RITA Office of Research, Development, and Technology

UTC Spotlight

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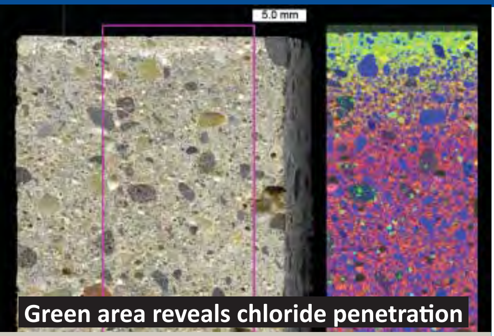
This month: Michigan Technological University



Green area reveals chloride penetration

Michigan Tech

***This monthly report** from the UTC Program highlights some of the recent accomplishments and products from one of the participating universities. The Program is administered by the U.S. Department of Transportation's Research and Innovative Technology Administration.*

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U.S. Department of Transportation

Research and Innovative Technology Administration

Helping to Build a Safe and Sustainable Transportation Infrastructure

The American Society of Civil Engineers' 2009 *Report Card for America's Infrastructure* notes that "one in four of the nation's bridges is either structurally deficient or functionally obsolete…" and that "33% of America's major roads are in poor or mediocre condition…[1]" Deteriorating roads and bridges lead to excessive wear and tear on vehicles, contribute to congestion, drain State maintenance coffers, and endanger lives. By helping to develop ever-more-durable materials and transferring research findings, the University Transportation Center for Materials in Sustainable Transportation Infrastructure (UTC-MiSTI) at Michigan Technological University (Michigan Tech) is playing an important role in developing a transportation infrastructure that is safe and sustainable.

Brockit, courtesy of UTC-MiSTI

UTC-MiSTI graduate student using a stereo optical microscope to perform the ASTM C457 test on a concrete pavement sample in the Material Characterization Facility at Michigan Technological University.

Recently, UTC-MiSTI participated in a nine-state[2] pooled-fund study led by the South Dakota Department of Transportation. UTC-MiSTI was active both in identifying factors that affect the performance of pavement and in communicating these and other project findings via the UTC's technology transfer (T2) activities. Although research was underway at the time Michigan Tech was established as a Tier II UTC through SAFETEA LU[3] legislation, the T2 activities were not a part of the original project and were directly the result of UTC-MiSTI's activities.

"The South Dakota project included an extensive field and laboratory investigation of deicers and anti-icing chemicals and their effects on portland cement concrete that yielded some very important findings. The original project did not include a T2 component. This provided a great opportunity for UTC-MiSTI to step up and deliver the outreach efforts and fulfill one of the roles of the UTC program," commented Larry Sutter, Ph.D., Director of the UTC and Principal Investigator on the research project. Sutter added "Until this research was conducted, there was a lack of awareness regarding the deleterious effects of deicing chemicals on portland cement concrete roads and bridges. The T2 efforts included communicating to those responsible for

[1] American Society of Civil Engineers, Report Card for America's Infrastructure, 2009 available at http://www.infrastructurereportcard.org as of Apr. 9, 2010.

[2] TPF-5 (042) was sponsored through the cooperation of Federal Highway Administration with financial support from the state department of transportation in California, Colorado, Idaho, Illinois, Iowa, Montana, South Dakota, Texas, and Wyoming.

[3] Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, Public Law 109-59, enacted to authorize funds for Federal-aid highways, highway safety programs, and transit programs, and for other purposes.

winter maintenance programs the potential impacts of the various deicing chemicals, with the hope that modified maintenance practices would be adopted to minimize the exposure of concrete pavements to these chemicals. It also gave engineers the information needed to design more durable structures."

This research project investigated the individual effects of concentrated brines including magnesium chloride, calcium chloride, sodium chloride, and calcium magnesium acetate on portland cement concrete. Although known to be effective at deicing and anti-icing, the potential harmful effects of these chemicals on concrete had not previously been well documented. As a result of this research, it was determined there is conclusive evidence that magnesium chloride and calcium chloride chemically interact with hardened portland cement paste in concrete resulting in expansive cracking, increased permeability, and a significant loss in compressive strength.

