GeoCast™ Pipe Renewal is a Value Engineered Technology

Microsilica Geopolymer Mortar

50 Year Design Life

Structural Repair for Horizontal Concrete Pipes, Culverts and Vertical Shafts…

The manufacturer was first to use **Geocast™ Geopolymer with Reliner MSP® Cement** to make structural repairs for horizontal concrete pipes, culverts and vertical shafts, and sewer manholes, and WTP works. The **"sustainable"** Geocast™ Geopolymer Mortar is a microsilica rich OPC with dry densified geopolymer and fly ash binders. Its formulation is based on alumina-silicate with silicon rich (Si) and aluminum (Al) source materials. It's original, distinctive formulation is unmatched for restoring structural integrity in corrugated steel culverts and concrete repairing deteriorated concrete pipes where access is difficult, and protecting concrete against alkali aggregate reaction, chloride corrosion and chemical attack in wastewater infrastructure, large tunnels, mine applications, main sewers, RCP and Fiberglas structures. Consequently, the Geocast™ Mortar undergoes a polymerization reaction during hydration to take on one-of-a- kind ceramic properties resulting in reduced permeability and the elimination of the calcium hydroxide and consistent long-term durability. It's performance is proven through verification and testing, and USEPA Environmental Verification Technology Evaluations protocol for +25-years in wastewater manholes across America. The Geocast™ Geopolymer Mortar benefits include:

Sydney Water Authority, Australia

84-in. CMP Rehabilitation

- Stop water infiltration/ inflow
- Restore structural integrity to pipes, culverts, shafts and sewer manholes
- Protect against hydrogen sulfide (H_2S) corrosion and chemical attack

"The investigation indicated the Geopolymer mortar liner was in good condition based on composition and structural integrity after 25-years in wastewater manhole service.
C. Vipulanandan, PhD., P.E.
University of Houston

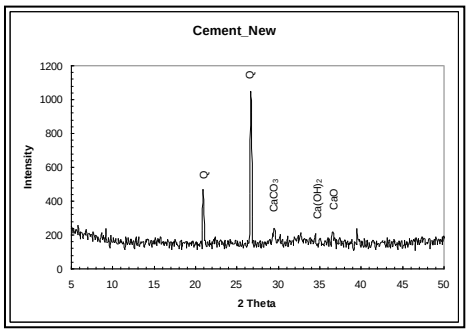
Patent

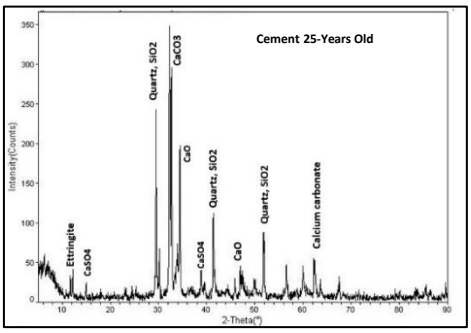
Patent No. 5,250,113 co-inventor "Dry Castable Concrete Compositions and Methods of Preparing and Casting the Same" W.R. Grace Company, NY.

Investigation

Beginning in 1987, the manufacturer introduced the use of microsilica geopolymer cement mortar in "Reliner MSP® Cement." Since 1990, the original, patent process is chief and has expanded the Reliner MSP® Cement's use including second generation formulation in "Geocast™ Geopolymer Mortar". Subsequently, the manufacturer is ahead with more than 50-years of product knowledge, versatility and corrosion resistance against chemical attack in ways never before possible and structural concrete repair applications in the sewage rehabilitation industry.

Furthermore, the company's experience and know-how has lead in investigations to measure the Reliner MSP® Cement durability at different ages in sewer service manholes (across a range of exposures) after 5, 10, 15 and 25 years. As a result, independent third party visual inspections including Thermal-gravimetric analysis (TGA) and X-ray Diffraction (XRD) examination have identified the cement paste constituents in specimens taken from the sewers that show the microsilica geopolymer specimens are in good condition. In addition, the samples were intact and undamaged with no cracking or spalling observed which proved to be a positive indicator as to their stability and long term durability.





NOTE: Aging and relative changes did not affect the microsilica cement lining's quality or its integrity after 25-years in service.

Two Main Constituents

The source materials in Geocast™ Geopolymer Mortar with Reliner MSP® Cement are based in its rich microsilica silicon (Si) and aluminum (Al) source materials. This unique silica source material also known as volatized silica fume or condensed silica fume [i.e. microsilica] is a by-product given-off in the production of metallic silicon or ferro-silicon alloys manufacturing in "submerged-arc electric furnaces." After a series of complex reactions occur in the furnaces, the condensed silica fume particles are formed by the oxidation and condensation of the gaseous silicon sub oxide, SiO, which is formed in the reaction zone. As a result, the solidified condensed

silica fume particles are entrained by the reaction gas-air mixture coming from the furnace and collected in de-dusting systems for packaging. As in many highly technological industries, there are different types of geopolymer including silica fume, fly ash, and blast furnace slag produced, and these are produced depending on the type of raw source materials burned or used in the process.

