

From the desk of the Director



Missouri S&T mascot Joe Miner, Summer 2013

As summer activities move into full swing on the Missouri S&T campus, so are the endeavors of the CTIS staff and researchers. One indicator of these activities is the network of research collaborators within the Center, which continues to grow. Over the past months, CTIS researchers have formed collaborative projects with leading researchers at several universities, including University of Nevada-Las Vegas, University of Nebraska-Lincoln, University of Minnesota, University of Arkansas, North Dakota State University and University of Texas-Austin and several state DOTs (MoDOT, MnDOT, NDOT and CalTran). In addition to these partnerships, CTIS researchers are further expanding the reach of their network by undertaking joint projects with counterparts in Belgium, Iceland, France, and Mexico. These joint projects have also led to several student exchanges.

The CTIS is currently working to finalize the details of

the second annual Transportation Infrastructure Conference, which will be co-hosted with the Missouri Department of Transportation, and held in Jefferson City, MO on September 13, 2013. Please mark your calendars. The conference will highlight field implementation projects of innovative technologies in the transportation industry. Further details of this event will be announced soon.



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FEATURED PROJECT:

Field implementation of recycled concrete aggregate – Mississippi River Bridge project

- Kamal H. Khayat, Professor, Dept. of Civil, Architectural and Environmental Engineering, Missouri S&T



Figure 1. General View of the Ramp Approach with the Reference Section Already in Place

Due to the increasing rate of demolition, it is essential to effectively reuse demolition waste in order to conserve the nonrenewable natural resources. Decreasing natural aggregate resources, as well as increasing problems with waste management, ecological hazards, landfill limitations, and increasing distances between the natural resources and consumption markets, support the idea of using recycled concrete as aggregate for new concrete production. As a result, the idea of incorporating recycled concrete aggregate (RCA) in concrete production, has emerged.

In February 2013, researcher from Missouri S&T started a study with the Missouri Department of Transportation (MoDOT) on the design and monitoring of the performance of concrete made with RCA for use in pavement. The project involved field evaluation of three selected concrete mixtures made using RCA in pavement construction that would be part of the Mississippi River Bridge (MRB) construction project in downtown St. Louis. The field demonstration project involved the construction of a 22.5 ft wide ramp approach (outside lane and shoulder) from the Cass Ave. stub out to the EB Parkway Bridge over I-70. The first part of the section was used to cast the control pavement made with conventional concrete. The experimental RCA sections were cast afterwards up to the end of the length of the lane and shoulder in three different sections. Approximate volume of 600 cubic yards, including three experimental concrete mixtures and the reference one, were incorporated in this field evaluation.



FEATURED PROJECT: MoDOT funds pavement preservation project

- David Richardson, Assoc. Professor, Dept. of Civil, Architectural and Environmental Engr., Missouri S&T

The Missouri Department of Transportation (MoDOT) has funded a project with the University of Missouri to enhance its pavement management system. The project is focusing on the development of a pavement maintenance process that will allow for a selection of appropriate maintenance treatments based on optimization of performance and cost at the project level. The total project funding is \$1.5 million, including matching funds from the Center for Transportation Infrastructure and Safety (CTIS) and the University of Missouri at Columbia. Seven faculty and research staff members from the Rolla and Columbia campuses include project PI David Richardson and co-PI's Michael Lusher, Ronaldo Luna, Lesley Sneed, Neil Anderson, and Columbia campus co-PI's Brent Rosenblad and Andrew Boeckmann. Eight graduate and undergraduate students are participating as well.



Figure 1. Hamburg Rutting and Stripping Test Performed on Asphalt Mixture

The two year project is comprised of the following six Tasks.:

Task 1: mining of MoDOT historical data and production of data for further assessment;

Task 2: development of pavement performance models and pavement treatment models;

Task 3: assessment of available non-destructive pavement evaluation (NDE) techniques;

Task 4: field use of several promising non-destructive pavement evaluation techniques;

Task 5: evaluation of maintenance materials, and the development of pavement treatment triggers, and a selection process of candidate treatments; and

Task 6: creation of a re-calibration process for models and triggers.

