 psi @ 28 days
Modulus of Elasticity	ASTM C 469	Min. 5,000,000 psi @ 28 days
Flexural Strength	ASTM C 293	Minimum 800 psi @ 28 days



[Project Short Title] SANITARY SEWER RENEWAL BY SPIN CAST PIPE LINING METHOD
Project No.: WBS No. [WBS No.], File No. [File No.]

Section 02551

SANITARY SEWER RENEWAL BY SPIN CAST PIPE LINING METHOD

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Proposed methods and materials for the renewal of deteriorated gravity sewer pipes by the Spin Cast Pipe Lining (SCPL) method.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Measurement and payment for SCPL is on a linear foot basis, measured along centerline of pipe from centerline to centerline of manholes or junction boxes, and shall be considered full compensation for all labor and materials required to install the liner to specified requirements. The depth range for payment is based on greatest depth measured at manholes from natural ground level to flow line of sanitary sewer for each pipeline segment.

2. No separate payment will be made for the following items of work. Include cost in the unit price for installing SCPL:

   a. Sealing the liner in manholes/services.

   b. Temporary meter and municipal water obtained from a City fire hydrant.

   c. Antimicrobial System, Epoxy (only when directed by Engineer) or approved substitute.

3. No separate payment will be made for pre-installation and post-installation cleaning and television inspection as specified in Section 02558 – Cleaning and Television Inspection.

4. Where post-installation thickness measurements or physical property testing is performed, payment for installed SCPL shall be made as follows:

   a. Full payment: If thickness, compressive strength and flexural modulus of elasticity of installed SCPL are all 95 percent or better of specified values, full payment shall be made.

   b. Adjusted payment: If thickness, compressive strength or flexural modulus of elasticity is between 90 percent and 95 percent of specified values, payment shall be made based on an Adjusted Unit Price, which shall equal the Unit Price bid, multiplied by a Value Factor calculated as follows:

$$\frac{\text{actual thickness}}{} \times \frac{\text{actual compressive strength}}{} \times \frac{\text{actual modulus of elasticity}}{}$$

02551-1
12-01-2013

COH Sanitary Sewer By Spin Cast Pipe Lining Method Section 02551

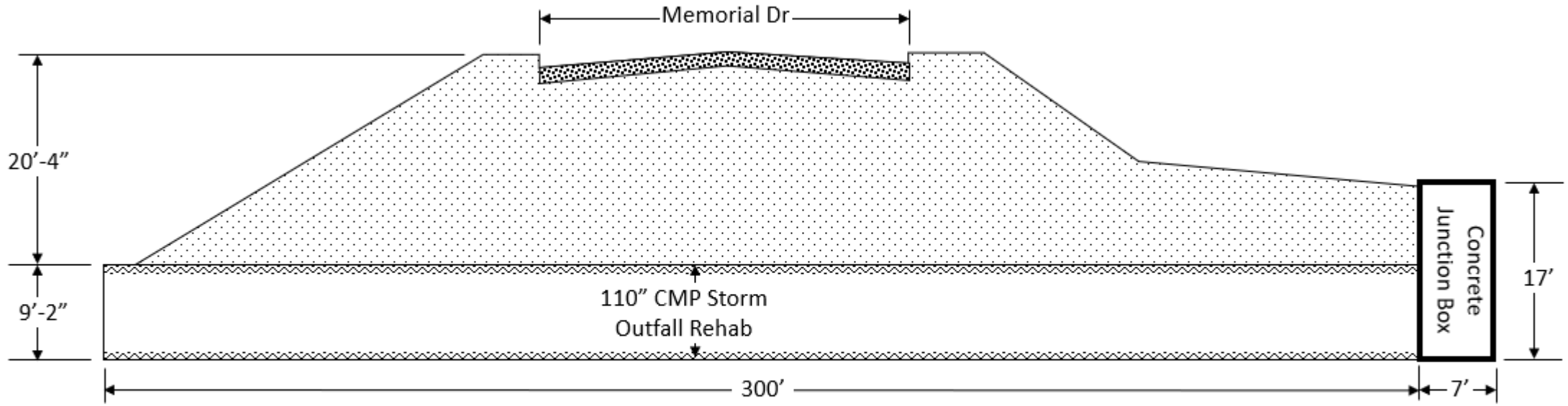
COH FY2019 Drainage Rehab WO #4

Project Details:

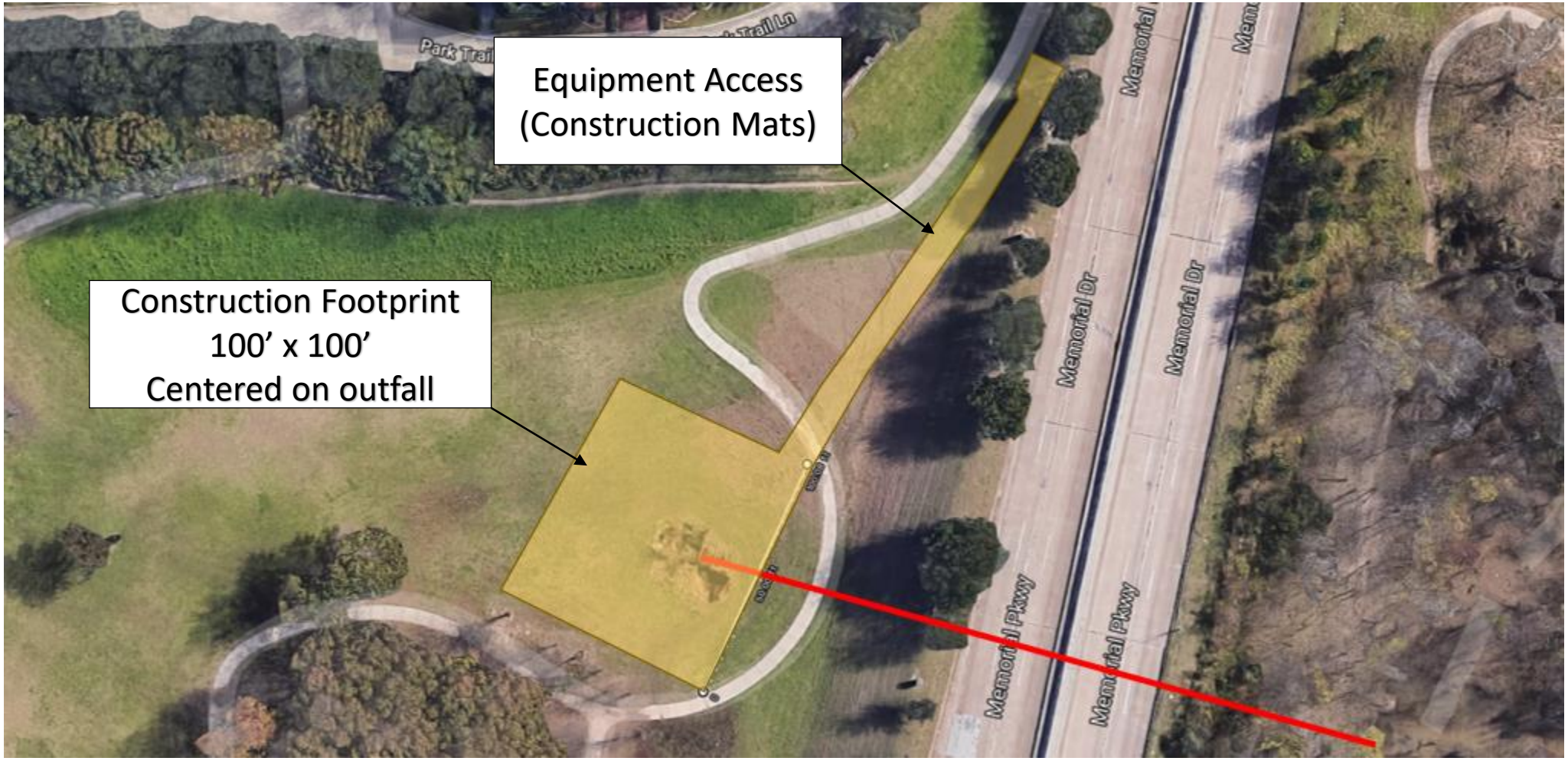
- 110” Diameter CMP
- 300 Linear ft
- Construction 2 weeks
- Material: GeoSpray® Geopolymer
- Contractor: Inland Pipe Rehab

