VORTEX companies

CIVIL INFRASTRUCTURE SOLUTIONS

# Verifying Geopolymer Liner Performance

*3rd-party results verifying geopolymer liner performance of multi-product pilot field test & 10-year evaluation study*

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# 224 Manhole Pilot Study Overview

- Single contractor applied all four test materials.
- Test materials were all designed for manhole rehabilitation.
- Materials included: cementitious materials, calcium aluminates, and a geopolymer product.
- Manhole preparation was standardized for all four products.
- Inspections were conducted by the owner of the assets.

# Manhole Rehabilitation Process Overview

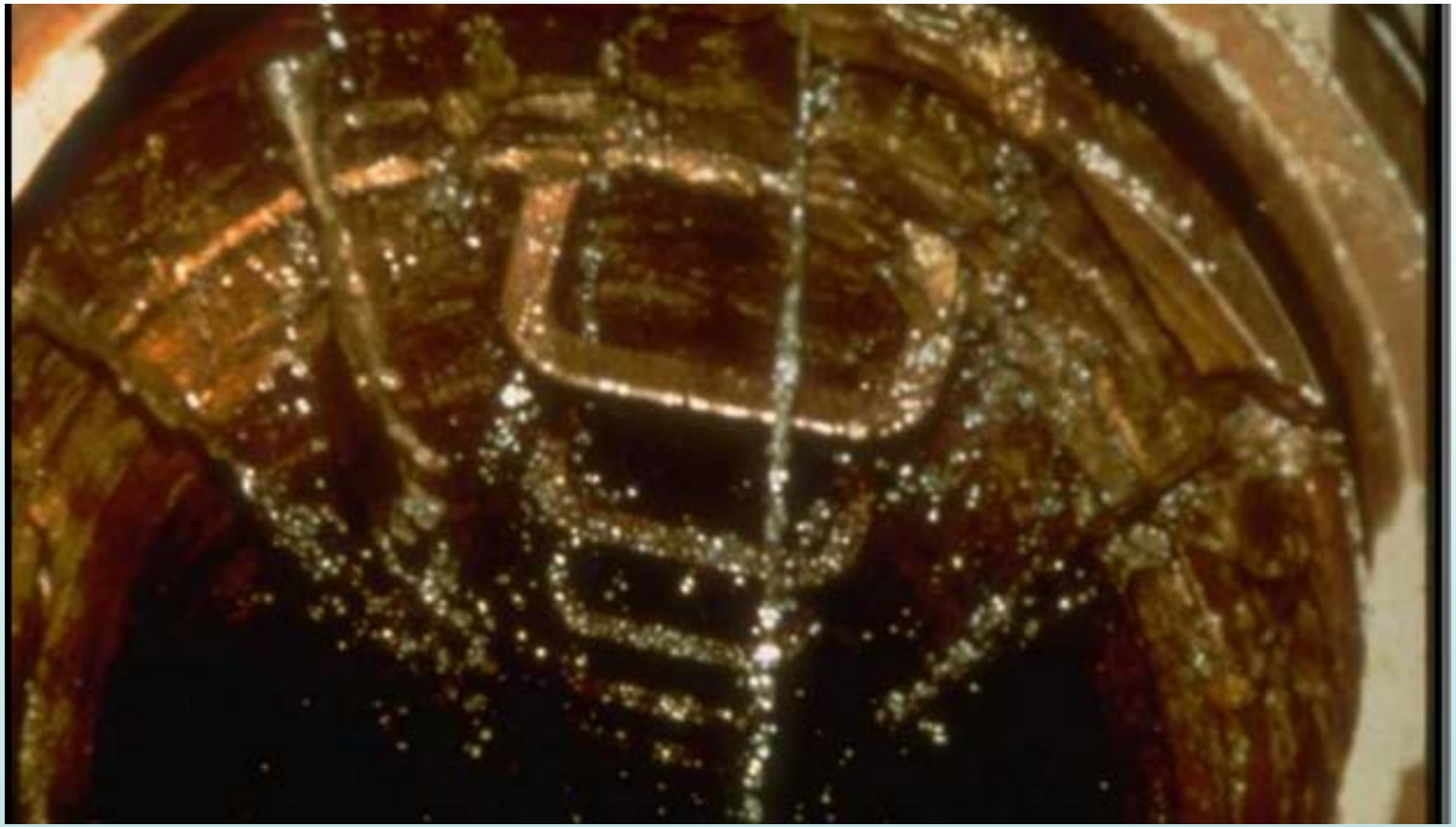
- Prioritize manholes to be inspected.
- Conduct standardized inspections.
- Determine manhole physical conditions.
- Choose appropriate repair technology or combination of technologies.
- Perform both field and laboratory QA/QC procedures as outlined in the bid document.
- Always perform all inspection and rehabilitation activities in a legal and safe manner.

# Manhole Determination Based on Population

- Determining the number of manholes in your system.
- Dr. Vipulanandan, with the University of Houston conducted a large scale survey that shows for every 100,000 residents a city will have very close to 6,000 manholes.
- This ratio works for cities of all sizes.

# Inspection Guidelines

- NASSCO, the National Association of Sewer Service Companies, has developed a comprehensive, unified system for evaluating Manholes.
- The Manhole Assessment and Certification (MACP) program entails using only approved descriptors of conditions and certified software for recording defects when using video cameras.



Close the Lid! We were never here.

# Rehabilitation Guidelines

- Manholes suffer a seemingly unending list of conditions that negatively impact the life of the structure.