RESULTS TO DATE INCLUDE:

- **Task 1:** Most of the various and fragmented repositories of MoDOT pavement performance data (pavement distress and smoothness), traffic data, and physical attributes (plans, etc.) have been identified, and researchers have learned how to retrieve, augment, and verify the accuracy of the information. Data continues to be accessed.

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Field implementation of recycled concrete aggregate (continued from page 2)

Testing included fresh concrete properties (slump, air content, and unit weight), mechanical properties (compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity) durability (freeze/thaw resistance, permeability, abrasion resistance and permeable void volume), as well as autogeneous and drying shrinkage. The structural health monitoring of optimized concrete mixtures made with 30% and 40% RCA replacements is assessed using vibrating wire strain gages (VWSG) embedded in the concrete pavement to monitor the long-term deformation.

The expected result from this study will provide guidelines for evaluating, selecting, and specifying RCA concrete. These guidelines will provide MoDOT and design engineers with information to design, test, and implement RCA in transportation-related infrastructure.



Figure 2.
Casting pavement sections with RCA-made concrete

MoDOT funds pavement preservation project (continued from page 3)

RESULTS TO DATE (continued):

- **Task 2:** Several pavement families have been devised which are based on pavement type (asphalt, concrete, or composite) and traffic level. Based on data produced from Task 1, various models are being developed for each family which will be used to learn how various types of pavements and treatments have performed in terms of smoothness and distress. This knowledge will lead to the ability to predict the life expectancy of various treatments.
- **Task 3:** A variety of NDE techniques and types of equipment have been evaluated. The results are being fed into Task 4.
- **Task 4:** Ten sites have been identified in MoDOT's highway system to be tested using the NDE techniques recommended by Task 3: penetrating radar, surface waves, electrical resistivity tomography, and falling weight deflectometer) along with several invasive methods (coring and dynamic cone penetrometer). Five of the site evaluations have been completed.
- **Task 5:** A variety of asphalt maintenance mixtures have been identified for longevity testing in Missouri S&T's Bituminous Laboratory, and several evaluations have been completed. Use of MEPDG (Mechanistic-Empirical Pavement Design Guide) software is also being evaluated for the possible prediction of pavement performance.
- **Task 6:** The work of this task will commence when the results of the other five tasks develops more fully.



FEATURED PROJECT: Influence of mixing procedure on the robustness of self-consolidating concrete

- Dimitri Feys, Asst. Professor, Dept. of Civil, Architectural and Environmental Engineering, Missouri S&T



Figure 1. Dr. Dimitri Feys Testing Cement Paste using Anton-Paar MCR 302 Rheometer

Self-Consolidating Concrete (SCC) is a relatively new, very fluid concrete type. As a main advantage, this concrete does not require any external form of consolidation, allowing contractors to increase speed of construction and to reduce labor use. Despite the increased material unit cost, money can be saved on time of construction, re-allocation of labor, and reduction of the need to consolidate and finish the concrete. However, SCC has not yet experienced a major break-through in the construction industry, partly because its fresh properties are sensitive to small changes in the mix design and the mixing procedure (e.g. an unnoticed change in sand moisture content), especially compared to normal concrete. In collaboration with Ghent University in Belgium, the researchers at Missouri S&T are investigating ways to increase the robustness of SCC: i.e. to decrease the sensitivity of the

properties to small changes in mix design and mixing procedure. While Ghent University investigates several moisture regulating additions (such as super-absorbent polymers), Missouri S&T researchers are investigating the influence of the mixing procedure on the properties of SCC. This involved the verification of the fresh properties of cement paste, mortar, and concrete by means of rheology. Rheology is the science of flow of materials, and cement-based materials are usually identified by two parameters: the yield stress, which is the stress needed to start the flow, and the plastic viscosity, which indicates the stress needed to accelerate the flow. The yield stress is related to the slump or slump flow of the concrete, while the plastic viscosity reflects its stickiness. By changing different aspects of the mixing process, the magnitude of variations in rheological properties indicates the significance

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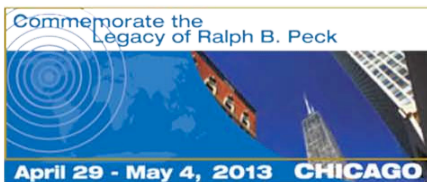


Influence of mixing procedure on the robustness of self-consolidating concrete (continued)

of certain steps. The sequence of addition of the constituent materials, the mixing time, the mixing speed, the time of addition of the admixtures, etc. are varied to identify the most significant aspects of the mixing procedure. The magnitude of these variations is compared to the standard changes in mix design, which are the water and superplasticizer contents.