Spotts Park Outfall – Arial View

Spotts Park Outfall – As Built



Spotts Park OutFall – Site Planning



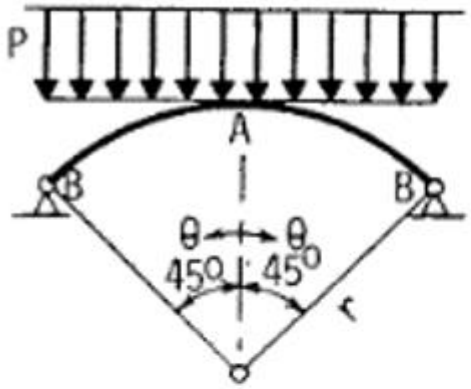
Spotts Park Outfall – Access Planning

Spotts Park Outfall – Access Planning

Spotts Park Outfall – Upstream Conditions

Spotts Park Outfall – Down Stream

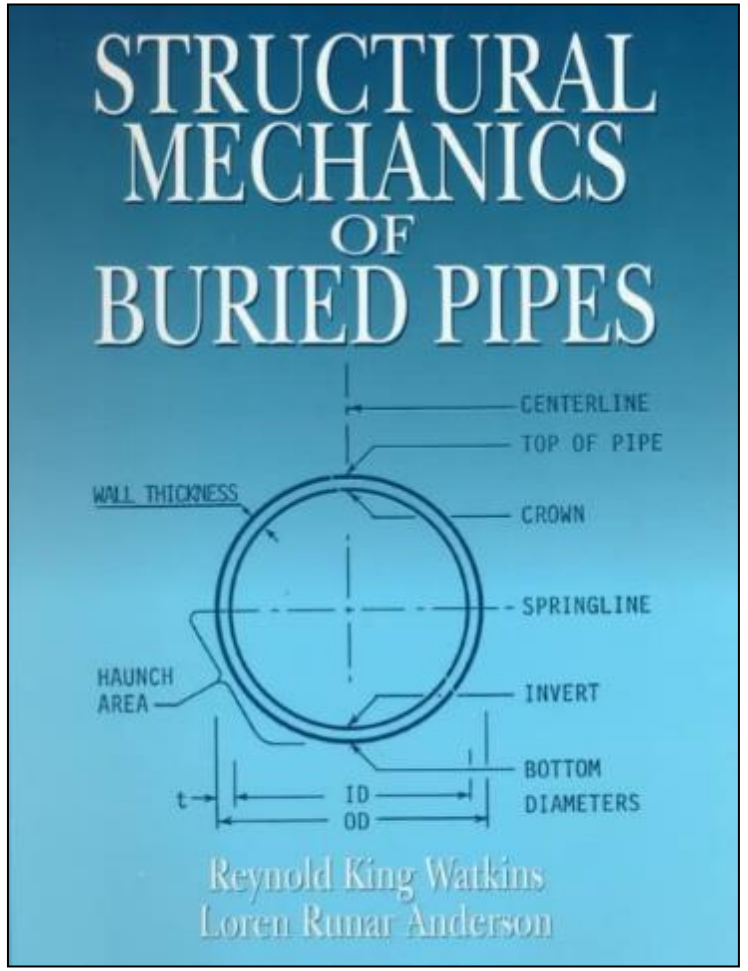
Development of Design method



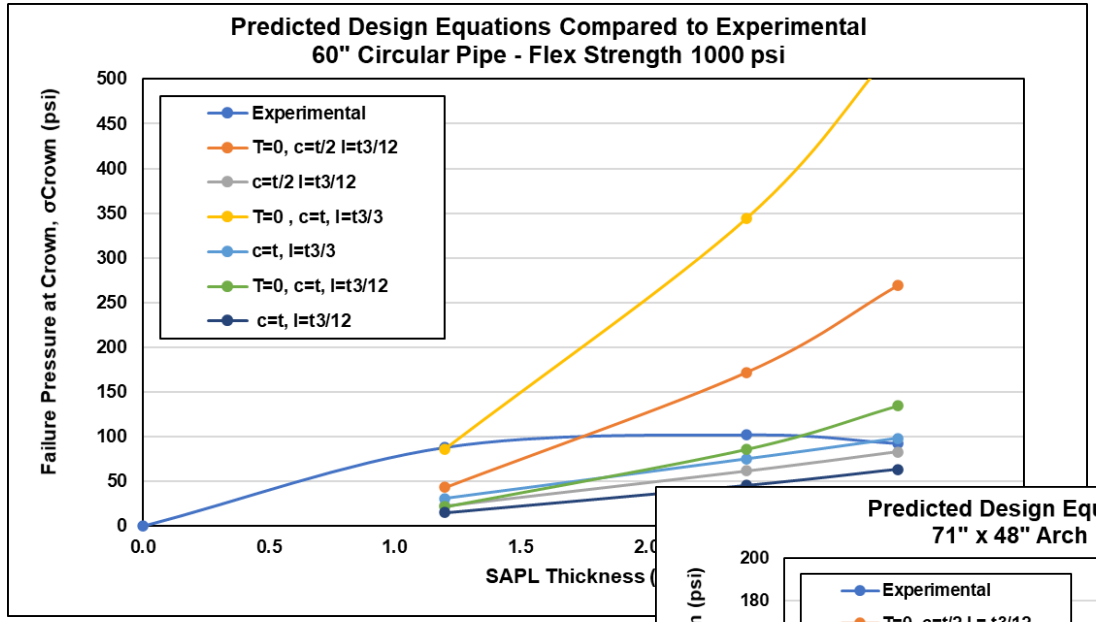
$$T_A = 0.8323Pr$$
$$M_A = 0.0062Pr^2$$

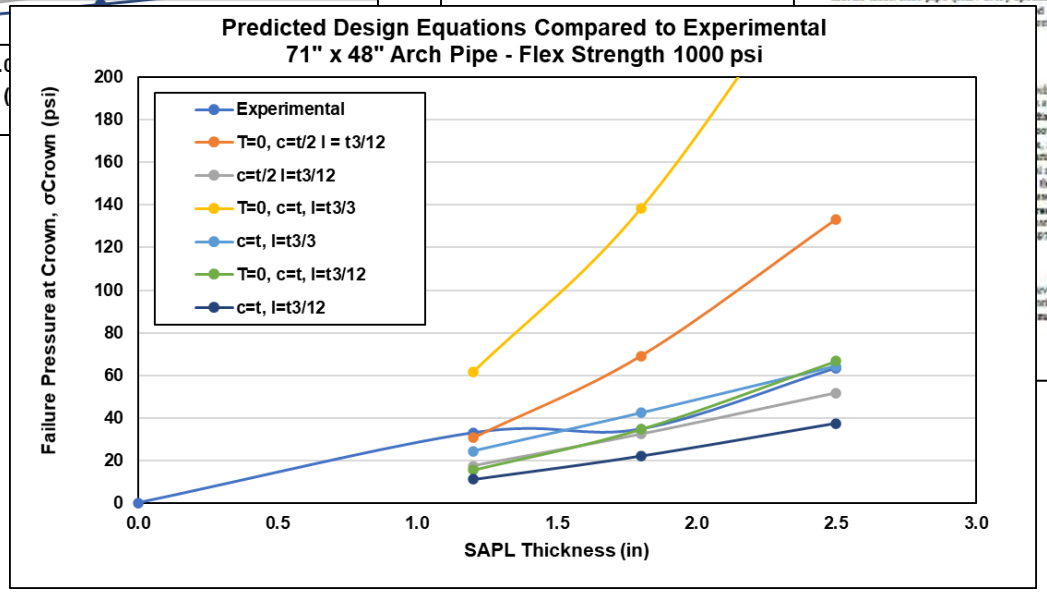
The resultant solution for this case is:

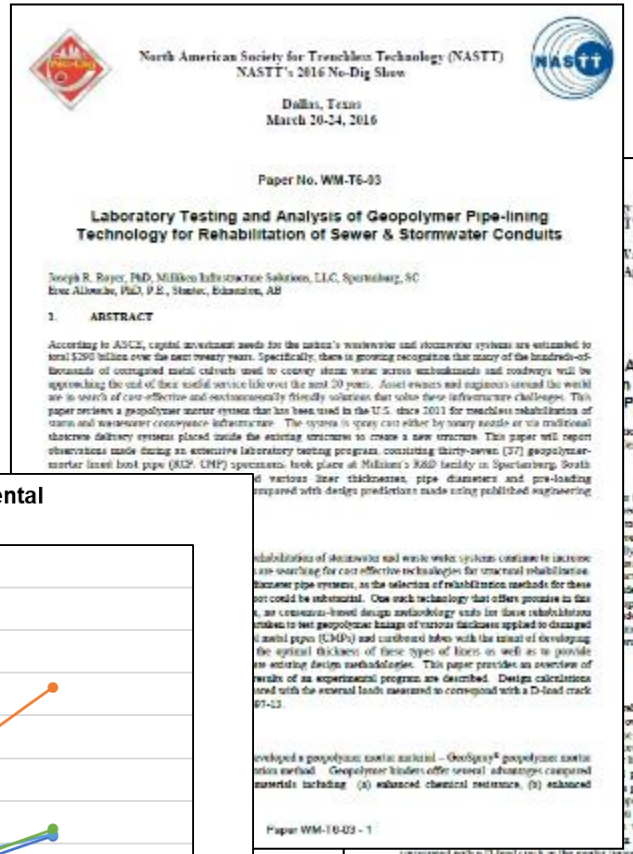
$$t = \sqrt{\frac{0.0744\,P\,r^2}{S_F}\frac{N}{C}}$$



