



## Project Number

BDV29-977-43

## Project Managers

Ron Simmons

*FDOT Materials Office*

## Principal Investigator

Kingsley Lau

*Florida International University*

## Florida Department of Transportation Research

# Development of Standard Methodology to Measure Sulfate Ions in Post-Tensioned Grouts

May 2022

### Current Situation

In post-tensioning, steel cables placed in plastic ducts in precast concrete components are tightened after the concrete has set. The tubes are backfilled with grout and sealed to protect the steel against corrosion, a serious concern in Florida's humid and coastal environments. These methods can effectively exclude external sources of corrosion such as chloride ions from sea water, but if the grout is deficient in some way, for example, if prepared with too much water, some of the natural mineral sulfate in grout becomes free sulfate ions that can migrate through the grout to the steel cables and initiate corrosion. Setting sulfate limits for grout would be useful, but this requires good testing methods. Because there are many mechanisms and conditions which influence conversion of mineral sulfate to free sulfate ions, it is difficult to design testing methods that do not also change the sulfate concentration in grout.

### Research Objectives

Florida International University researchers identified mechanisms by which sulfate ions move through grout and identified the effects of grout sampling methodologies for deficient grouts.

### Project Activities

Test specimens were prepared from both fresh and expired grout products using 10% more water than recommended. Grout samples were injected into inverted tee (INT) and modified inclined tube (MIT) setups. Test conditions included the amount of moisture absorbed during storage (prehydration), the height of the column into which the grout was pumped, and the effect of a constricted injection channel. Grout was cured for 28 days, and then, to measure sulfate stratification, the columns were sectioned, the sections were crushed, and sulfate was extracted. Six leaching methods were used to assess the effect on sulfate measurements of leaching heating, heating time, leaching volume, grout sample mass, and drying temperature.

Stratification and accumulation of sulfate ions varied widely among the grout products. Excess mix water and prehydration promoted development of grout deficiencies, including the accumulation of sulfate ions, even without external sulfate ion sources. Sulfur content in the raw grout products correlated poorly to sulfate ion stratification. Constriction had little effect on sulfate ion accumulation, but additional moisture enhanced sulfate ion mobility.

Corrosion measurements of the steel embedded in the grout sections were correlated to the grout sulfate content, showing values consistent with earlier research and further verifying the adverse effects of elevated sulfate ion concentrations in segregated grout.

The expired grouts developed the highest sulfate ion concentrations and showed the greatest susceptibility for corrosion development. Therefore, the researchers recommended testing grouts for sulfate levels to assess the susceptibility of grout materials to stratification. Further, they recommended extraction of grout from locations typically associated with moisture and/or bleedwater such as at high points, points of deviation, and joints.

### Project Benefits

The methods developed in this project can help reduce the repair and maintenance of pre-tensioned concrete structures and help assure that they fulfill their designed service life.

*For more information, please see [www.fdot.gov/research/](http://www.fdot.gov/research/).*



*The Broadway Bridge in Daytona Beach is one of many made possible by post-tensioning.*