Technical paper

Reference US 10/06

1 Introduction

SewperCoat is a ready-to-use, spray-applied mortar specifically designed to provide a structural, abrasion and corrosion-resistant, protective lining against biogenic corrosion relative to hydrogen sulfide (H_2S) found in municipal wastewater environments. SewperCoat is a 100% pure fused calcium aluminate mortar premix. Its unique properties result from the mineral phases formed during the hydration process.

The components of SewperCoat (all 100% calcium aluminate) are manufactured by a fusion process. The raw materials for this process are calcium and alumina. The calcium source is limestone and the alumina source is bauxite (also a raw material for the primary manufacture of aluminum). The limestone and bauxite are proportionately fed into a reverbatory furnace where they are melted into a liquid phase. The purity of the finished calcium aluminate is dependent upon the purity and proportions of the raw materials. SewperCoat mortars are composed of both calcium aluminate cement and manufactured calcium aluminate aggregates. The unique mineralogy of the cement and aggregates are the key to SewperCoat's ultimate performance. Both the calcium aluminate cement binder and aggregate system of SewperCoat are of the same chemical and mineralogical nature. Upon hydration, a strong physical and chemical bond can be achieved between the cement and aggregates in SewperCoat.

SewperCoat can be used for the rehabilitation of existing wastewater structures, as well as in new construction. SewperCoat is formulated for a spray-applied installation in wastewater structures. SewperCoat can be applied with low-pressure, wet process, or with the traditional high-velocity, dry-gunite or shotcrete process. Typical applications for SewperCoat include the lining of manholes, wet wells, lift/pump stations, piping systems, and treatment plant structures.

2 Experience

Calcium aluminates have been used for more than 65 years in extreme wastewater applications worldwide. The first U.S. application was in 1959 located at the Hyperion Treatment Plant in Southern California.

Kerneos Inc. is a business unit Kerneos Aluminate Technologies and is the world leader in the manufacture of calcium aluminate cements. Calcium aluminates cements were developed and first manufactured by this group in 1908 (J. Bied patent). Headquartered in Paris, France, the Aluminates business unit operates eight ISO 9000 certified manufacturing plants worldwide, with the U.S. facility being Kerneos Inc. located in Chesapeake, Virginia.

3 Products

There are two versions of SewperCoat, each designed for new and old structures with different installation processes.

SewperCoat PG is the "pumpable grade" version. It is designed to be applied with low-pressure, wet spray equipment. The material is mixed with water and conveyed through a hose with a progressive cavity (rotor-stator) or piston type (swing

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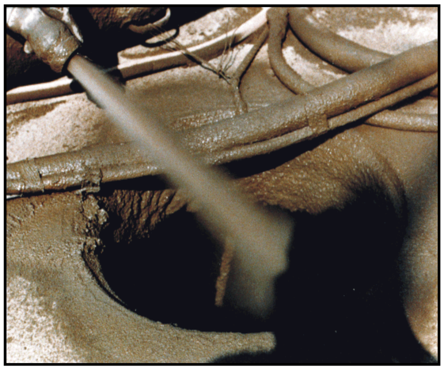
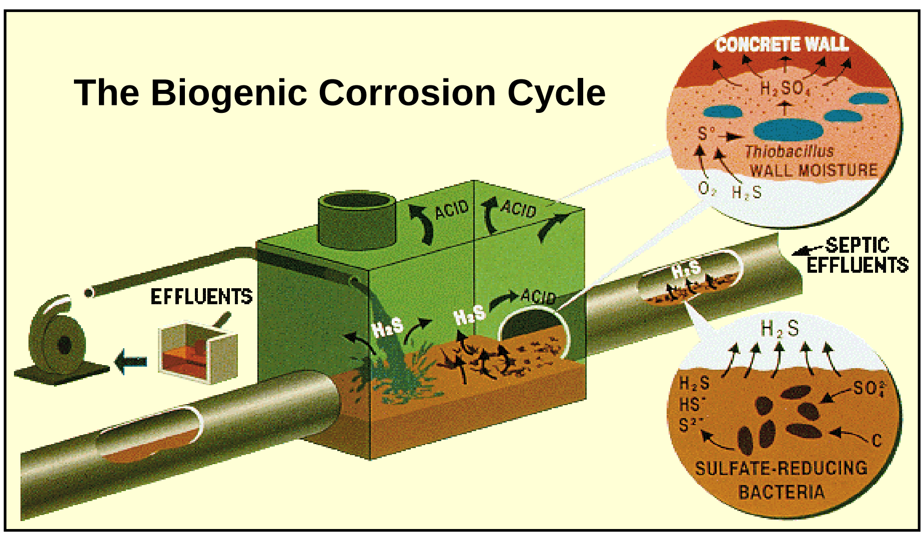
tube) pump system. There is an air nozzle on the hose that atomizes the wet material, spraying it onto the surface at a low velocity.

