Kansas Department of Transportation

TECHNICAL SUMMARY

Measurement of the Pore Size Distribution of Limestone Aggregates in Concrete Pavement Cores: Phase I

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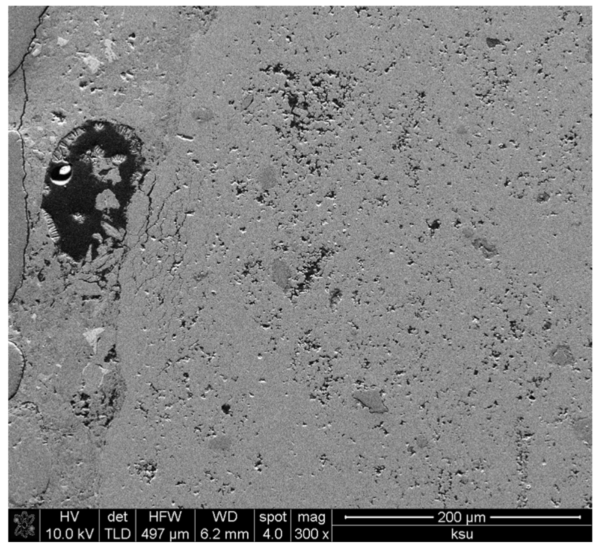
Introduction

Recently, the Kansas Department of Transportation (KDOT) began a large study aimed at determining the efficacy of the current concrete aggregate specifications in preventing poor quality materials from being used in concrete pavements. It was found from this study that many of the concrete pavements are failing before their expected 20 year design life, even though the aggregates passed all of the current KDOT concrete aggregate specifications.



Microcracking Seen in the Aggregate from Pavement B near an Air Void

Although KDOT recognizes that damage from alkali-aggregate reaction (AAR) and D-Cracking have unique cracking patterns, damage from AAR can often resemble D-Cracking in pavements, with damage at the joints appearing first because of the increased moisture and salt availability. AAR includes both alkali-silica reaction (ASR) and alkali-carbonate reaction (ACR). Besides causing cracking, ASR can also worsen freeze-thaw damage by filling in air voids with ASR gel (Niels, Ulla Hjorth, and Boyd 1996). Kansas limestone aggregates are not required to be tested for AAR susceptibility, but may still be ASR reactive because of chert particles embedded in limestone or ACR reactive if it is a dolomitic limestone.

Freeze-thaw damage to Kansas concrete pavements can occur because of poor quality limestone aggregates. In cement paste, entrained air voids provide a location for the ice to form, preventing the expansion from occurring inside the cement paste pores. Limestone aggregates do not however contain entrained air voids that remain dry until the freezing event. In order for water to escape the aggregate and freeze inside of an entrained air void, all aggregate pores must be reasonably close to an air void. This is the reasoning behind KDOTs maximum aggregate size requirements that have helped prolong the life of some concrete pavements. Even with the smaller aggregate sizes, certain pore size distributions make it more difficult for water to escape the aggregate and reach an air void.

Project Objective

This report documents Phase I of a study with the overall goal of determining if the pore size distribution of the aggregate could be correlated with field performance. Two of the problems that have been identified by KDOT engineers in Kansas concrete pavements are freeze-thaw damage and alkali-aggregate reaction. The main purpose of this phase of study was to develop a methodology to measure the pore size distribution of aggregates in concrete pavement cores using image analysis of scanning electron microscope images. A secondary purpose of the study was to determine if the aggregates used in the study were potentially AAR reactive.

Project Description

The main purposes of this study were:

1. Develop a method for preparing and imaging samples of limestone coarse aggregates taken from concrete pavements for examination in the SEM.

2. Develop a computer program for image analysis of the limestone SEM images.

3. Use the sample preparation method and computer program developed to quantify the aggregate pore size distribution on concrete cores taken from two pavements with different field performance. The pavement performance has been kept from the researchers and labeled pavement A and B to make this a blind study.

4. Test the potential ASR reactivity of the aggregates in concrete cores taken from the same two concrete pavements using a method similar to the ASTM C 1260 accelerated mortar bar test (ASTM C 1260 2005).

Project Results

Software for automating image analysis of aggregate pores in SEM images has been developed and used on samples taken from two different concrete pavements with different levels of field performance. A procedure has also been developed for sectioning, epoxy impregnating, and polishing limestone coarse aggregates from concrete cores for SEM image analysis. SEM image analysis showed that the aggregates from pavement B had a higher total porosity, and higher amount of small pores. Aggregates from pavement A however had a higher percentage of small pores (below 10 μm2). The aggregates in pavement B showed a high potential for future AAR expansion given enough moisture and alkalis, which would be more available at the joints.

Project Information

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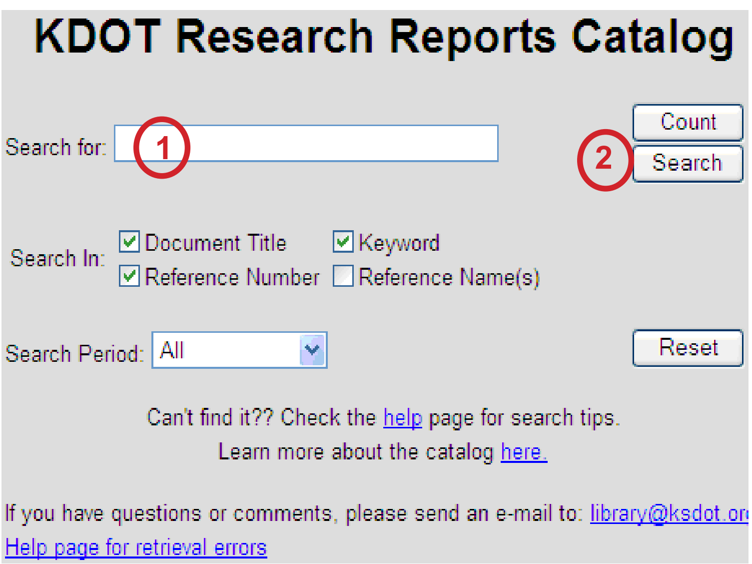

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