- Traffic loading, freeze/thaw cycles, a very corrosive environment, abrasion, erosion, surcharging, and loss of support are just some of the conditions encountered.

# Proper Cleaning is Imperative

- Every manhole rehabilitation method, with the exception of chemical grouting, requires a cleaned interior surface.
- Manholes should be cleaned with water at a minimum pressure of 3,500 psi.
- Water infiltrating into the manhole is stopped before liners are applied.

# Rehabilitation Product Guidelines

- There are a variety of products including cement mortars, calcium aluminates and geopolymers used to repair manholes.
- These three materials were chosen for this specific study.

# Manhole Design Guide, Structural

- Manholes needing structural support can use cement mortars, calcium aluminates, or geopolymers at designated thicknesses.
- Typically, liners are applied at a minimum of ½ inch to an inch or more.
- Design calculations range from simple to complex.

# Manhole Design Guide, Corrosion

- Lining products Corrosion resistance
- Mid-range acidity (7 to 3 pH) cementitious products.
- Calcium aluminates are viable products for a pH down to 2.
- Geopolymers are utilized for a pH down to 1.

# Rehabilitation Products

- Cementitious, calcium aluminate, and geopolymer mortars can be hand applied, hand sprayed, or centrifugally cast on to the surface of the manhole.
- ASTM F-2551 *Standard Practice for Installing a Protective Cementitious Liner System in Sanitary Sewer Manholes* describes the installation process.

# Pilot Study Project

- Mark Christel, Principal Engineer for the Town of Cheektowaga, NY, contracted with a local general contractor to perform the pilot study utilizing three commonly specified cementitious spray-applied manhole rehab products as well a geopolymer spray- applied product. Having had success with a geopolymer product on other projects, the general contractor proposed that it should be considered in the study.

# Long-Term Viability

- The town of Cheektowaga was presented with a case study of a 10-year-old geopolymer application in the City of Neenah, Wisconsin.
- They decided with this information they would include geopolymers in their town’s pilot study.

# Installation and Testing Parameters

- As directed by the town, the manhole rehab work was performed during regular working hours. Each product was installed (spray-applied) on 56 manholes for a total pilot size of 224.
- Inspections were performed on each of the manholes several hours following each rehabilitation.

# Brick Manhole

- All of the 224 manholes in the study were brick.
- The brick was surprising dry and porous.
- Many manhole lids were highly vented further drying the manhole interior environment.

# Brick Manhole

# Field Application Training

- All product manufacturers had the opportunity to monitor the mixing and application of their specific products.
- The geopolymer product requires much less water than the other three products and requires a slightly longer mixing time.

# Rehabilitation by Geopolymer Mortars

- Geopolymer mortars are a common repair product.
- They are used to stop infiltration, provide enhanced corrosion protection,  and provide structural support.
- They are typically applied from .5  inches to 1 or more inches, as determined by the manhole condition, location, traffic loads, an hydrostatic pressure .

# Rehabilitation by Geopolymer Mortars

- Geopolymer mortars are appropriate for highly acidic conditions.
- Geopolymer mortars provide the enhanced corrosion protection required as a stand alone product.
- Geopolymers provide excellent freeze thaw characteristics.

# Geopolymer Liner Environmental Properties

- The Geopolymer lining product evaluated is composed of a high percentage of Class F fly ash.
- This fly ash, is a consistent powerplant waste product, with known physical and chemical properties.
- Fly ash is a critical component of the chemistry creating the geopolymer.

# Defining a Geopolymer

- The term *Geopolymer* is used when describing the inorganic polymerization reaction produced from the synthesis of alkali aluminosilicates with alkali activator.

- Unlike cementitious products, they are generally low in CaO (Calcium Oxide) (<25%) and high in SiO2 (Silicon Dioxide) and Al2O3 (Aluminum Oxide) (>50%) providing superior resistance to sulfuric acid.

# Geopolymer Physical Attributes

- Geopolymers typically use less than 50 % of the water used for standard cementitious products, as well as calcium aluminate products.
- This reduced water enhances freeze thaw characteristics as well as greatly reducing shrinkage.
- Geopolymers chemical reaction does not create the heat that cementitious products, especially calcium aluminates, exhibit.
- Geopolymers do not need a curing agent, and in fact require that none be used.

# Making a Geopolymer

- You combine an aluminosilicate powder with an alkaline solution to form a geopolymer.
- Basically, creating a Synthetic Stone.

# Analyzing a Geopolymer

- There are several processes that can be used to determine if, in fact, a product is actually a Geopolymer. This should include oxide and phase composition through the use of X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) testing.
- Fourier Transform Infrared Spectroscopy (FTIR) can be used to analyze the geopolymer molecule in more depth, and Nuclear Magnetic Resonance (NMR) can determine a particular geopolymer structure precisely.
- Standard ASTM Physical Properties should also be considered, with slight modifications in some cases.

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# Study Results

- Mark Christel conducted multiple post application inspections which revealed that the three different cementitious lining materials — each with a sample size of 56 manholes – were showing cracking in 20-25 percent of the manholes.
- The 56 manholes that had been sprayed with the  geopolymer GeoKrete were found to have a  0% crack rate.

# Brick Manhole with Geopolymer Liner

# Pilot Study Factors

- Using a single contractor to apply all of the test products reduces the application variables.
- Having a very large sample size, 54 manholes, provides a statistically accurate study foundation.
- The asset owner conducted all inspections, further reducing study variables.

# Pilot Study Conclusions

- Because this large pilot project reduced the field application variables to a minimum, the geopolymer liner clearly outperformed the other three materials.

# Questions