Testing – Internal & CURIE Data






North American Society for Trenchless Technology (NASTT)
NASTT's 2016 No-Dig Show

Dallas, Texas
March 20-24, 2016

Paper No. WM-T6-03

Laboratory Testing and Analysis of Geopolymer Pipe-lining Technology for Rehabilitation of Sewer & Stormwater Conduits

Joseph R. Royer, PhD, Milliken Infrastructure Solutions, LLC, Spartanburg, SC
Ernz Allouche, PhD, P.E., Stantec, Edmonton, AB

1. ABSTRACT

According to ASCE, capital investment needs for the nation's wastewater and stormwater systems are estimated to total $290 billion over the next twenty years. Specifically, there is growing recognition that many of the hundreds-of-thousands of corrugated metal culverts used to convey storm water across embankments and roadways will be approaching the end of their useful service life over the next 20 years. Asset owners and engineers around the world are in search of cost-effective and environmentally friendly solutions that solve these infrastructure challenges. This paper reviews a geopolymer mortar system that has been used in the U.S. since 2011 for trenchless rehabilitation of storm and wastewater conveyance infrastructure. The system is spray cast either by rotary nozzle or via traditional shotcrete delivery systems placed inside the existing structures to create a new structure. This paper will report observations made during an extensive laboratory testing program, consisting thirty-seven (37) geopolymer-mortar lined host pipe (RCP, CMP) specimens, took place at Milliken's R&D facility in Spartanburg, South


for Trenchless Technology (NASTT)
T's 2017 No-Dig Show

Washington, D.C.
April 9-12, 2017

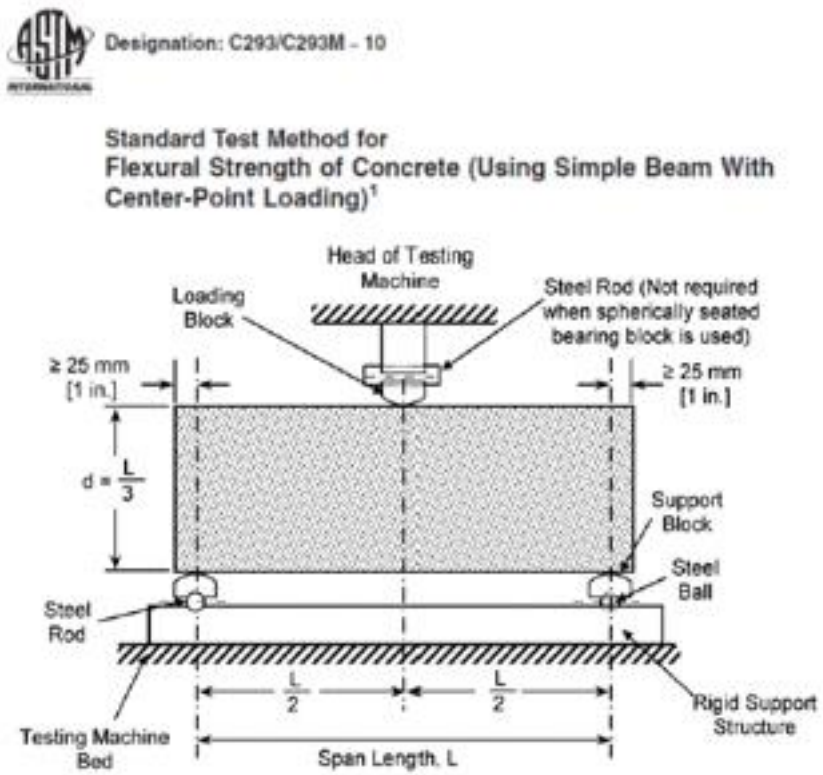
TM2-T3-04

Analysis of Geopolymer Pipe-lining
n of Sewer & Storm Water Conduits, Part
P Culvert Analysis

