# Understanding the Science Behind Advanced Geopolymer Mortar Lining Systems

By Steve Henning and Mike Vellano

Over the last two decades, the use of spray or centrifugally-applied, cementitious mortar systems have found their niche as a cost-effective and efficient method of rehabilitating very large circular and non-circular structures and manholes of all shapes, sizes and material makeup.

Even more exciting news about this rehabilitation method are the recent advancements in the lining materials' product formulation and the improved precision of the subsequent application equipment and methods.

Historically, basic Portland cement-based cementitious mortars were the standard specified material. While effective, the consistency and speed of application needed improvement, cure times need to be accelerated and structural integrity enhanced.

With the recent development and introduction of advanced geopolymers, the industry is now beginning to see the performance and application difference between them and traditional cementitious mortar lining systems.

## Understanding Geopolymers

There are two primary geopolymer families, Phosphate based and Aluminosilicate based. The latest in geopolymer mortars use for this type of infrastructure rehabilitation fall into the aluminosilicate family; which when fully cured, basically turns into a synthetic aluminosilicate stone, or ceramic.

Silica, Alumina and Oxygen atoms are the primary ingredients in an aluminosilicate geopolymer which form its primary "polymer" backbone or chain of covalently bonded atoms.

This inorganic polymer forms three-dimensionally throughout the mass as long cross-linked chains of atoms, forming a crystalline polymer system.

Geopolymers work by having the covalently bound atoms at the surface of the particles displaced by alkali molecules such that their molecular structure is disrupted creating future attachment sites. The attachment and cross-linking of molecules creates a monolithic structure that results in superior material properties.

Through the process of polycondensation (atoms are linking everywhere in the mass in all directions) higher complexes are created, in effect creating a system with infinite chains, rings, ribbons, and layers. The designed performance properties of the end-product is achieved by controlling the chemical composition and physical properties of the raw materials.

Some advantages of using a geopolymer mortar as a pipe or structure relining material are:

- More durable with higher compressive strength, higher flexural strength and higher modulus of elasticity.
- Once the material is applied onto the damaged pipe, it quickly forms into a crystalline structure for higher resistance to acids, lower porosity and greater surface durability.
- The quick cure rate also shortens by-pass time and allows flows to be reestablished much quicker than Portland cement based mortars.
- The material properties are exceptionally resistant to environmental factors like heat and cold and allows for extended application environments.
- Advanced geopolymers will stick and adhere to virtually any surface. Unlike traditional cement mortars, geopolymers are capable of bonding and building to great thicknesses.
- Geopolymers qualify for LEED credits and are styrene free. They are made from recycled industrial waste material and there is a substantial reduction in greenhouse gases.

Process and equipment improvements make for better quality control and ensure faster more consistent applications. The ability to deliver the engineered liner is dependent on the application process and equipment in addition to the materials. The process and equipment needs to deliver a consistent material applied at a constant preset speed. Advanced geopolymers are applied with a precision-controlled spray application equipment. This allows the product to be consistently applied to a preset engineered thickness with each pass. Traditional cementitious mortar application systems are mixed in batches and manually pulled through a pipe or structure at varying speeds creating inconsistencies within the new liner.

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Thanks to ongoing research and an industry that is dedicated to continuous improvement, the future is bright for spray or centrifugally-applied mortar structural lining systems. Portland cement-based spin cast systems have served our industry well for nearly four decades. It is only natural for new product and improved equipment technology to take this rehabilitation process to the next level. We've all seen it happen with pipe bursting (with the improvement in bursting tools) and with CIPP lining technology (with the improvement in liners, and the introduction of epoxy resins). In this case, it is the development of advanced geopolymer mortars, and carefully designed application equipment, that will carry the spray and centrifugally applied rehabilitation projects into the future.

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