Florida Department of Transportation Research

Durability Evaluation of Ternary Mix Designs for Extremely Aggressive Exposures

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Current Situation

Many transportation structures are built using steel-reinforced concrete. The integrity of these structures, especially those that are exposed to salt water, depends on the concrete's resistance to ion migration through its pores, degrading the concrete and corroding the steel reinforcement. The surface resistivity test is currently specified by the Florida Department of Transportation (FDOT) for determining the durability of concrete mixtures in aggressive chloride environments, but concerns have been raised as to whether this test adequately predicts durability.

Research Objectives

University of Florida researchers tested a variety of concrete mixtures using the surface resistivity test and several other tests to determine how well surface resistivity measures concrete resistance to water and ion penetration. They examined the underlying theory of the tests and compared the results of the various tests to understand their implications for concrete durability.

The concrete in this coastal bridge must withstand exposure to salt water for decades.

Project Activities

The researchers conducted a literature review on concrete ion penetrability, the effect of mixture proportions on concrete ion penetrability, and test methods to measure the concrete resistance to ion penetrability. Eight tests were selected: surface resistivity; bulk resistivity; rapid chloride permeability test; rapid chloride migration test; water permeability; concrete water absorption rate; mercury intrusion porosimetry; and concrete volume of permeable voids. Additional testing was selected to determine general concrete properties.

The literature review also included investigation of concrete mixtures and additives – "ternary mix" means that concrete samples were prepared with Portland cement, aggregate, and a third component called a supplementary cementitious material (SCM), which might be fly ash, slag cement, silica fume, metakaolin, or a combination of these. Based on findings from the literature review, the researchers designed 38 mixes to be tested in the project.

Materials for concrete mixes were sourced and characterized before mixing. Fresh concrete was tested by standard methods, including for example the slump test and air content measurement. Concrete cylinders were cast as test samples for general testing, but several test required special sample preparation. After appropriate curing periods, the concrete samples were tested using the selected tests.

The preliminary testing conducted in this project indicated a good correlation between surface resistivity and other measures of concrete's susceptibility to ion penetration. A second phase of testing will re-examine the samples to determine any change in concrete properties over a longer time period.

Project Benefits

Accurate predictions of the durability of concrete mixes is critical to understanding new concrete mixes and ensuring the performance of concrete structures.

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