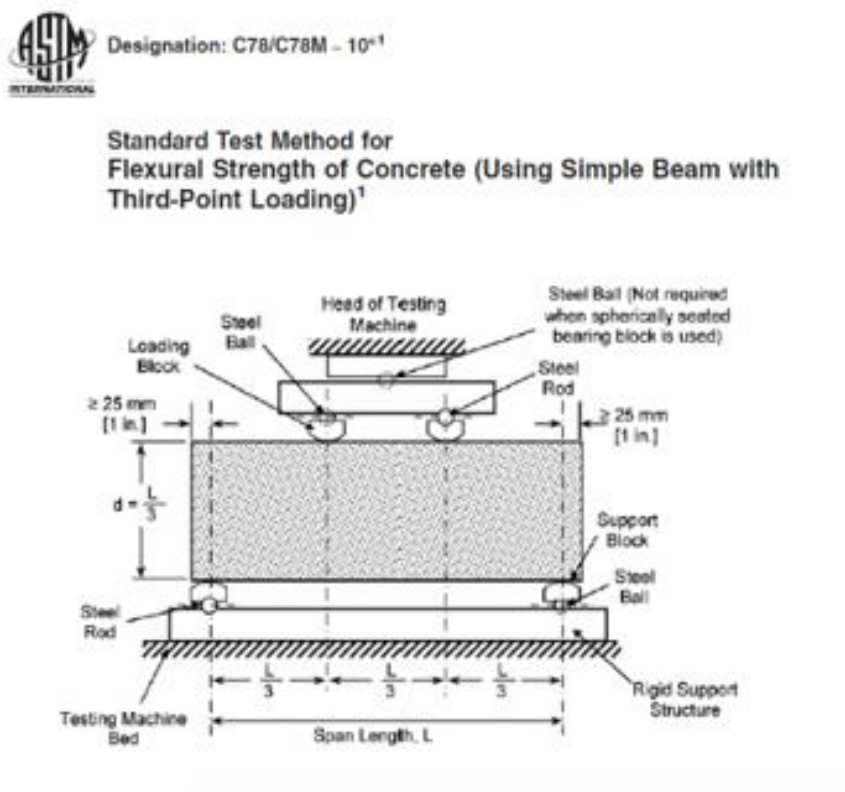
3. GEOPOLYMER LININGS

Paper TM2-T3-04 - 1

Different Flexural Strengths



ASTM C293



ASTM C78

Design

Project Design:
Minimum Thickness = 2.5”

Project Information

Asset Owner:	City of Houston	Date:	
Project Name:	Spotts Park Outfall	Project Number:	
Location:	Houston TX		

GEOTREE

Cells in Light Green In This Document are Adjustable Entry Varabiles

Project Conditions/Design Assumptions

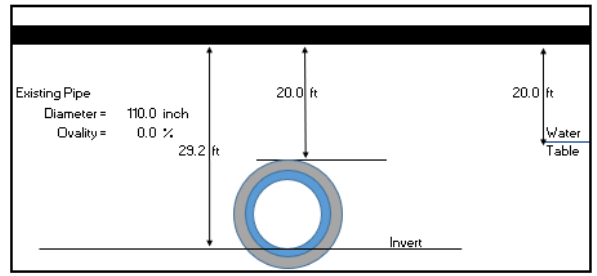
		Values	Units	Notes
Condition of Pipe		FD		PD = Partially Deteriorated; FD = Fully Deteriorated; ASTM F 1216-09 As Defined in X1.1 Terminology
Inside Diameter of Host Pipe	D=	110.0	Inches	As Measured - This should be reflective of the curvature of the crown of the structure for non-circular syster
Ovality of Host Pipe (for strucutres that have deflected)	Δ=	0.0	%	Δ= 100*(Mean Inside Diameter - Minimum Inside Diameter)/Mean Inside Diameter; As defined in ASTM F1216-09 X.1.2.1 for calculation of ovality reduction factor - C
Factor of Safety	N=	2.0		Default Value is 2.0
Depth of Pipe	D_i=	20	ft	As Measured from Top of Pipe (Crown)
Water Table Depth Below Surface	D_w=	20	ft	As Measured from Surface
Soil Density	w_s=	120	lb/ft³	Consult Charts on Soil Tab if not specified by assest owner (Higher Value is more conservative)
Soil Modulus	E_{soil}=	1500	psi	Consult Charts on Soil Tab if not specified by assest owner (Lower Value is more conservative)
Flexural Strength	σ_F=	1,500	psi	From Geopolymer physical properties - USE ONLY ASTM C78 28 Day Values - Please refer to Current GeoSpray technical data she
Assume Soil Arching		No		If "Yes" Height of Soil used to calculate soil load on pipe will be capped at 3X the pipe diameter
Soil Type		LRFD any other soil		Choose LRFD any other soil unless specified Granular as this is the more conservitive condition (see Concrete Pipe Design Manual)
Direction of Pipe with Respect to Traffic		Perpendicular		If Pipe is under Traffic Load, Please Select Orientation of Pipe with Respect to Traffic Flow
Live Load Calculation Method		Airport		Choose Between AASHTO HS20; AASHTO HS25; Railroad E80, Airport, Other o Other Specifed Live Load 0.00 psi
Total Soil & Hydraulic Load	P_w or q_s=	16.67	psi	Calculated from Soil Load & Water Height Inputs
Total Live Load	W_L=	4.00	psi	Calculated from Type of Load and Bury Depth & Soil Conditions.
Total Load	W_T=	20.67	psi	