Although the same effects were not seen with sodium chloride brines, it was shown that sodium chloride brines have a high rate of ingress into hardened concrete, contributing to the corrosion of embedded steel. The mechanism for attack of hardened cement paste varies with deicer chemicals, but in general, a chemical reaction between chlorides and cement hydration products results in the dissolution of the hardened cement paste and formation of oxychloride phases. The chemical attack of the hardened cement paste is significantly reduced, however, if supplementary cementitious materials are included in the concrete mixture.

Both coal fly ash (byproduct of the production of energy from coal) and ground granulated blast furnace slag (byproduct from the production of steel) were found effective in mitigating the chemical attack caused by the deicers tested. In the tests performed, ground granulated blast furnace slag performed better as a mitigation strategy as compared to coal fly ash. Additionally, siloxane and silane sealants were effective at slowing the ingress of deicing chemicals into the concrete and reducing deterioration. In general, the siloxane sealant appeared to be more effective than the silane, but application of either should be considered as a maintenance strategy.

Identification of the reaction mechanism was accomplished through microstructural characterization in UTC-MiSTI's Petrography Lab. The term microstructure describes the physical and chemical structure of a material that cannot be seen with the naked eye; it can only be seen by the use of microscopes and other methods of characterization that can detect properties on the scale of fractions of a millimeter. It is the structure of a material at this scale that dictates how the material will perform and why it may fail prematurely. Through petrography, researchers are able to see the effects of loading, materials substitution, environmental exposure (e.g., exposure to deicing chemicals), and other factors that affect performance. Changes can be made in the material, or new materials can be evaluated, and the effects can be studied and assessed providing insight into why our pavements and bridges don't last longer. Without these advanced capabilities being made available to the sponsoring States, the work could not have been accomplished.

After the research was completed, UTC-MiSTI sponsored a series of T2 activities, including the development of a one-page general audience Project Summary and a four-page Technical Brief for state and federal DOT and municipal engineers. Both of these documents are available on the UTC-MiSTI website and are distributed at conferences and meetings. Four national webinar broadcasts, sponsored by UTC-MiSTI and Michigan's Local Technical Assistance Program, delivered the research results to 859 participants in 29 states and 3 countries. Research results were communicated through on-site presentations to numerous audiences in South Dakota, Wisconsin, Michigan, Iowa, Minnesota, Illinois, Montana, and Washington. The information was also presented at national meetings including the Transportation Research Board and the National Concrete Consortium.

For a copy of the *Executive Summary, Final Report or Implementation Guide*, visit the South Dakota DOT Office of Research Website at http://www.state.sd.us/Applications/HR19ResearchProjects/project_reports.asp . The Technical Brief and Project Summary for this investigation are available on the UTC-MiSTI website at http://www.misti.mtu.edu/index.php?p=pubs.

About This Project

This project was conducted through the cooperation of the Federal Highway Administration as TPF-5 (042). Lawrence Sutter, Ph.D., Director of the Michigan Tech Transportation Institute and the University Transportation Center for Materials in Sustainable Transportation Infrastructure at Michigan Technological University served as Principal Investigator (PI) on this project. Other contributors included co-PIs Karl Peterson, Ph.D. and Thomas Van Dam, Ph.D., Michigan Technological University; and. R. Doug Hooton, Ph.D., and Gustavo Juilio-Betancourt, University of Toronto. The Project Manager was Dan Johnson in the Office of Research at the South Dakota Department of Transportation. The technology transfer activities conducted by UTC-MiSTI, in support of TPF-5 (042), were coordinated by Elizabeth Hoy, Assistant Director, UTC-MiSTI; Scott Bershing, Technical Editor, Region 2 Tribal Technical Assistance Program; and John Rynnanen, Webinar Delivery Specialist, Michigan's Local Technical Assistance Program.

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