ABSTRACT

Cheng, Liqiu. Ph.D., Purdue University, May 2014. Microbial Biofilm Development on and Degradation of Concrete Surfaces. Major Professors: M. Katherine Banks and W. Jason Weiss

Microbially induced corrosion (MIC) may result in severe concrete deterioration and incur great financial cost for infrastructure maintenance especially in extreme environments. Biofilm consisting of sulfur-oxidizing bacteria (SOB) on wet concrete surface may produce biogenic sulfuric acid under certain conditions which leads to structural degradation. Determination of the specific deterioration process is limited due to the failure of current research methods to simulate microbial activity and lack of appropriate test methods to characterize bacterial interaction with concrete surfaces. This study explored the corrosion mechanism at both meso- and micro-scale.

Two identical biological simulation chambers were built using advanced sensors and controllers to automatically maintain the optical growth conditions for sulfur-oxidizing bacteria. Key elements were explored that limit MIC resistance of concrete specimens at a meso-scale. Twelve mixture designs varying in water to cementitious materials ratios (w/c), supplementary cementitious materials (SCM), cement type, aggregate type, and air content were used in the test. Sample appearance, surface pH, mass, dynamic elastic modulus, and surface profile were monitored periodically. The limited corrosion in the specimen suggests the damage was still at an early age. Future investigation with extended H_2S exposure time was needed to differentiate between mixture designs and further understand microbial development on the concrete surface.

A noninvasive, self-referencing microsensor technique was used to quantify real time changes of oxygen, proton and calcium flux for the *Thiobacillus* species biofilm developed on cement sample surfaces. This approach simulates a small-scale short term degradation scenario to provide more information of bacterial behavior during deterioration. Mixtures of different water/cement ratios, SCMs, cement types and the impact of anti-microbial chemicals were assessed. Results showed that specimens with different water/cement ratios had similar performance during MIC. Aluminum content in the mixture increased cement corrosion resistance. The use of anti-microbial admixture improved cement tolerance against deterioration. Increases in anti-microbial dosage and mixing time results in better anti-corrosion performance. The bacterial function and interspecies activity during corrosion process were assessed as well. Results confirmed the different behavior between acidophilic sulfur-oxidizing bacteria (ASOB) and neutrophilic sulfur-oxidizing bacteria (NSOB), and suggested that *T. intermedius* was similar to other *Thiobacillus* species while *T. novellus* served as an intermediate.