Florida Department of Transportation Research

# Chloride Diffusivity and Resistivity of Cured and Mature Binary/Ternary Concrete

May 2019


**Project Number**
BDV27-977-09

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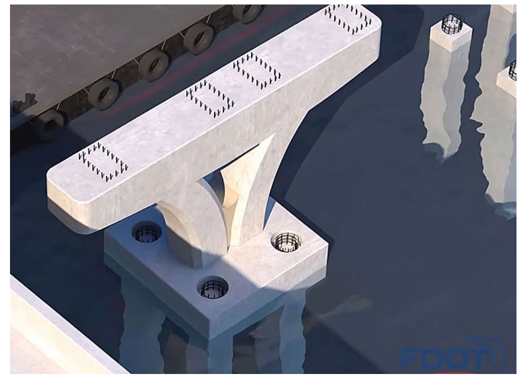
## Current Situation

Concrete structures in marine environments are constantly exposed to salt. Over years, the chloride ions in salt can migrate through concrete and cause the steel that reinforces the concrete to corrode, causing cracks that let in more chloride ions, further weakening the structure. Understanding how fast chloride ions migrate through concrete is important for finding the most chloride-resistant concrete blends and for estimating the service life of steel-reinforced concrete structures. The migration of ions through concrete is slow, and it can take years for enough chloride ions to build up near the steel to initiate damage. However, during those years, for some compositions, the migration rate decreases, thus possibly extending the time until corrosion begins. Further complicating the situation are additives, such as fly ash or slag, that can change the diffusion rate of chloride ions.



*Steel reinforcement of concrete bridge components is shown in this rendering of a support column for the Pensacola Bay Bridge, now under construction.*

## Research Objectives

Florida Atlantic University researchers examined chloride diffusion rates using field and laboratory specimens and for several concrete mixes. They studied how supplementary cementitious materials affect the change in diffusion rates over time.

## Project Activities

Concrete cylinders were prepared in 2016 for this project, but the researchers had access to concrete samples prepared in 2010, 2011, and 2012, which were composed of either limestone or granite aggregate, and various proportions of cement, fly ash, and slag. The ratio of fine aggregate to coarse aggregated varied within narrow bounds. Four compositions of the same materials were used for the specimens prepared in 2016. The specimens were divided into groups which were exposed to different conditions for several time periods. The specimens were subjected to a variety of preconditioning exposures, including elevated temperatures, calcium hydroxide solutions, and high humidity. Companion specimens were subjected to simulated field conditions for a few months up to a few years. Actual field samples were also cored and examined as part of Florida Department of Transportation project BDK79-977-03.

A variety of tests were performed, including surface resistivity, rapid migration, bulk diffusion, chloride content, sorptivity, density, absorption, and examination for voids in the concrete. These tests were used to calculate diffusion ($D_{nssd}$) and migration ($D_{nssm}$) coefficients. The wide range of samples, exposures, and testing provided an equally wide range of results for comparison and a broad picture of chloride diffusion and related properties in concretes of various compositions.

## Project Benefits

The improved understanding of chloride migration in concrete provided by this project can be used to update models used to estimate time to corrosion and provide better guidance for inspection schedules. A better understanding of long-term performance based on early characterization of concrete samples was also developed.

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