Subsequently, the type of alloy produced gives the condensed silica fume (microsilica geopolymer) its chemical composition. As a result, microsilica, known as CSF varies in color from pale to dark gray and its weight is usually very light having a loose bulk weight (density) consistency which is lighter than smoke, and a residue thickness which is composed of vitreous silica particles with a specific gravity of about 1.9 to 2.2. These appear (observed through electron microscope) to have a round, spherical, glassy form or smooth clusters of particles. Consequently, there are two main constituents in the Geocast™ Geopolymer Mortar with Reliner MSP® Cement namely its microsilica silica rich material and its low-calcium fly ash content. Lastly, if desired, **an alkaline liquid solution can also be used to cause a reaction between the salient factors with the silicon (Si) and aluminum (Al) minerals and the microsilica geopolymer (pozzolan) to produce additional geopolymer binder** (or calcium-silicate-hydrate paste) which produces increased strength, stronger bond and reduced permeability, and reduced calcium hydroxide of the hydrated cement as compared to conventional OPC concrete. The chemical reaction that takes place is called "polymerization." Also, independent testing in cement mortars containing microsilica CSF geopolymer have shown the lime (material) formed by the hydration process is consumed at different levels by the microsilica geopolymer and water. These source materials for geopolymer can be other finely divided natural minerals such as kaolinite and clays. Alternatively, by-product materials such as fly ash, silica fume, blast furnace slag, rice-husk ash, red mud, etc. can also be used as source materials.

Comments: Joseph Davidovits [1988] proposed an alkaline liquid can be used to react with the silicon (Si) and the aluminum (Al) in a source material of geological origin or in by-product materials such as microsilica, fly ash and rice husk to produce binders. As a result, the writer has listed some materials for the user's usage — branded names include poly (siloxonate) silicate-based Geopolymer, Metakaolin 750-based Geopolymer, calcium-based Geopolymer, rock-based Geopolymer, silica-based Geopolymer, fly ash-based Geopolymer, phosphate-based Geopolymer, organic mineral-based Geopolymer and fiber composite-based Geopolymer. Lastly, the choice of source materials for making the Geocast Geopolymer Mortar with Reliner MSP® Cement with microsilica binders depends on factors such as material preference, availability, cost and type of application, and specific demand of the end user.

Applications

The Geocast™ Geopolymer Mortar is suitable for applications including increased compressive and flexural strength, enhanced bond, durability, restoring dimensional stability, reduced permeability, improved hydraulic abrasion and protect against aggressive chemicals to protect the steel reinforcement. Additionally, the Geocast™ Mortar with microsilica provides light weightness, minimizes water demand, improves workability and increases water tightness which dramatically improves deep-depth structural repairs in concrete, sewer manholes and lift station concrete rehabilitation, and WTP component reinstatements. These features and returning structures back-to-service in less than 24 hours pay big savings to Owners. Furthermore, the Geocast™ Mortar with Reliner MSP® Cement is unequalled for combating the dangers of biogenic corrosion and chemical attack, and saltwater exposure in marine uses. As a result, the cement is widely accepted by engineers, designers and contractors for both new constructions and reinstatement of existing structures suffering from damage or weakened constructs. The distinctive Geocast™ Geopolymer Mortar holds exceptional features for new systems, restorations and refitting structures for extended service beyond their intended design life.

Chemical Resistance

The durability of horizontal concrete pipes, culvert, and vertical shafts, and sewer main structures, and manhole linings, and (water) WTP components depends on many factors such as general use, exposure to moisture, sulfate resistance, corrosion and chemical attack, cement type, permeability, absorption, water-to-cement ratios, and the use of good construction practices. Further, in today's large coast-to-coast industry, the manufacturer adds an air-entraining admixture to give the Geocast™ Mortar a measured, increase in durability to freezing and thawing affects for use in main sewers, storm sewers, pipes, culverts, and bridge culverts. Furthermore, it's noteworthy to mention since the costs associated with failure is high, the Geocast™ Geopolymer Mortar has been tested for chemical resistance using dry/ wet concrete [brick] substrates in a sulfuric acid solution having a pH 1.25 to pH 12.5 in accordance with ASTM C 267 Standard Test Methods for Chemical Resistance of Mortars, Grouts and Monolithic Surfacing's and Polymer Concretes. The results are shown below in Table 1.

Note to specifier:

Independent third party investigations of core samples containing microsilica geopolymer at a 1-inch thickness measured after 20-years in active service determined the most resistant concrete mixtures were those made with sulfate resistant cement in which the cementitious materials had been replaced with a microsilica admixture (Fiskka, Pfeiffer, D.

W. and Scali, M. J. Concrete Sealers for Protection of Bridge Structures, NCHRP Rep. No. 244, Transportation Research Board, 1991).

Table 1.

pH = 7	**Water** **Change in weight** **Appearance of specimen**	**Neutral** **+0.39** **Good. Slightly cloudy medium.**	**90-days**
pH = 2.20	**Sulfuric acid** **Change in weight** **Appearance of specimen**	**2000 ppm** **+0.26** **Good. Slight scaling on corners. Particles in solution.**	**90-days**
pH = 1.25	**Sulfuric acid** **Change in weight** **Appearance of specimen**	**20000 ppm** **-0.88** **Slight scaling with salt deposits on surface. Slightly cloudy medium. Particles in solution.**	**90-days**

Sewer Manhole Applications

Reliner MSP® Cement with microsilica Geopolymer restores and greatly increases the service life of culverts, pipes and sewer manhole structures.

Before- force main destroys MH wall.

After - structural restoration.

References

City of Dayton OH
Caldwell St. Sanitary/ Storm Improvements
15”-108” Cementitious Pipe Lining
Cory Kinnison
Telephone: (937) 333-3739

Fisher Wastewater Utility
Nottingham Culvert Project in Fisher
FDOT Control T-3426
Dan Tucker
Telephone: (317) 595-3167

Texas Department of Transportation
STP 2013 (126); FBC – Highway 361 N
TXDOT Control 0912-34-171
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47" Arch Culvert Pipe
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SR – 20 Blountstown Highway to Smithy's Way
FDOT Control T-3426
FRN 423067-1-52-01
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