Distributed Beam Model Results

Calculated t_{min}= 2.490 inches

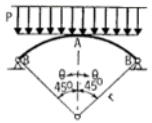
obal Recommended t_{min}= 2.490 inches

Insert Stamp or Seal Here if Required



Calculated using Distributed Beam Model Shown Below:

Designed By: Insert Designer Name Here



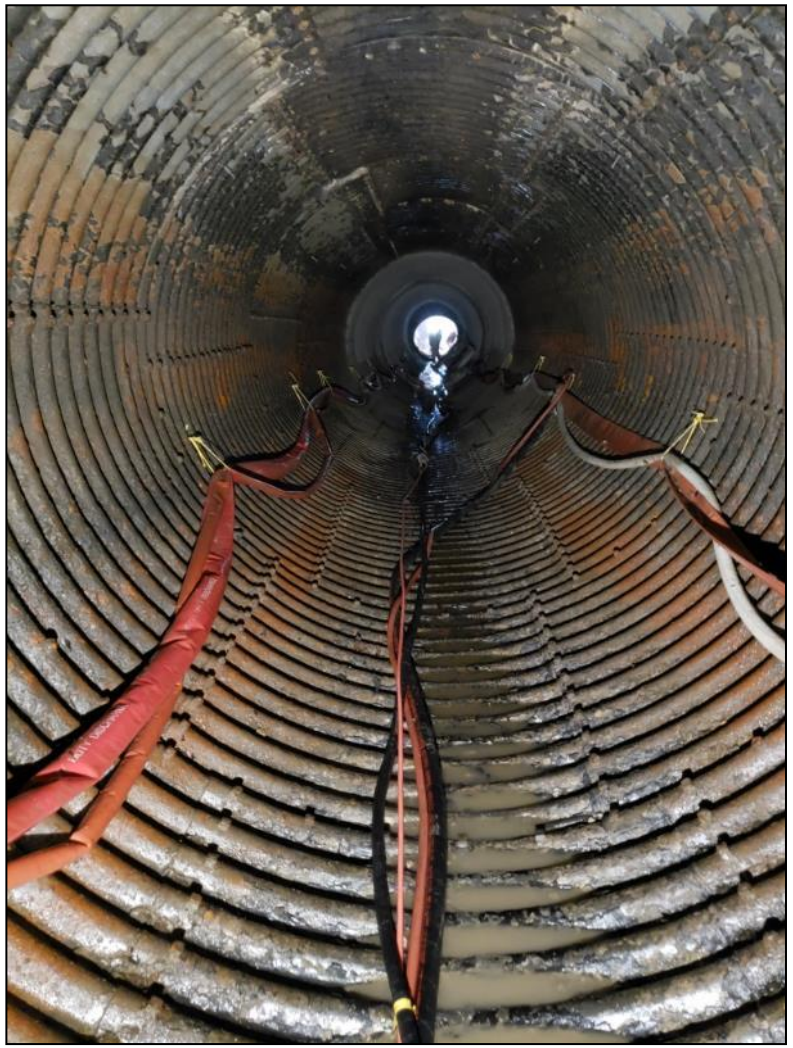
$$t_{min} = \sqrt{\left(\frac{0.0744 \cdot W_T r^2}{\sigma_F} \frac{N}{C}\right)}$$

