LOUISIANA TRANSPORTATION RESEARCH CENTER
LTRC

TECHSUMMARY *January 2021*

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Influence of Internal Curing on Measured Resistivity

INTRODUCTION

State highway agencies (SHAs) have begun to implement more internally cured concrete (ICC) mixtures in the design and construction of pavements and structures. Internal curing provides moisture throughout concrete after setting by utilizing agents such as pre-wetted lightweight aggregates (LWAs). Internal curing has been shown to extend hydration, improve performance by increasing the reaction of supplemental cementitious materials (SCMs), and ensure sufficient curing occurs in mixtures. By prolonging hydration, this process also mitigates the negative effects of autogenous and plastic shrinkage, as well as self-desiccation.

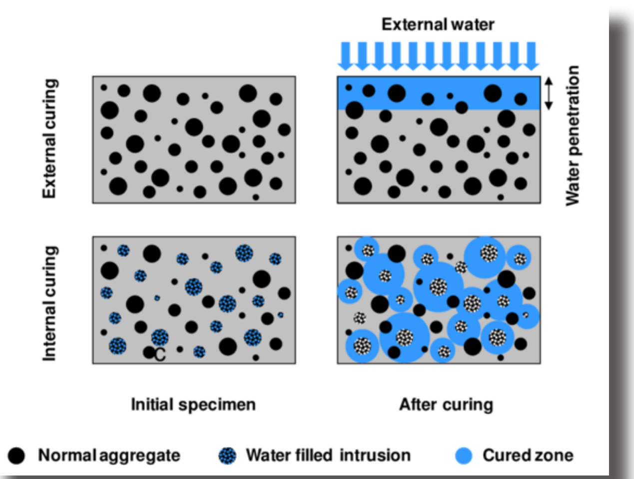

Figure 1. Differences between external curing and internal curing provided by pre-wetted LWAs

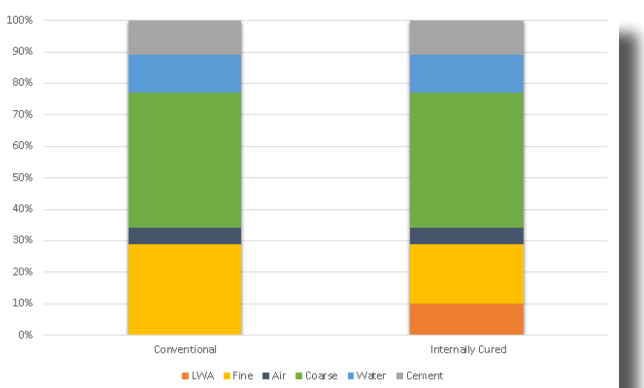

Figure 2. Example of volumetric mixture proportions of both conventional and ICC concrete

As SHAs are increasingly looking to adopt performance-based specifications (as opposed to prescriptive ones) to improve the durability of concrete infrastructure, there is a need to understand the effect of LWAs on concretes transport properties, particularly when measured through surface resistivity. In recent years, several SHAs have begun requiring surface resistivity results for the approval of structural concrete mixture designs. However, there is limited information regarding the effect of saturated LWA on surface resistivity. As such, this study seeks to further analyze the effects of internally cured concrete on concrete's surface resistivity over time by identifying effects of coarse aggregate, water-to-cementitious (w/cm) ratios, LWA source, and variations of SCMs.

OBJECTIVE

The objective of this study was to analyze the effects of internally cured concrete on concrete's surface resistivity over time by identifying effects of coarse aggregate, water-to-cementitious (w/cm) ratios, LWA source, and variations of SCMs.

METHODOLOGY

Surface resistivity was measured per AASHTO T 358 for all samples at days 7, 14, 28, 56, 90, and 180. Concrete cylinders of 100 mm x 200 mm (4 in. x 8 in.) in dimension were prepared per ASTM C192 for this study. Once the samples were cast, they remained in the cylinder molds for 48 hours before demolding to simulate the worst-case scenario allowed by specification for field

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cast cylinders. After demolding, the samples were placed in a 100 percent relative humidity room until testing. Fresh concrete properties such as slump were evaluated following ASTM C143 standards, and compressive strength tests were conducted per ASTM C39 once concrete reached 28 days of age.

Concrete Mixture Design

The influence of internal curing on concrete's surface resistivity was evaluated by taking into account the following variables: lightweight aggregate (LWA) source, coarse aggregate type, water-to-cementitious (w/cm) ratio, and supplementary cementitious materials (SCMs). Three sources of LWAs were selected (namely, from Texas, Alabama, and Louisiana) and featured different absorption values. Pre-wetted LWA was added to the concrete mixture design by replacing a portion of fine aggregate with 148 kg/m3 (250 lb/yd3) on a volume-to-volume basis. The LWAs were soaked in water for 72 hours prior to usage in concrete. Moisture corrections were done for LWAs by following the centrifuge procedure. Control specimens with no LWAs were used for comparison.

Four different combinations of cementitious materials were evaluated using Type I portland cement, Class C fly ash, and grade-100 ground granulated blast furnace slag. Specifically, samples were prepared using (a) 100% Type I portland cement (100TI); (b) 70% Type I portland cement and 30% Class C fly ash (70TI-30C); (c) 50% Type I portland cement and 50% grade 100 ground granulated blast-furnace slag (50TI-50S); and (d) a ternary mix of 30% Type I portland cement, 30% Class C fly ash, and 40% grade 100 ground granulated blast-furnace slag (30TI-30C-40S). In addition, three different types of coarse aggregates were tested to analyze their influence on surface resistivity as well, all with a No. 67 gradation. The concrete used a 60/40 coarse to fine aggregate ratio. Lastly, a superplasticizer was used to ensure workability. A total of 96 mixtures were produced for this study.

CONCLUSIONS

Based on the results of the analysis, the following findings and conclusions may be drawn:

- The slump test results showed that a majority of zero-slump concretes were observed with samples containing LWAs. While a lower workability can be expected when using LWAs for internal curing, modest increases in super plasticizer dosage are recommended to improve the workability without altering the w/cm ratio.
- The compressive strength tests showed that in most cases, the presence of lightweight aggregate had a positive effect on strength (i.e., similar or better strength). Few exceptions were observed where LWAs had lower strengths than the control specimens, most notably within the ternary mixtures.
- With respect to surface resistivity, the statistical analyses determined that the use of SCMs, w/cm ratio, coarse aggregate type, and presence of LWAs had significant effects. The use of SCMs caused significant increases in surface resistivity for all groups due to their pozzolanic activity. The presence of slag cement caused the highest increases in surface resistivity, which were also attributed to slag's influence on concrete's pore solution chemistry. Class C fly ash also produced higher resistivity values over time than the samples prepared with only portland cement.
- The w/cm ratio was highly influential in resistivity as expected, where the lower w/cm ratio consistently produced higher resistivity values over time for all specimen groups. The presence of LWAs had an overall positive effect on resistivity, where each of the LWA sources had an equal or better performance than the control specimens based on the findings from the statistical analyses. Lastly, the coarse aggregate type had an effect on resistivity, albeit predominantly based on the porosity of the aggregate itself. While siliceous limestone and gravel have a different morphology and mineralogy, the statistical analysis did not find significant differences between the measured resistivity overall. Significant differences were only observed with the mixtures prepared with the porous limestone aggregates, as these specimens consistently had the lowest surface resistivity values.

RECOMMENDATIONS

Based on the results of this study, internally cured concrete through LWAs made from expanded shale or clay did not have detrimental effects on concrete's surface resistivity over time. As such, no correction factors are warranted.