TECH NOTE

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Microbial Induced Corrosion (MIC) Attack of Concrete in Sewage Applications

It is well known that concrete often ages more quickly in sewage applications. Why does this occur and what can be done to minimize such deterioration?

Both physical and chemical attack of concrete in sewage systems are possible. However the more prevalent of the two, by far, is chemical attack and the two most common chemical attack processes are sulphate attack and acid attack. In the wastewater industry, the acid attack mechanism or cycle is normally referred to as Microbial Induced Corrosion or MIC, and this TechNote focuses on this particular process. The photograph (below) of a wastewater treatment plant intake structure illustrates the significant impact MIC can have on concrete structures. The reinforcing steel (not clearly evident in the photo) was exposed in many wall locations indicating a loss of approximately 2” of concrete caused by MIC attack.

Household as well as certain industrial wastes contain organic matter that, if not kept cold will start to breakdown or biodegrade in a short period of time. This is a process by which bacteria eat and digest the organic matter and, as with all living things, produce waste. The bacteria in sewage typically produce two kinds of waste depending on the oxygen level of the water. The tendency is for such bacteria to produce sulfur-oxygen compounds called “sulfates”. However, if the water flow is such that there is not enough turbulence to get sufficient air into the water, all of the oxygen will be quickly depleted and the bacteria will instead form Hydrogen Sulfide as their waste product.

Hydrogen sulfide, in a natural room temperature state, is a gas and, while some will bubble out of the water, some, like carbon dioxide gas in soda, will also stay in solution in the water. If the water is shaken or disturbed much of the dissolved gas, again like soda, will be emitted as bubbles. Hence, in sewage systems that have areas of slow flow there will be a significant formation of hydrogen sulfide gas that will come out of solution and accumulate in areas of greater water turbulence as often seen in manholes, lift stations and the sewage entrance structures of wastewater treatment plants.

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There is a misconception that hydrogen sulfide gas, in itself, is corrosive to concrete. It is not and, on its own, will not affect concrete at all. However, being heavier than air, hydrogen sulfide will settle on the surface of the sewage water and, as well, be circulated around a structure's air filled cavity through convective currents. The hydrogen sulfide gas will then re-dissolve in the water of the slime that adheres to the concrete walls. In this solution the hydrogen sulfide forms a weak sulfuric acid that will both attack the concrete directly as well as lower the pH of the concrete surface from approximately pH 12.5 to pH 9. This allows a new strain of bacteria to grow on the nearly pH neutral surface.

This newly formed bacteria is called Thiobacillus and it is this bacterium that is the primary cause of MIC in concrete sewage structures. Thiobacillus bacteria consume hydrogen sulfide gas and excrete sulfuric acid as waste. As the environment becomes more and more acidic, lesser strains of this bacterium die out to be replaced by more aggressive strains. The 6th level or strain of bacteria is called Thiobacillus Thiooxadans and it can exist in an environment where the pH is as low as 0.5 which is equivalent to a 7% solution of sulfuric acid. This most aggressive strain of Thiobacillus bacteria is most commonly found in the upper areas of a structure. The diagram illustrates the effect of the process on a concrete pipe.

A Xypex treatment is an inexpensive, permanent way to protect concrete in acidic environments as low as pH 3 while also performing as a belt-and-suspenders, secondary line of defense in the highly acidic environments described above. The American EPA estimates that 95% of manholes have a pH environment of 3 or above and are therefore receptive to Xypex as a stand-alone treatment for both waterproofing and chemical protection. The remaining 5% of manholes, being in an even more aggressive environment would warrant both Xypex and some other level of protection against such highly aggressive MIC attack.

The production of hydrogen sulfide gas and the resulting MIC lowers the pH environment of many sewage structures. The Xypex treatment of concrete – as a coating on existing concrete or as an admix in precast and poured-in-place concrete – is an excellent way to waterproof these structures as well as provide a strong level of chemical protection against sulfuric acid attack.