Florida Department of Transportation Research

Feasibility of Atomic and Molecular Laser-Induced Breakdown Spectroscopy (LIBS) to In Situ Determination of Chlorine in Concrete

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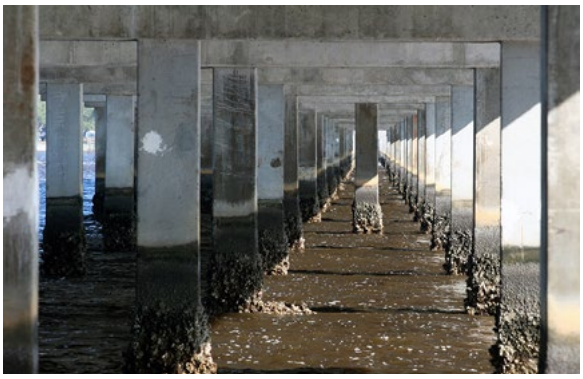
Current Situation

One of the most serious threats to Florida's extensive coastal transportation infrastructure is the invasion of steel-reinforced concrete structures by chloride ions. These corrosive ions occur in high concentrations in seawater or sea spray. If the chloride penetrates the concrete and attacks the steel, the steel will be weakened and eventually destroyed. The expansion of the corroding steel can crack or spall the surrounding concrete. The Florida Department of Transportation (FDOT) employs several methods to assure the integrity of concrete structures and constantly seeks new and useful additions to its monitoring toolkit.



Pilings that support the Ochlockonee Bay Bridge are constantly exposed to seawater with its high level of chloride.

Research Objectives

In this project, University of Florida researchers investigated the use of a novel method of detection of chlorides in cement.

Project Activities

Laser-induced breakdown spectroscopy (LIBS) uses a laser to transform the atoms and molecules in a sample of interest to a plasma, which emits characteristic patterns of light that can be interpreted to determine not only the constituents of the sample but also the amount of those constituents. Conceptually, LIBS can be conducted on any type of sample, but the specifics require careful experimentation and setup. To develop the proper technique for determining the concentration of chloride ions in concrete, the researchers tested a number of possible LIBS approaches, including a variety of lasers, different configurations of the test equipment, and both single- and double-pulse methods.

One of the challenges of the project was to find the most useful wavelengths for determining the presence and concentration of chlorine in the samples. The scientific literature provided information indicating that the chlorine line at 837 nm would be useful. However, this study found that the chlorine line at 479.5 nm provided a better level of accuracy and detection. The signature of the molecule CaCl (836 nm) was also investigated.

Numerous samples for investigation were supplied by FDOT and the Federal Institute for Materials Research and Testing (known by the German acronym BAM) in Berlin, Germany, where a mobile LIBS method is being developed that could allow this technique to be used to investigate structures in the field. Once methods are refined in the laboratory and a practical LIBS field method is developed, the in situ determination in the title will be a reality.

Project Benefits

The methods developed in this project promise to add another tool to the FDOT toolkit for inspection of concrete structures in coastal environments. Additional monitoring tools offer the ability to detect trouble spots earlier and address maintenance issues when they are easier and less expensive to treat. This LIBS technique will offer a better mechanism by which FDOT will be able to predict the remaining service life of existing structures.

For more information, please see dot.state.fl.us/research-center