Preliminary Investigation of the Role of Bacteria in Concrete Degradation

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Background

Various types of bacteria are commonly found in nature and are known to interact with inorganic materials in a variety of ways. Like any life form, their metabolic activity and by-products can chemically alter their surroundings. This has been well documented in the case of *Thiobacillus* species. Two common strains are the *Thiobacillus thiooxidans*, which oxidize sulfur as part of their metabolic cycle, and the *Thiobacillus ferrooxidans*, which oxidize iron. There has been some discussion in the literature regarding the occurrence of these bacteria (Covino, 1999) in transportation structures but in general, the role of bacteria in concrete degradation is not well understood. Acidophilic organisms are the most likely to cause damage in concrete and have been known to cause severe damage in concrete sewer pipes. In sewers, hydrogen sulfide, generated by anaerobic sulfate reducing bacteria, is transported to the wall and crown of the pipe, where the sulfur is oxidized to sulfuric acid. The acid then reacts with calcium hydroxide, destroying the concrete (Islander, 1999). Whether these organisms are viable and active in concrete roads and bridges is not known. There are reasons to suspect that bacteria or other organisms may be present in concrete structures but there are also reasons to doubt their presence. In support of their viability, evidence has been presented (Muethel 2001) that bio-organisms are present in concrete that has deteriorated prematurely. Additionally, at the pavement joint, the pH can typically be much lower than that of normal concrete due to carbonation and exposure to the groundwater. These conditions could provide local environments where bacteria and other microorganisms could be viable. Detracting from the possibility of bacteria being present in concrete, most aerobic bacteria require a low pH environment to flourish. Although they produce acid as a by-product, thereby maintaining a proper environment to live in, it is not known if concrete will buffer this acid and therefore raise the pH locally to the point where the bacteria are no longer viable. Also, microorganisms require a reduced form of sulfur, iron, or organic carbon as an energy source. These energy sources may be present in concrete, depending upon the materials used in batching the concrete. This would suggest that the choice of concrete constituents might play a role in providing a habitat for biological life. For example, blast furnace slag has significant quantities of reduced iron and sulfur, the latter in the form of oldhamite (CaS). The type of degradation that could result varies but one possible example is sulfate expansion as a result of oxidizing sulfur to sulfate. Additionally, if any bacteria do become viable, the localized reduction in pH by the bacteria itself will lead to acid attack of the concrete. Likewise, if ferrous iron is oxidized to ferric iron, the ferric iron will spontaneously oxidize any reduced sulfur to sulfate, possibly leading to expansion or dissolution of the aggregate, or degradation of the concrete cement paste. As for carbon, a number of sources are possible with one strong possibility being fly ash. The two key questions regarding microorganisms in concrete are whether these organisms can survive in concrete given its relatively high pH and if they can, do they contribute to concrete failure.