GeoTree Soltions - Minimum Design Thickness Recommendations
Diameter < 54 Inches (Thickness Minimum = 1.0 Inches)
Diameter ≥ 54 Inches (Thickness Minimum = 1.5 Inches)
Calculator Version: July 17, 2020

Construction Process

1. Plug Inlet/Outlet
2. Internal By-Pass Pump (when needed)
3. Clean and Remove Debris
4. High Pressure Wash (3500 psi minimum)
5. Invert Repair
6. Infiltration
7. Spray Lining
8. Inspection – QA & QC

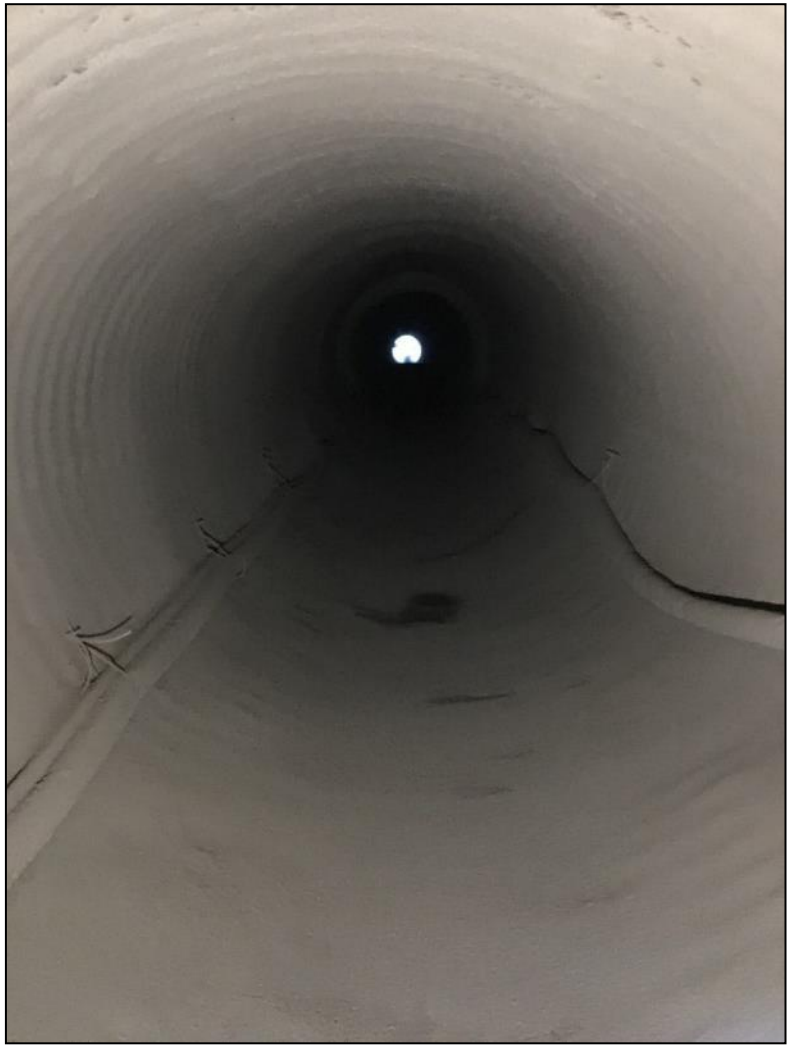
Spotts Park Outfall - Preconstruction



Benefits of Internal By-Pass

- No Disruption of Traffic
- Can Spray with “Flow Through”
- Unique Feature of Spray Applied Linings
- Low-Cost Pumping Options
- Only Required when Flow Conditions Dictate

Lining in progress



Thickness Verification – 5 Options

Depth gauge: During application; spot verification.

Depth Screws: During application; most common method.

Laser profile: Before and after application, and compare difference; most accurate, but most expensive.

Coring: After completion, in specific areas as a spot check; least desirable.

Calculated: Calculation of material applied, based on pipe shape.

Outfall – Before & After

Conclusions

- Cheaper, cleaner, smaller footprint, less invasive than Cipp
- Able to utilize a passive bypass system (would not have been possible with any other technology
- Cost savings offer to customer
- Quick execution
- Green
- Fully structural

Questions

Justin Mouton
Inland Pipe Rehab
jmouton@teamipr.com

Joe Royer
GeoTree Solutions
jroyer@cs-nri.com