Introduction

SewperCoat® is a ready-to-use premix mortar, composed entirely of calcium aluminate materials manufactured by Lafarge Aluminates. It is specifically designed for spray-applied installation methods to provide a protective lining for structures exposed to abrasion and biogenic corrosion resulting from the hydrogen sulfide (H₂S) cycle that occurs in municipal wastewater environments. Its unique properties result from its particular mineral phases and hydration process.

The components of SewperCoat® are manufactured by a fusion process. The raw materials for this process are bauxite and limestone. The limestone and bauxite are proportionately fed into a reverberatory furnace where they are melted into a liquid. The composition 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 aggregate are key to the ultimate performance of SewperCoat®. Both the calcium aluminate cement and aggregate are of the same chemical and mineralogical nature. Upon hydration, a superior physical and chemical bond is achieved between the cement and aggregates. This, coupled with the hardness of the manufactured calcium aluminate aggregates, allows SewperCoat® mortars to have excellent abrasion resistance as well as superior corrosion resistance properties.

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

Experience

Calcium aluminates have been successfully used for more than 78 years in extreme wastewater applications worldwide. The first U.S. application was in 1959 located at the Hyperion Treatment Plant in Southern California.

Kerneos Aluminate Technologies is the world leader in the manufacture of calcium aluminate materials. Calcium aluminates cements were developed and first manufactured by the group in 1908 (J. Bied patent). Headquartered in Paris, France, Kerneos Aluminate Technologies operates eight ISO 9001 certified manufacturing plants worldwide, with the U.S. facility being Kerneos Inc. located in Chesapeake, Virginia.

Products and Installation

There are two rehabilitation versions of SewperCoat®, each designed for 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 tube) pump system. There is an atomizing nozzle on the hose that uses air pressure to propel 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 equipment. The material is blown dry through a hose with high pressure air. There is a nozzle on the hose that contains a water ring, which injects 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 the application method, careful attention should be given to surface preparation to ensure proper bond strength development. The typical subsurface for structural wastewater applications is generally composed of portland cement concrete. There are several industry guidelines available regarding surface preparation for concrete repair materials. In general, all sub-surfaces should be clean and free of laitance, loose material, residue and all existing coating and lining materials. Inflow and infiltration prevention measures should also be undertaken. For a detailed explanation of the surface preparation requirements please see ACI RAP-3 “Spall Repair by Low Pressure Spraying” page 2. ACI 546R “Concrete Repair Guide”, chapter 2 also provides a good reference for important considerations for repairing concrete surfaces using mortar.

The International Concrete Repair Institute (ICRI) Guideline No. 03732 can also be a useful reference for gauging degrees of substrate roughness. This reference document explains the means and methods of achieving different degrees of surface roughness and defines these different degrees through the use of actual molded rubber samples taken from prepared concrete surfaces.

A newly cast portland cement concrete structure may require a significant amount of surface preparation to achieve the desired degree of surface roughness. A severely corroded existing structure may be well in excess of desired degree of surface roughness at the time of rehabilitation and may require only high-pressure water cleaning. Regardless, SewperCoat® must be applied to clean, sound, rough, damp surfaces. Any unsound concrete or contaminated surface materials must be removed and all active and potential leaks must be addressed prior to installation. SewperCoat® is generally applied at an installation thickness ranging from ½” to 1”, but can be installed up to a 4” thickness depending upon the application.

It should also be noted that corroded portland cement mortars and concretes that have been cleaned down to a sound subsurface may still be damaged chemically by the biogenic corrosion process. The presence of efflorescence, scale, carbonation, or precipitates after wet cleaning may be an indication that this process is not completed and that further washing or surface removal may be necessary.

Kerneos maintains a list of competent contractors who have demonstrated requisite skill and training and can be considered qualified applicators of SewperCoat® products.

