Florida Department of Transportation Research

Durability Evaluation of Ternary Mix Designs for Extremely Aggressive Exposures - Phase II

June 2021

Project Number
BDV31-977-100

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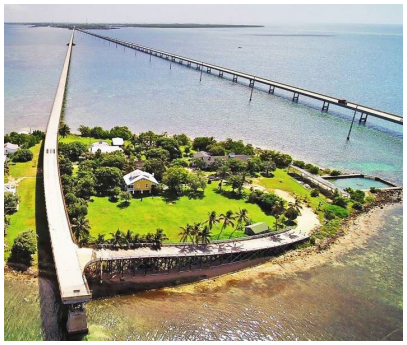
Current Situation

Steel-reinforced concrete is widely used in Florida bridges, which face the possibility that moisture will penetrate the concrete, corrode the steel, and weaken the structure. Coastal bridges also face salt water and its chloride ions that are a potent promoter of steel corrosion. Supplementary cementitious materials (SCMs) that are added to concrete to improve its strength and durability have been shown to reduce chloride penetration, but proving this effect requires complex laboratory testing. Rapid test methods are needed to demonstrate the benefits of concrete made with SCMs to facilitate approval of concrete mixes for construction projects. Surface resistivity measurements have been used, but the microscopic spaces in concrete – the pore structure – harbor a liquid that can affect these measurements. A method is needed to measure both surface resistivity and pore solution effects.



Coastal Florida bridges both large and small are vulnerable to chloride penetration and corrosion.

Research Objectives

University of Florida researchers determined whether tests for resistivity can also be used to quantify the formation factor, which is related to concrete's pore structure, and then be used to qualify concrete containing SCMs for construction projects.

Project Activities

The researchers conducted chloride binding tests on 38 concrete mixes, matching the series used in Phase I of these studies (BDV31-977-65). Chloride binding tests were conducted on cured concrete made from these mixes in order to distinguish between bound chloride in concrete and chloride retained in pore solution. The formation factor was calculated for the mixtures tested as a parameter that accounts for the solution composition in the pores. Samples were cured for pore solution measurement using several temperature-time programs and then subjected to numerous tests. Pore solution was removed from concrete using a hydraulic press and tested for resistivity by multiple methods. The researchers developed an equation that related pore solution resistivity to concrete mix properties better than standard equations.

Tests were also conducted to determine sulfate resistance of concrete mixtures. Samples submerged in sulfate solution for periods up to two years showed a moderate correlation between the formation factor and expansion of the samples, an indicator of corrosion.

In field work, six piles were constructed and placed in salt water: one control made from portland cement only and five containing SCMs. Pile cores were tested for electrical resistivity, water absorption, and chloride bulk diffusion. Chloride penetration measured on core samples placed in a chloride tank corresponded well with laboratory results.

The researchers recommended continued use of resistivity measurements to qualify concrete mixes and to continue research to clarify the complex role of pore solution. Specific recommendations included resistivity acceptance criteria and SCM content limitations.

Project Benefits

The results of this project will help to improve the concrete mixes used in Florida bridges as well as providing more accurate means of testing for chloride penetration resistance

For more information, please see www.fdot.gov/research/.