The research team aims to develop guidelines

for mix design and mixing procedure to improve the robustness of SCC. In this way, the construction industry has more support to successfully develop and use SCC for infrastructure construction and repair. This collaboration with Ghent University can create new opportunities for international exchange with other European Universities in the growing field of transportation infrastructure.



Seventh International Conference on Case Histories in Geotechnical Engineering

and Symposium in Honor of Clyde Baker



The seventh international conference on case histories in geotechnical engineering was held in Chicago, Illinois from May 1 to 4, 2013 to commemorate the legacy of Professor Ralph B. Peck for introducing Observational Methods in Geotechnical Engineering. In a special session on this subject, six world renowned leaders who had worked with Professor Peck made technical and non-technical presentations. These included Gholamreza Mesri, Edward Cording, Elmo Di Biagio, Shamsheer Prakash, Nancy Peck Young, and David Rogers.

A luncheon was held to recognize Dr. Shamsheer Prakash for his achievements and to thank him for the direction he has provided for the Geotechnical Case Histories and Earthquake conference series over the past four decades. After serving the profession for more than 55 years, Dr. Prakash has decided to retire, and this conference was his last major professional activity on behalf of Missouri University of Science and Technology.

The conference was sponsored, in part, by the Center for Transportation Infrastructure and Safety.

Local Transportation News:

New training opportunity for local government agencies and engineering consultants



The Missouri Local Technical Assistance Program (Missouri LTAP) is pleased to announce a new training opportunity for local government agencies and engineering consultants with a new class, *Introduction to Materials: Concrete, Asphalt & General Materials*.

There are three main reasons a project fails prematurely: inadequate design, poor construction, and/or poor materials. This class focuses on materials and covers the basic properties of materials used in road and bridge projects. It also explains why it is important for an agency to care about materials. Agencies do not want to have to rebuild projects for many years. If an agency can add even five years to the life of a road, bridge or sidewalk, they may easily recoup the cost associated with the testing and inspection of materials. Time and money spent ensuring that quality materials are used will be returned with better performing and longer lasting products or in this case projects. Therefore, it is critical to determine the properties of materials correctly and what the proper frequency of testing is to ensure that what is being incorporated into a project meets the specification limits.



The following topics are covered:

- Acceptance methods for materials
- Concrete
- Asphalt
- General materials
- How to get testing done
- Having a quality plan
- Conflict resolution
- Specifying what you need

The first class is scheduled for August in Rolla. This will be a Level II class under the new structure in the Missouri LTAP “Show-Me” Road Scholar Program. Missouri LTAP is located at Missouri University of Science and Technology (Missouri S&T) and operates on funding provided by the Missouri Department of Transportation (MoDOT) and the Federal Highway Administration (FHWA). Missouri S&T’s National University Transportation Center also supports the efforts of the Missouri LTAP by providing 1:1 matching funds to aid in LTAP’s services and deliverables.

For more information on Missouri LTAP or to view a schedule of other upcoming classes, please visit the LTAP website at www.moltap.org.





FEATURED PROJECT: Non-destructive evaluation of bridge decks

- Lesley H. Sneed, Asst. Professor, Dept. of Civil, Architectural & Environmental Engineering, Missouri S&T
- Neil L. Anderson, Professor of Geology, Dept. of Geological Sciences and Engineering, Missouri S&T



Figure 1.
Ground Penetrating Radar Unit Scanning Bridge Deck

This project started in August 2012 through a joint effort between Dr. Lesley Sneed, Dr. Neil Anderson, and the Missouri Department of Transportation (MoDOT) with the objective of evaluating the application of non-destructive test methods to assess the structural condition of bridge decks. Missouri has over 10,400 bridges that are a part of the state highway system, which is the seventh largest total nationwide. Inspecting and maintaining these bridges requires a tremendous effort by MoDOT. This project is focused on evaluating the decks of 11 bridges in Missouri using Ground Penetrating Radar (GPR) and the Portable Seismic Property Analyzer (PSPA) to improve the overall quality and cost of bridge deck evaluation.