An example of the typical manhole rehabilitation process with SewperCoat® PG:

**Biogenic Sulfuric Acid Generation**

The microbial induced corrosion (MIC) mechanism is a well-known phenomenon [Thornton (78), Sand (84), Ehrich (96), ACPA (01), Scrivener (03)]. Surprisingly, wastewater itself is rarely corrosive. The corrosion process begins with sulfide (H₂S) created by the decomposition of sulfates by micro-organisms within the wastewater. Sulfur compounds, such as sulfate, sulfite or other inorganic or organic sulfur, must be present in the wastewater to provide the raw material for conversion to sulfide. Most domestic sewage naturally contains sufficient sulfates for this to occur. This H₂S builds in concentration in the areas of laminar flow. At sufficient
concentration, the additional $H_2S$ is not soluble and is then ejected as gas into the sewerage atmosphere. The ejection rate is increased in areas of turbulent flow (outfall and force main type situations). Turbulent flow can occur in piping systems, manholes, pumping situations, and treatment plants. The $H_2S$ gas is then dissolved into the moisture on the structure's surfaces and is oxidized to elemental sulfur. In some instances, a pronounced yellowish build up can actually be seen on the interior surfaces of wastewater structures. This elemental sulfur is a food source for naturally occurring bacteria (thiobacilli) present in the sewerage system. The byproduct of the digestion process of these bacteria is sulfuric acid. It is this sulfuric acid that is corrosive to wastewater structures, not the $H_2S$ gas. Factors that can enhance this biogenic corrosion cycle include long retention times (for example flat terrain and low flow velocity), high ambient temperatures, high humidity, etc. 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.

How SewperCoat® Combats MIC

Wastewater structures are typically constructed of portland cement concrete or mortar. Portland cement is a calcium silicate and its hydration leads to the formation of calcium hydroxide ([portlandite], $Ca(OH)_2$) and calcium silicate hydrates (CSH). The calcium hydroxide is rapidly dissolved by sulfuric acid ($H_2SO_4$) excreted by the sewer bacteria. This produces a soft paste-like gypsum precipitate. The CSH is also decalcified by sulfuric acid to form friable gypsum and structureless silica gel. This corrosion is progressive and continually leaves a fresh layer of portland cement concrete or mortar for attack.

$$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2(H_2O)$$

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).

At pH levels above 4, $AH_3$ is inert to acid attack. Corrosion of the CA hydrates above pH 4 leads to the precipitation of more $AH_3$ gel which acts as a diffusion barrier and blocks the pores of the concrete, protecting it from the ingress of acid. Below a pH of 4 the alumina gel contributes to neutralize the acid at the surface through the consumption of hydrogen ions.

$$\{AH_3 = [Al(OH)_3]\} + 3H^+ \rightarrow Al^{3+} + 3H_2O$$

The reaction of three moles of acid with each mole of alumina enhances the neutralization capacity of SewperCoat® as compared to normal portland cement based materials. The total neutralization capacity of SewperCoat is about 10 times that of normal portland cement concrete.
The University of Hamburg (Germany) has identified different strains of bacteria that are responsible for the microbial induced corrosion (MIC) cycle described above. The interaction of bacterial activity for these strains versus pH is displayed in the graph below.

Many thiobacilli are acidophiles. However, some of them, such as T. tioparus, T. novellus, and T. neapolitanus, are able to tolerate a slightly alkaline environment. They are the first to settle on the concrete surface as the pH of the concrete drops through carbonation or the formation of sulfurous acid. The pH of the concrete surface is thus further reduced by acid produced by these species, so that suitable growth conditions for other species of bacteria such as T. thiooxidans are created. This latter is the most aggressive of the thiobacillus species since it is capable of living in a very low pH environment, where it continues to excrete sulfuric acid. In this environment, the pH of portland cement concrete surfaces have been reported as low as 1.0. It is well known that aluminum ions have an inhibitory effect on the growth rate of most of bacteria [Karlik et al., Sigel, Johnson, Exley, Appanna].

The combination of bacteria-inhibiting effects and increased neutralization capacity allow calcium aluminate mortars to perform significantly better than the original structure in most wastewater applications. In the case of SewperCoat®, both the cement and aggregates are calcium aluminate and posses the bacteria-inhibiting and neutralization effects mentioned above. Being composed entirely of calcium aluminate, the long-term performance of SewperCoat® is unequalled as a mineral based solution.

Through its alumina gel barrier at higher pH levels (> 4.0) and its very high neutralization capacity and inhibitory effect on the activity of thiobacilli strains at low pH levels (< 4.0), SewperCoat® has demonstrated in numerous wastewater reference projects and applications that it is able to effectively limit bacterial activity and stabilize the pH level of a wastewater structure to a relatively high pH (near 3.0). The overall result is a very low corrosion rate and excellent protection of wastewater structures.

The combination of product composition and unique mineral phases are the key to SewperCoat®’s performance as a protective lining of structures exposed to abrasion and microbial induced corrosion (MIC) found in wastewater environments.

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.