Project Summary

Texas Department of Transportation

0-6137: Prevention and Repair of Microbial Acid-Produced Attack of Concrete

Background

The Texas Department of Transportation (TxDOT) has approximately 50,000 bridges in its inventory and the deterioration of concrete under these bridge structures, most of which are reinforced, has been a critical issue affecting the service condition of these bridges. Recent research on deteriorated concrete pillars on bridges in Texas indicated that microbial colonization might be a factor promoting the surface deterioration of bridge pillars continuously exposed to water. The microbes present were found to be acid-producing and directly correlated with the degree of deterioration. Although microbial activities may be involved in the surface deterioration of these bridge pillars, it is not clear how severe the deterioration is and whether it is a significant contributor to the deterioration. Field and laboratory investigations are needed to identify the impact of microbial induced deterioration (MID) on TxDOT bridges.

The goal of this project was to identify the microbes degrading concrete, understand the mechanism of attack, evaluate methods for *in situ* and laboratory evaluation of MID and evaluate commonly used TxDOT concrete materials for MID resistance and provide recommendations for possible remedial actions.

What the Researchers Did

Researchers performed an extensive literature review focused on the mechanism of MID, test methods, factors that affect the corrosion generated by MID, and state-of-the-practice MID remediation methods.

Twelve selected TxDOT bridges with suspected MID issues were investigated. Visual inspection together with a number of *in situ* tests including rebound hammer, ultrasonic pulse velocity, covering thickness, half-cell corrosion potential and phenolphthalein pH analyses were performed to evaluate the integrity of the pillars under these bridges. Water, mud, core and surface concrete samples of pillars were also collected for laboratory analyses including microbial, chemical composition, mineralogy and petrographic analysis to investigate the potential cause and extent of the deterioration. Results from this comprehensive study were used to provide evidence of concrete degradation and ascertain the degree of deterioration caused by microbial attack.

The study also evaluated the effectiveness and consistency of various measurements used in this study and provided a suggested *in situ* and laboratory test procedure to identify microbial attack on concrete and evaluate the integrity of deteriorated concrete due to the attack.

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In addition, a preliminary evaluation of the microbial attack resistance of concrete containing different types of cement, supplemental cementitious materials (SCM) and coating agents was performed. A series of typical TxDOT concrete mixes were prepared and subjected to field and/or sulfuric acid solution exposure. Resistance against microbial attack from selected TxDOT mixes was evaluated.

What They Found

The present research shows that while visual inspection, nondestructive tests together with *in situ* phenolphthalein (pH) measurements provide a good indication of level of deterioration, laboratory analyses based on microbial, chemical, mineralogy and petrographic analysis can be used to further evaluate the severity of deterioration. The comprehensive inspection of the twelve bridges in this study indicated that despite the different levels of surface spalling observed, the deterioration of concrete mostly stays on the surface. Covering thickness measurements revealed sufficient concrete covers over existing reinforcements and the remaining concrete structures were still sound in general. The microbes identified on these bridge pillars are not comparable to those found in sewer systems. The deterioration observed in these structures is believed to result from the production of gypsum and ettringite from the biogenic release of sulfuric acid and dissolution of substituent in concrete (particularly C-S-H) due to the low acid environment that the concrete experiences over time.

The preliminary evaluation of the microbial attack resistance of typical TxDOT concrete materials indicated that mixtures with type V cement and SCM provide better resistance to MID. A concrete preservation treatment solution may also provide protection to the concrete and can be considered as a remediation method for deteriorated concrete.

What This Means

Results from this study could provide TxDOT with a better understanding of how significant is the issue of MID in TxDOT structures and the mechanism of microbial attack, together with insights into the factors that contribute to microbial degradation. Based upon results from *in situ* measurements together with microbial, chemical, mineralogy and petrographic analysis, considering the fact that most of the bridges visited were more than forty years old, rates of deterioration are slow and MID should not be considered to post an immediate threat to the integrity of these structures.

In addition, the suggested *in situ* and laboratory test procedure can be used to identify microbial attack on concrete and evaluate the integrity of deteriorated concrete due to the attack, which would be helpful in determining concrete structures that might be susceptible to failure and appropriate for remediation. The study of microbial attack resistance of concrete with different materials and mix design will also point toward improved measures to prevent and remediate microbial attack.

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