GPR is becoming more commonly used for the evaluation of many civil engineering endeavors. GPR transmits high-frequency electromagnetic (EM) waves into the structure of interest. The waves are then reflected back to the GPR unit after encountering an embedded object. For this project,



Figure 2.
Portable Seismic Property Analyzer

the reinforcement in the bridge deck is used to reflect the EM waves back to the GPR antenna. Based on the amplitude and arrival time of the reflection, deterioration levels of the concrete can be predicted. Using a ground-coupled GPR (**Figure 1**), an entire bridge deck can be scanned in a few hours.

Another non-destructive tool used in this project is the PSPA, shown in **Figure 2**. The PSPA device induces high frequency seismic waves in the structure and then records the return of the waves using two accelerometers. The PSPA can be used to locate areas of delamination, or large voids in the concrete, as well as to determine the seismic modulus of the concrete. Data acquisition for each test location takes around one minute.

In order to determine the ability of the GPR and PSPA to predict deterioration, six to ten cores were taken from each bridge deck investigated. These cores have been carefully examined and documented for visible signs of deterioration. Chloride ion tests are



Non-destructive evaluation of bridge decks (continued)

also being performed on the cores to determine how the intrusion of deicing salts and the resulting concrete deterioration correlates to the GPR data. Additionally, four of the eleven bridges scanned are currently undergoing hydro demolition, where the deteriorated concrete is removed using high pressure water jets and then replaced with new concrete. With the help of Dr. Norbert Maerz at Missouri S&T, the bridges were scanned with LIDAR to determine the volume and location of deteriorated concrete removal. The LIDAR results are being compared to the GPR and PSPA results to determine the accuracy of the deterioration predictions (**Figure 3**).

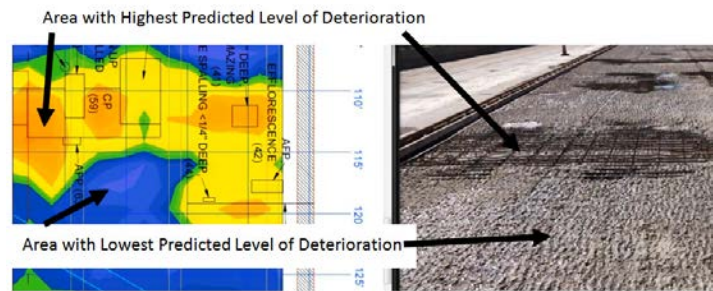
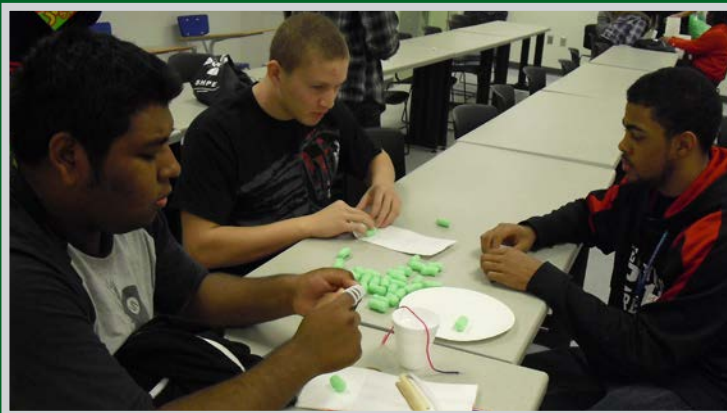


Figure 3.
Ground Penetrating Radar Deterioration Predictions (Left) versus Bridge Deck after Hydro Demolition (Right)

Upcoming Outreach Activities



The CTIS is proud to co-sponsor several outreach activities. These programs are designed to increase the number and diversity of students prepared to enter college and successfully pursue science, technology, engineering and math degrees. For more information about any of our upcoming Outreach Events, please contact our Student Diversity, Outreach and Women's Programs Office at 573-341-4212; sdowp@mst.edu

Upcoming Events

Hit the Ground Running Summer Enrichment Program	July 7th - 26th 2013
Fall Si Se Puede	November 2013
National Society of Black Engineers Pre-College Initiative	February 2014