EXECUTIVE SUMMARY

The evolution towards performance-based specifications that is beneficial to the ready mixed concrete industry is constrained to some extent with the availability of a reliable test method that is an indicator of the permeability of concrete. This requirement is important for concrete subject to exposure conditions that can cause deterioration due to penetration of water and dissolved chemicals that impact the durability and prolonged service life of concrete. The current way of specifying for durability is to impose a maximum w/cm limit on concrete. This is not verifiable and does not recognize the significant benefit provided by supplementary cementitious materials (SCMs). A commonly used electrical test, referred to as the rapid chloride permeability (ASTM C1202) is more expensive, has deficiencies, and subject to error by less proficient testing agencies. The risk of rejecting acceptable concrete is high.

A promising electrical test method that predicts the permeability of concrete is to measure the resistivity of concrete and is gaining increased acceptance. The method is easy to perform, non-destructive, and can be measured on strength test specimens before those are broken. However, there are significant differences in the measured resistivity depending on how the specimens are cured and conditioned before measurements are obtained. The primary factors that impact resistivity include the resistivity of the solid portion, the resistivity of the pore solution that depends on the chemical species dissolved, and the degree of saturation of the test specimen. Another important requirement for the use of this method is that it should characterize concrete mixtures consistently with our understanding of reduced permeability.

In this research study, four types of air-entrained and non-air-entrained concrete mixtures with different SCMs – fly ash and slag cement – and at varying w/cm were evaluated. Test specimens were cured and conditioned, typically for 56 days, by several different methods that included sealing specimens without exposure to external moisture, immersion in saturated lime water, immersion in a solution that mimics the composition of typical concrete pore solutions, and several other variations. Two types of resistivity measurements were performed – surface resistivity measured along the circumference of cylindrical test specimens, and bulk resistivity measured parallel to the axis of the cylinders. Test specimens included typical 4 by 8-in cylinders and 2 by 4-in slices from cylinders. The degree of saturation of test specimens was determined to evaluate its impact on resistivity measurements.

This study indicates that measuring the resistivity of concrete is a reliable test method to predict its permeability property and potential durability. Characterization of mixtures is similar to expectations of reduced permeability. The variability of the test is considerably lower than that seen for RCPT. The bulk resistivity is the more robust measurement with reduced variability compared to measuring surface resistivity. It is recommended that a single curing/conditioning method and test age be established by agencies using this test for determining the acceptance of concrete. While the preference in the currently written standards is to cure/condition test specimens in a carefully composed simulated pore solution, this research identified some potential problems with this option. These include a lower measured resistivity (indicating a higher level of permeability), difficulties with obtaining a stable reading, and potential problems with preparing this solution to the required accuracy by testing agencies. The research also observed a significant effect of saturation of concrete in providing an incorrect assessment of concrete and could potentially accept unacceptable concrete. The final suggestion of this work is to cure

and condition test specimens in saturated lime water for 56 days. This method has been traditionally used for strength specimens and testing agencies are familiar with it. It also recognizes that the test age may need to be extended for some of the slower reacting SCMs or an accelerated curing procedure could be used. It also indicates that the resistivity of test specimens conditioned in simulated pore solution will be unstable and more variable and suggests a wash process of test specimens before measurement to achieve stable and consistent results. The results of this research can be used to develop improved testing protocols for improved reliability of results to predict the potential durability of concrete and can be used as an alternative to w/cm in industry codes and standards for more optimized concrete mixtures.