ABSTRACT

Spragg, Robert Paul. Ph.D., Purdue University, May 2017. Development of Concrete Performance Specifications That Include Formation Factor. Major Professor: Jason Weiss.

This dissertation is broken into two distinct parts: the advancement of resistivity testing to evaluate microstructure through evaluation of a materials formation factor and the development of performance ranges based upon variations in acceptance quality characteristics for concrete pavements.

The first part investigates resistivity testing, and highlights how water-cured specimens undergo a phenomenon known as alkali leaching making it difficult to understand the pore solution in a porous material. This leaching can be described using a diffusion approach, but can have large impacts on the pore solution and ultimately the measured concrete resistivity. To this end, curing in lime-water or tap water is not advised when measuring concrete resistivity to evaluate the quality of the pore network, and sealed curing is preferred because it reduces leaching. Once the pore solution properties are known, and electrical test can be used to calculate a formation factor. A microstructural material property related to the fluid-filled phase and its connectivity. The research shows how it can be linked to both a measure of resistivity (that can be conducted easily) and serve as an input to life-cycle models. This is beneficial, as concrete specifications can be developed that specify a formation factor based upon the desired level of performance (time to corrosion using a diffusion approach), but whose compliance can be measured using a simple resistivity test. Furthermore, the study highlights findings from a multi-laboratory study on the typical values of formation factor that are achieved by a wide range of mixture designs from across the United States. This will help in guidance for

practitioners on steps they can take to achieve the desired formation factor for their application. Furthermore, a summary of best practices based upon the lessons learned from this multi-laboratory study is presented.

The second part of the dissertation investigates variation in concrete pavements and how variation can influence service life costs. Variation in previous acceptance data from forty-three recently constructed concrete pavements are evaluated, with goal of informing typical variations levels that should be specified in acceptance procedures. Particular emphasis is placed on the testing variation, with caution that variation levels below testing variation should not be specified. The Mobile Infrastructure Testing Laboratory was used to visit on-going construction operations to gather data for typical levels of variation associated with durability tests that are making their way into pavement specifications around the country.

Lastly, this dissertation investigates how variations in acceptance quality characteristics, specifically strength and thickness, influence life cycle costs. It is shown that increases in variation in acceptance quality characteristics result in similar average life cycle costs but drastically increase the life cycle cost standard deviations. A methodology to incorporate life cycle cost standard deviations into pay adjustment factors are shown, providing a way for a specifying agency to develop specifications that are based upon average and the variation levels in acceptance quality characteristics and provide incentives and disincentives at the time of construction based upon estimated performance.