SewperCoat 2000 HS Regular is the “dry-gunite” version. It is designed to be applied with high-velocity, dry-gunite/shotcrete equipment. The material is blown dry through a hose with very high air pressure. There is a nozzle on the hose that contains a special water ring, which injects a precise amount of water into the dry material as is passes through. The SewperCoat is mixed as it hits the sub-surface. The nozzleman uses a circular application pattern that shears the material and mixes it through displacement.





Regardless of application method, careful attention should be given to surface preparation to ensure proper bond strength development. The typical sub-surface for structural wastewater applications is generally composed of portland cement concrete.

4 Biogenic corrosion

The hydrogen sulfide (H_2S) corrosion mechanism is a well-known phenomenon. Surprisingly, wastewater itself is rarely corrosive. The corrosion begins with H_2S created by the decomposition of the organic materials within the wastewater. This H_2S builds in concentration in the areas of laminar flow. The H_2S is then released into the sewerage network in areas of turbulent flow (outfall and force main type situations). Turbulent flow can occur in piping systems, manholes, pumping situations, and treatment plants. This turbulent flow causes the dissolved H_2S to become an airborne H_2S gas. The H_2S gas is heavier than air and initially exists above the effluent level, dissolving in the moisture on the concrete surfaces above the flow level. As water is formed by the oxidation of the hydrogen, the H_2S gas deposits elemental sulfur onto these surfaces. In some instances, a pronounced yellowish build up can actually be seen on the interior surfaces of manholes. This elemental sulfur is a food source for naturally occurring bacteria present in the sewerage system. These bacteria, present in the slime layer, actually “eat” the elemental sulfur (as a source of oxygen). The byproduct of the bacteria’s digestion process is sulfuric acid. It is this sulfuric acid that is corrosive to wastewater

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structures, not the H_2S gas. Factors that can enhance this biogenic corrosion cycle include long retention times, high ambient temperatures, flat terrain, and low flow values. With the current growth of outlying suburban areas, feeding into the existing infrastructure of larger metropolitan areas, these factors are becoming increasingly prevalent throughout the United States.

5 How SewperCoat works

Wastewater structures are typically constructed with portland cement concrete. Portland cement is a calcium silicate and its hydration inescapably liberates calcium hydroxide (portlandite), $Ca(OH)_2$. The sulfuric acid (H_2SO_4) excreted by the sewer bacterium will react with the calcium hydroxide liberated from the portland cement. The reaction is as follows: $Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$. This reaction produces gypsum and water. Gypsum is water-soluble. In a humid sewerage environment, gypsum is dissolved. This ongoing disruptive phenomenon continually leaves a fresh layer of portland cement for attack. Contrary to this, the hydration process of calcium aluminate cement does not produce portlandite but liberates only CA hydrates and AH_3 ("alumina gel" / gibbsite). The alumina gel liberated from calcium aluminate cement hydration is not susceptible to an attack of this nature.

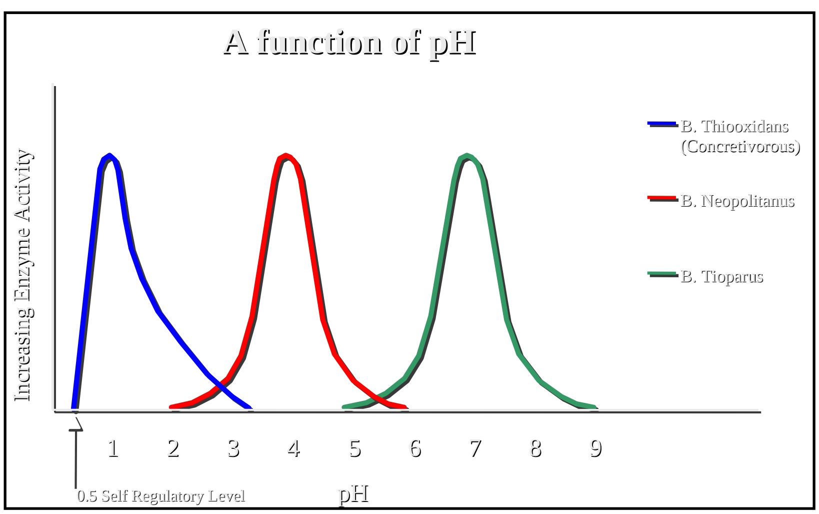
At pH levels above 3.5 "alumina gel" is insoluble and blocks the pores of the concrete, protecting it from the ingress of acid. Below a pH of 3.5 the "alumina gel" contributes to neutralizing the acid at the surface by the consumption of hydrogen ions:

$$\{AH_3 = 2[Al_2(OH)_3]\} + 6H^+ \rightarrow 2Al^{3+} + 6H_20$$

By removing hydrogen ions from solution, the surface pH is locally raised. In this way it acts as a Protective - Reactive Barrier, greatly reducing the corrosion of the concrete.

6 The Hamburg study

The University of Hamburg (Germany) has conducted accelerated tests using an artificial sewer chamber that duplicates the highly corrosive environments found in sewer systems. The Department of Microbiology identified the existence of three separate bacteria responsible for the microbiologically induced corrosion (MIC) cycle described above. The interaction of bacterial activity for these three strains versus pH is displayed in the graph below.



A new sewerage system will generally start at a neutral pH of 7.0. The Tioparus strain of bacteria will start the MIC cycle in this range. The bacterial activity of Tioparus is at its highest level when the pH is near 7.0. The Tioparus strain will go through the cycle of sulfur digestion, excreting sulfuric acid through the process. The excretion of sulfuric acid continues to lower the pH of the system. The Tioparus strain is effectively killing itself off by going through its life cycle by creating an

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environment not conducive to its own existence. As the pH level reaches 6.0, the second identified strain of bacteria (Neopolitanus) begin to thrive. When the pH reaches 5.0, the Tioparus strain has created such an acidic environment that it can no longer survive. The Neopolitanus strain then begins to thrive. This strain will go through the MIC cycle, effectively lowering the system pH to approximately 2.0. At a pH of 2.0, the Neopolitanus strain has created such an acidic environment that it cannot survive. When the pH reached approximately 3.5 during the Neopolitanus life cycle, the Thiooxidans strain's life cycle begins. Under certain conditions, these bacteria can bring the pH level down to 0.5. This 0.5 pH is referred to as the self-regulatory level because it is the lowest pH level attainable biologically through the MIC cycle. It is this third strain of bacteria (Thiooxidans) that is thought to be the key to the ultimate performance of SewperCoat. The "alumina gel" liberated during the hydration process of SewperCoat creates a surface environment that inhibits the activity of the Thiooxidans strain. By inhibiting the activity of Thiooxidans, SewperCoat can locally raise the pH level of a wastewater structure. This pH increase further inhibits the bacterial activity and the continued creation of sulfuric acid. This inhibiting effect on the Thiooxidans strain is referred to as the Protective - Reactive Barrier Effect of SewperCoat.

In November of 1991, a connection chamber at a wastewater treatment plant in Virginia was rehabilitated with SewperCoat. The original portland cement concrete structure had corroded a depth of 3" after only 7 years of service. The surface pH measured was 1.5 at that time. The SewperCoat was installed using the high-velocity, dry gunite process. Annual inspections have been conducted since the installation of SewperCoat in this structure. The lowest surface pH level recorded since the SewperCoat installation has been 2.8. The recent 10-½ year evaluation exhibited a surface pH of 4.0.

This reference, as well as others, confirms the Protective - Reactive Barrier Effect of SewperCoat. The key to the Protective - Reactive Barrier Effect is the formation of the mineral phase gibbsite (AH_3) during the hydration process. Both the cement and aggregates in SewperCoat are calcium aluminate and hydraulic, creating not only a physical bond between cement and aggregates, but a chemical bond as well. The combination of product composition and its mineral phases are the key to SewperCoat's ultimate performance as a structural, abrasion and corrosion-resistant protective lining relative to hydrogen sulfide (MIC) based corrosion found in wastewater environments.

7 For more info

For additional information about SewperCoat, please visit the Kerneos Inc. web site at http://www.Kerneosinc.com or contact us directly at:

1-800-524-8463

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