TECHSUMMARY December 2019

LTRC Project 19-01TA-C

A Review of the Louisiana Department of Transportation's Structural Concrete Specifications in Response to House Resolution No. 309

INTRODUCTION

The latest infrastructure report card from the American Society of Civil Engineers (ASCE) has determined that the U.S. civil infrastructure is poorly maintained with insufficient funds to improve roadways and bridges throughout the nation, earning a D+ grade. From the nation's bridge infrastructure, more than one-fourth of all bridges are over 50 years old, the average design-life of a bridge. In addition, 38 percent of the nation's 616,087 bridges need repairs, of which 47,000 have been rated as structurally deficient by the Federal Highway Administration (FHWA). These compromised bridges are crossed by America's drivers 178 million times a day. The state of Louisiana ranks second in the nation for the number of structurally deficient bridges based on bridge deck area.

The leading cause of premature degradation of bridges has been attributed to corrosion. The National Association of Corrosion Engineers (NACE) estimates that the annual direct cost of corrosion for highway bridges is approximately $13.6 billion. As infrastructure continues to deteriorate, the cost of maintenance and repair increases accordingly, where the backlog of rehabilitation projects for the nation's bridges has been estimated at $123 to $171 billion. As such, there is a pressing need to design and construct more durable civil infrastructure. With concrete structures in particular, this can be achieved by giving special attention to concrete's transport properties. It is well recognized that concrete's durability is controlled by permeability or diffusivity, which measures the ability of ions and fluids to move through the material.

When considering permeability in concrete, the properties of portland cement concrete (PCC) relating to chloride ion penetration are of particular concern to owners, designers, and materials engineers. The penetration of chloride ions can negatively affect the durability of PCC pavements and structures by (a) corroding the steel reinforcement, (b) affecting the chemical/electrical balance within concrete, and (c) inducing premature deterioration in concrete. Thus, it is imperative to develop concrete that strongly resists chloride penetration to extend the service life of PCC pavements or bridge structures. In order to effectively measure chloride permeability, electrical test methods have been developed to provide a rapid indication of concrete's resistance to the chloride penetration including the ASTM C1202/AASHTO T 277 rapid chloride permeability test (RCPT), the AASHTO T 358 surface resistivity test, and the AASHTO TP 119/ASTM C1760 bulk resistivity test. These test methods have been developed by correlating the electrical conductance of concrete with long-term chloride ponding exposures such as those described in AASHTO T 259 or ASTM C1556.

As a state highway agency (SHA), DOTD aims to develop concrete materials specifications that can deliver higher performance and longevity. Surface resistivity measurements have been required by DOTD specifically for structural concrete applications since 2013, and the

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most recent standard specifications for roads and bridges released in 2016 included a surface resistivity requirement as a pay item. Besides Louisiana, Florida and Kansas require surface resistivity results for certain classes of structural concrete mixture design approvals. At least 12 other departments of transportation (DOTs) are in the process of adopting similar requirements for the acceptance of mixture designs.

OBJECTIVES

The objective of this report is to respond to the inquiries stated in House Resolution No. 309. Specifically, this report addresses the reliability of the surface resistivity test method, the cost-effectiveness of the method for developing concrete, construction time period requirements, and the expected long-term benefits resulting from the implementation of the surface resistivity specifications.

SCOPE

The scope of work includes a review of the concrete materials specification developed by DOTD. Specifically, the material requirements pertaining to the surface resistivity of structural concrete are examined. The effectiveness of the test method, and the implication of requiring such a test method for the approval of structural concrete for transportation infrastructure is discussed.

RESEARCH APPROACH

DOTD implemented the surface resistivity test method for acceptance of structural concrete in its standard specifications for roads and bridges in 2016. In response to the House Resolution No. 309, this document discusses the reliability of the test method for measuring resistivity, the cost-effectiveness of the method for developing concrete, construction time period requirements, and a life-cycle cost assessment as a result of the specification changes.

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this report was to review the DOTD materials specifications, focused particularly on the implementation of surface resistivity requirements for structural concrete. A comprehensive literature review was conducted on concrete durability, which unequivocally relates concrete's transport properties (measured through permeability, absorption, or diffusion) to its durability. The more susceptible concrete is to the penetration of aggressive fluids or ions, the more likely premature deterioration will take place. As such, it is imperative to measure the transport properties of concrete for quality control purposes.

Several test methods used to measure permeability, water absorption, or concrete's susceptibility to chloride ion penetration were reviewed for potential adoption in Louisiana's specifications for roads and bridges. Based on the literature search, surface resistivity remained consistently regarded as one of the most reliable and efficient methods to characterize concrete's chloride ion penetrability rating. Indeed, its reproducibility, ease of use, and rapid test time made it a highly desirable test method to adopt for the acceptance of structural concrete. In addition, DOTD and industry contractors benefited from the implementation of surface resistivity as a test method for quality control as it yielded significant cost savings per sample.

The Department recently made several changes to specifications that include the use of surface resistivity. First, all structural concrete applications that require high early strength concrete have had the surface resistivity requirement removed. This is due to the very high degree of difficulty of meeting both the surface resistivity and high early strength requirements.

A note has been added to the master proportion table noting that when a Class A1 concrete (structural) is substituted for a Class M (minor structure) concrete, the resistivity requirements are removed. This is due to the Class M concrete not requiring surface resistivity for acceptance.

Additionally, the Department is considering changing how the penalties for failure to meet surface resistivity are applied. As new corrosion resistant reinforcement materials come onto the market for use, DOTD will re-evaluate the current long-life structural concrete strategy and perform a cost-benefit analysis utilizing the new materials with a reduced demand for surface resistivity.

A review on the bid pricing history of structural concrete since DOTD's implementation of the surface resistivity requirement determined that the cost differences are no more than 4 percent greater, and with no reported delays in construction time. Lastly, a preliminary life-cycle cost assessment of a bridge deck evaluated the expected long-term benefits from the adoption of the surface resistivity requirement. The results showed that when the produced concrete exceeds the surface resistivity requirement, the expected service life increases significantly and therefore reduces the frequency of major maintenance and repairs, leading to 86 percent in cost savings to the Department.