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Project Summary

Technology Transfer Outreach Publication

Researcher

Dr. Lawrence Sutter
Professor
Michigan Tech
Transportation Institute

lsutter@mtu.edu
906.487.2268

Sponsor

Wisconsin Department of Transportation (WisDOT)

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Project Title

Evaluation of Methods for Characterizing Air-Void Systems in Wisconsin Paving

Co-Investigators

Michigan Tech University
Dr. Thomas Van Dam
University of New Brunswick
Dr. Michael Thomas

A New Low-Cost Approach for Determining the Air-Void System Parameters in Hardened Concrete

Portland cement concrete (PCC) is an inherently durable material but its properties and durability can vary widely depending upon the relative volumes of cement, sand, aggregate, and water used along with the volumetric content of air. To construct durable roads, it is necessary to monitor and control the addition of air entraining admixtures used in making concrete. This is generally accomplished by monitoring the total air content of fresh concrete delivered to a job site. The two most common methods used for assessing the air content of fresh concrete are ASTM C 231 *Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method* and ASTM C 173 *Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method*.

There are established alternatives to measuring the air content in fresh concrete. The principal alternative is ASTM C 457 *Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*, which is performed on polished slabs cut from concrete cores. Although this method is generally viewed as being the most widely accepted characterization of PCC air void systems, inherent difficulties associated with conducting the test include reproducibility and the need for an experienced technician. For these reasons, a low-cost automated approach is desired.

Research Objectives

1. Perform a literature synthesis to document best construction practices and materials selection for producing a consistent, adequate air-void system in PCC used in pavement applications. Additionally, the literature review was used to identify if other methods of determining the air-void system parameters, not identified in the original proposal, were available and viable.
2. Examine the relationships between various methods of measuring air content in fresh concrete and measurements of air-void system parameters using ASTM C 457 for mixtures made with vinsol resin and synthetic air entraining agents.
3. Evaluate three new emerging technologies that show promise for characterizing the air-void system in hardened concrete.
4. Correlate measured air-void system parameters collected using all techniques with freeze-thaw testing data obtained from ASTM C 666.

MiSTI U.S. DOT University Transportation Center for Materials in Sustainable Transportation Infrastructure

University Facts

Total Enrollment	6,550
Graduate Enrollment	916
Number of Faculty	417
Placement Rate	95%

Michigan Tech is located in Houghton, MI on the south shore of Lake Superior. This rural area is known for natural beauty, pleasant summers, abundant snowfall, and numerous all-season outdoor activities. In addition, the University maintains its own downhill and cross-country ski facilities and golf course. There are numerous cultural activities and opportunities on campus and in the community. Michigan Tech has also been rated as one of the safest college campuses in the United States, and the local community provides excellent resources conducive to an outstanding quality of life.

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Research Findings

- High correlations were obtained between the results of the three fresh concrete tests (ASTM C 138, ASTM C 173 and ASTM C 231). No particular combination of air entraining admixtures, air content, or fly ash replacement, resulted in better or worse correlations between the results.
- Good correlations exist between the results of the fresh concrete tests and the results obtained in performing manual point counts (ASTM C 457) of the hardened concrete specimens prepared from each of the 18 mixtures.
- A flatbed scanner was clearly demonstrated to be a viable device for performing ASTM C 457.
- The flatbed scanner method tends to report slightly higher air content values than those determined by manual point counting. Image processing approaches may eliminate this error. In general there was good agreement between the scanner, other automated methods, and manual point counting.
- The degree of correlation with manual results depends on the method used to establish thresholds for segmenting the gray scale image.
- Increased confidence in the automated systems can be achieved by refining the processes involved in the preparation of the sample surface. Improvements in surface preparation quality reduce the quantity of defects analyzed by the automated systems. Therefore, it is easy to appreciate the fact that most researchers dealing with these types of analyses identify the sample preparation as the key factor in obtaining quality results.

Implementation

The final report and the developed software will soon be available for download on the Wisconsin Highway Research Program (WHRP) Web site (http://www.whrp.org/). The software is generic in that it will run on any PC using Microsoft Office, Adobe Photoshop, and any high quality flat-bed scanner. A "cookbook" for applying the software and preparing the samples is distributed with the software.

Publications

Carlson, J.C., L.L. Sutter, K.R. Peterson, T.J. Van Dam, "Comparison of a Flat-Bed Scanner and the RAPIDAIR 457 System for Determining Air-Void System Parameters of Hardened Concrete", Submitted to Transportation Research Record-Journal of the Transportation Research Board, TRR1779, 2006, pp. 54-59.

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Peterson, K.R., L.L. Sutter, T. J. Van Dam. "Air Void Analysis of Hardened Concrete with a High Resolution Flatbed Scanner." Proceedings of the 24th International Conference on Cement Microscopy, San Diego, California. April 8-11, 2002, pp. 304-316

Peterson, K.R., R.A. Swartz, L.L. Sutter, and T.J. Van Dam, "Air Void Analysis of Hardened Concrete with a Flatbed Scanner," Transportation Research Record-Journal of the Transportation Research Board, TRR1775, 2001, pp. 36-43.

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