SOUTHERN PLAINS TRANSPORTATION CENTER

HIGHLIGHTER

SURFACE RESISTIVITY TESTING FOR QUALITY CONTROL OF CONCRETE MIXTURES

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PROJECT TITLE
SURFACE RESISTIVITY TESTING FOR QUALITY CONTROL OF CONCRETE MIXTURES

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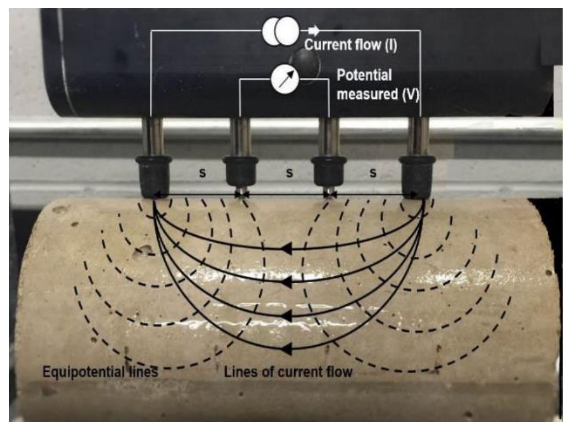
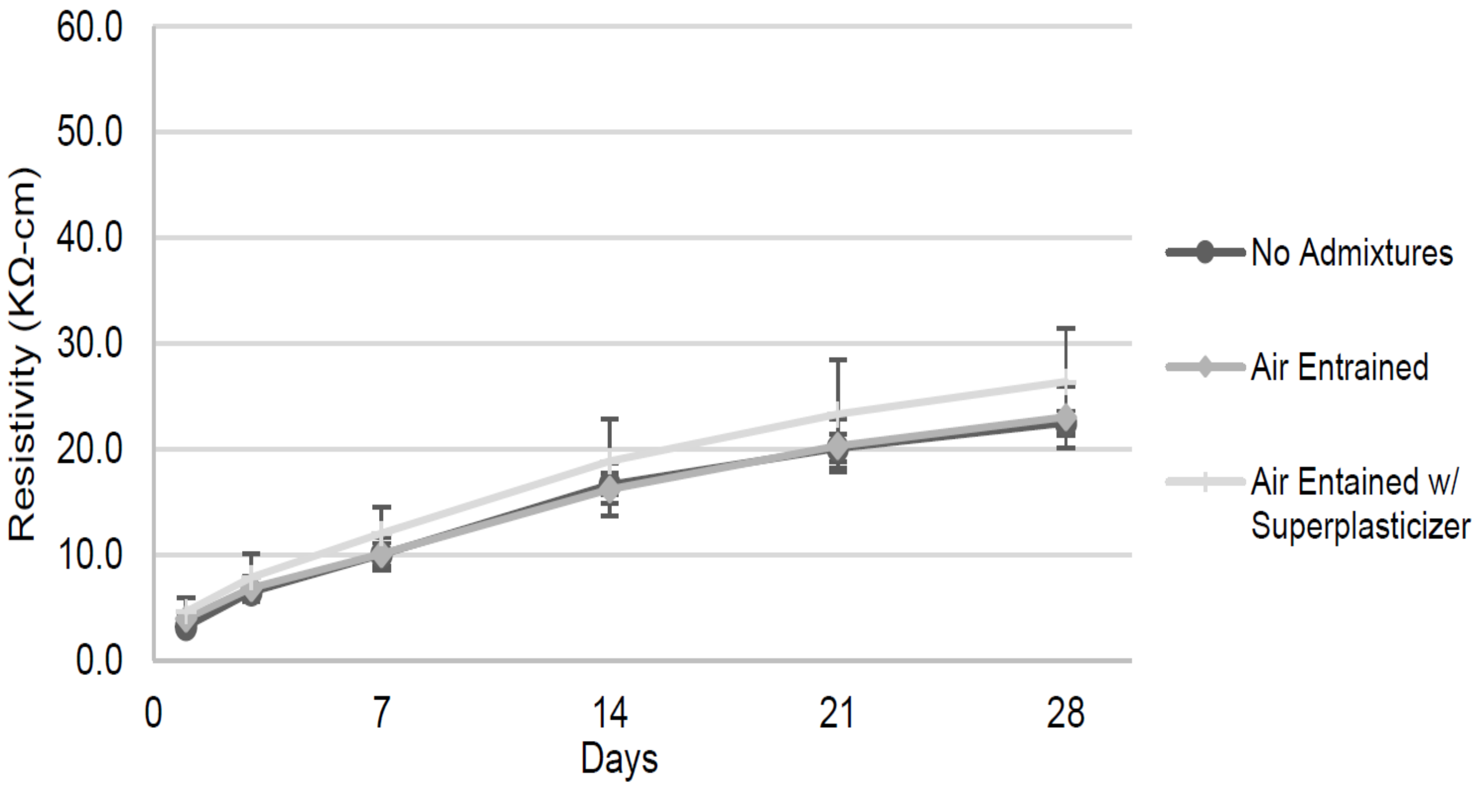
OVERVIEW Several properties of fresh and hardened concrete are routinely tested to verify the quality of the construction material indicative of certain mixture ingredients or properties; however, there is still a level of uncertainty when it comes to validating water-to-cement ratio (w/c) or the presence of beneficial supplementary cementitious materials. Both these parameters are prescribed to attain a required level of durability in accordance with an exposure class. Thus far, there is no simple utilitarian test method which can assess such parameters within a routine quality control and assurance program.

