Milliken GeoPolymers – 202
Chemical Resistance & Microbial Induced Corrosion – Aggressive Acidic Conditions

Milliken®

GeoSpray™ AMS

Corrosion Resistant Geopolymer System

Background

In sanitary sewers and other wastewater environments, the general corrosion mechanism of cementitious based materials is well known and widely documented. It is often referred to as Microbial Induced Corrosion or (MIC).

The process of MIC involves a 3 step mechanism:

- First, hydrogen sulfide gas (H_2S), commonly referred to as sewer gas, is released by the reduction of sulfates in the sewer effluent from anaerobic bacteria – generally living in a "slime layer" below the water line.
- Secondly, sulfuric acid (H_2SO_4) is formed on exposed surfaces through the oxidation of H_2S by aerobic *Thiobacillus* bacteria.
- Finally, the sulfuric acid reacts most often with $Ca(OH)_2$ found in many cements to form gypsum ($CaSO_4 \cdot 2H_2O$) which is water soluble and will wash away.

The exact mechanism of attack in the final step will depend on the specific chemistry of the cementitious materials present. A schematic representation of the MIC environment is a sewer pipe is shown in **Figure 1**.

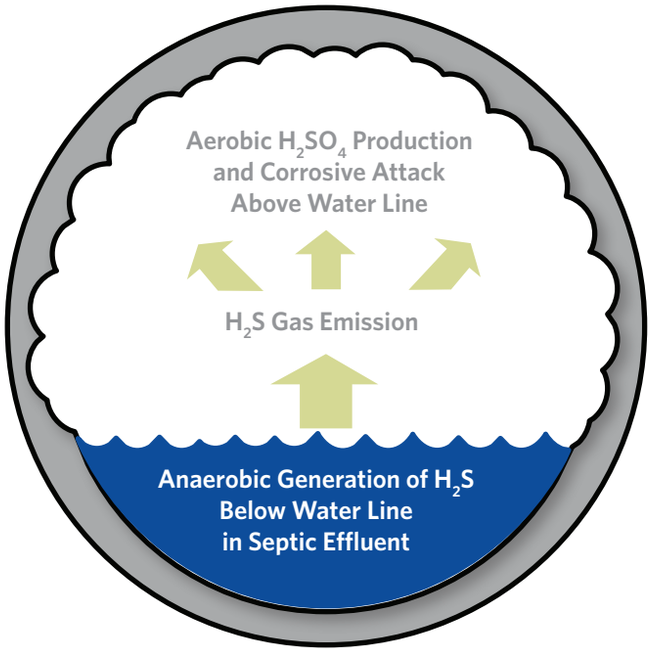

Figure 1. Mechanism of MIC

The GeoSpray™ Advantage

The chemical make-up of GeoSpray AMS makes it inherently acid resistant to the MIC mechanism found in many sewer environments. Geopolymers (dependent on the exact formulation) will contain greatly reduced concentrations of $Ca(OH)_2$ (calcium hydroxide) essentially the acid corrosion mechanism found in many typical cements. In addition to the base geopolymer chemistry, GeoSpray AMS includes an added layer of chemical protection from the proprietary PostCoat that creates an additional glass-like chemically resistant surface.

Milliken™ | Milliken Infrastructure Solutions, LLC

Testing

Chemical resistant studies were performed following the procedures of ASTM-C267. GeoSpray AMS sample cubes were cast and allowed to cure for 28 days before being soaked in both water and 7% sulfuric acid (pH 0.9). Portland cement (OPC) cubes were also cast and soaked as representative samples for standard reinforced concrete pipes commonly found in sanitary sewer systems.

Samples were measured for weight and dimensional changes after soaking for 1, 7, 14, 28, 56 and 84 days. 3 samples of the materials were soaked and tested, and the solution volume relative to the cubes was held constant. The chemical solutions were refreshed on day 14, 28, and 56. A picture of GeoSpray AMS cubes soaking in solution is shown in **Figure 2**.

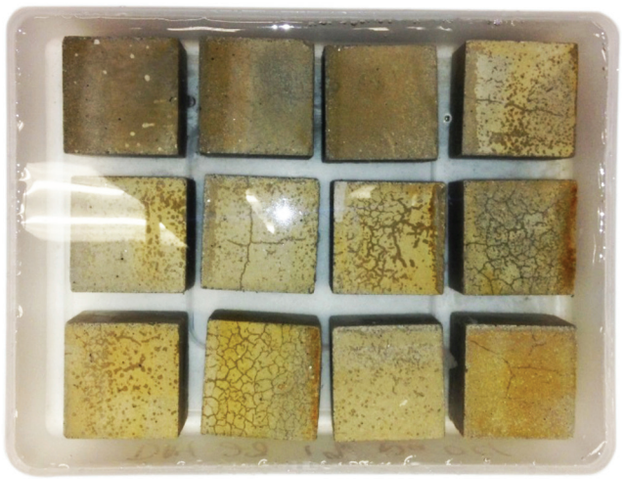

Figure 2. GeoSpray AMS Cubes soaking in acid solution

Results

GeoSpray AMS samples showed only slight loss of mass and signs of surface corrosion through the 84 days exposure to 7% H_2SO_4 (sulfuric acid), while the portland cement samples lost more than 50% of their weight over the same time period. **Figure 3** shows samples cubes before exposure and after 84 days of exposure.

Figure 3. Portland Cement loses 50% of its mass when exposed to 7% Sulfuric acid, GeoSpray AMS is an order of magnitude better in performance

Figure 4 shows the effect of the 7% sulfuric acid on weight of the GeoSpray AMS and OPC cubes over the same time period. The results of weight are normalized to the percentage of weight change of samples soaked in water to account for the absorption of water. Through the 84 days exposure the GeoSpray AMS corrosion was an order of magnitude lower than the standard OPC material.

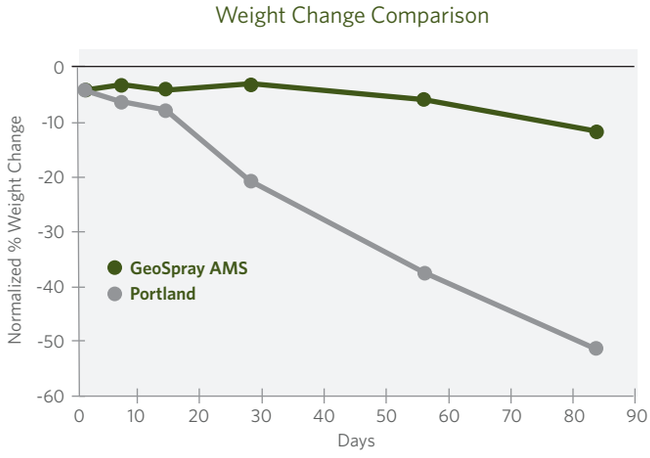

Figure 4. GeoSpray AMS and OPC weight loss after soaking in 7% H_2SO_4

Conclusion

When tested under the ASTM C-267 protocol against aggressively corrosive 7% sulfuric acid (pH 0.9), GeoSpray AMS showed only slight surface corrosion compared to the 50% weight loss observed in OPC samples that reflect concrete sewers in use today. Where concrete pipes and structures exhibit the effects of microbial induced corrosion, GeoSpray AMS should provide significant MIC resistance improvement over OPC.

Milliken | Milliken Infrastructure Solutions, LLC

geopolymers.milliken.com