RESULTS This study investigated the potential of resistivity testing in assessing key mixture design parameters critical for durability performance of concrete mixtures. The methodology enabled the development of a procedure based on resistivity criteria to identify the water-to-cement ratio of a given mixture whether the mixture contains a certain type of supplementary cementitious material, as illustrated in the photo. The procedure is based on the Wenner probe method initially developed for geotechnical purposes. First, the four water saturated probes are placed on the surface of a concrete cylinder (along its longitudinal axis). The two outer probes produce a small alternating current traveling through the concrete medium. Meanwhile, the two inner probes connected to a voltmeter measure the voltage response to current flow. The measuring device will display the apparent resistance of the concrete cylinder tested. It is determined from the measured voltage and knowledge of current amplitude, probe spacing, and specimen dimensions. To determine the true resistivity of the concrete, the value recorded can be factorized to compensate for specimen geometry by multiplying the value with a factor based on a ratio of the sample's cross-sectional area to its length.



The study performed an experimental parametric investigation to determine the time-resistivity behavior of typical concrete mixtures used in pavement and infrastructure construction and to determine the efficacy of resistivity testing in differentiating key mixture components. It was found that resistivity testing is sensitive to water-to-cement ratio, with some exceptions, and sensitive to supplementary cementitious replacement. The results will aid in the development of a new quality control and assurance criteria for concrete mixture approval in addition to currently used test methods and specifications.

Unlike mixtures prepared with silica fume, the addition of admixtures seem to have a beneficial impact on the resistivity for slag cement concrete mixtures. Reported in Table 3-8, the presence of a high range water-reducer significantly changes the results outcome. The addition of a high-range water reducer resulted in a percent difference of 8.0%, 17.1%, 8.1% for mixtures of 0.40 w/cm (illustrated in the following graph), 0.45 w/cm and 0.50 w/cm respectively. This behavior is also seen for the fly ash mixtures but to a lesser extent. Again, the low COV obtained could have overshadowed the comparative analysis or, there is truly a slight gain in resistivity for mixtures containing a water-reducer. Here, the effects of grain dispersion provided by the admixture may have an impact on increasing the measurement by permitting an increased in reaction kinetics. This beneficial aspect of water-reducers has been reported for other properties of concrete such as compressive strength. However, due to the limited sample size investigated, further research into this concept must be carried-out to determine the repeatability of this outcome at different admixture dosage ratios.



Comparison of addition of admixtures for mixtures prepared with Type I cement, 40% slag cement and 0.40 w/cm

In terms of chloride ion permeability classification as prescribed in AASHTO 358, looking at the resistivity value alone on a given day (e.g. 28), may not be an adequate parameter for evaluating the durability performance of a concrete mixture design. The benefits of slag cement mixtures (SCM) addition, like fly ash, have been well demonstrated in the industry; however, their potential is not demonstrated within a 28-day curing period. Depicted in this study, the resistivity value increases in time for mixtures containing SCMs and it has been recommended to determine a more realistic resistivity potential of a mixture at a later age (56 to 91 days); thus, early-age testing may not be adequate for the purpose of classification of mixtures.

POTENTIAL BENEFITS The tools and evaluation methodology are practical for DOT's to perform as part of a quality control / quality assurance program. A meaningful method of evaluation has been developed including resistivity gain for early age assessment critical for durability performance of concrete mixtures. The results in this study demonstrates this potential for identification of mixture design parameters. The presence and potential content of SCMs can be distinguished based on the trend in resistivity gain in time and its 28-day value.