Research on Concrete Applications for Sustainable Transportation

RE-CAST

MISSOURI S&T

Vol. 2 :: Issue 2 :: APRIL 2015

In this issue:

CONSORTIUM MEMBERS:

Missouri University of Science and Technology

University of Illinois at Urbana-Champaign

Rutgers, The State University of New Jersey

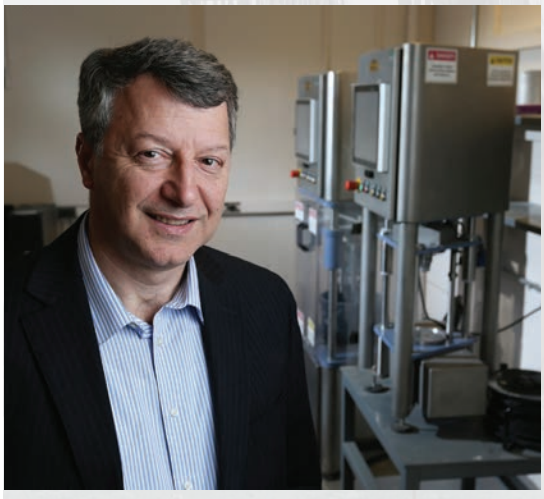
University of Miami

Southern University and A&M College

Director's Message

As the summer approaches, RE-CAST has many exciting plans in place to engage several different audiences in our research and outreach activities.

We are proud to report an outreach activity sponsored by Dr. Antonio Nanni, Associate RE-CAST Director at University of Miami, that engaged young children in the exciting science of making concrete. Children from United Way Center for Excellence Demonstration School visited the lab facilities at UM and learned how to make their very own mix design. These types of activities will help engage the next generation of transportation professionals, from a very early age.



On March 30, the RE-CAST Center offered a webinar jointly presented by Dr. David Lange, Associate RE-CAST Director at University of Illinois at Urbana-Champaign, and his student Dr. Tyler Oesch from U.S. Army Engineer Research and Development Center at Vicksburg, MS. The recorded webinar is available for viewing on our website.

We also have two webinar scheduled in May that will be announced on our website.

This summer, RE-CAST is offering a summer internship experience for undergraduate students to participate in RE-CAST project.

This issue of our newsletter provides many more updates on the exciting activities happening at RE-CAST.

-Kamal H. Khayat
RE-CAST Director

OUTREACH/WORKFORCE DEVELOPMENT

"Start Early, Repeat Often" – the next STEM generation

Children from the United Way Center for Excellence Demonstration School learn to make concrete with students from the University of Maimi

For children from the United Way Center for Excellence Demonstration School, a laboratory experiment that might intimidate most young adults starting college, is instead a fascinating wonderland waiting to be explored and re-invented. This group of very young students aged three to five came to visit the University of Miami's College of Engineering Structures and Materials laboratory to learn about concrete and construction materials.

After a brief lab tour showing the large test frames required for structural testing and a discussion of what they knew about concrete, the young students were set up in groups to make their very own concrete mix designs. They used different kinds of gravel and sand, which they were eager to feel with their own hands and even put some in their pockets. Because actual cement would be harmful to their skin, they were given cooking flour instead, then some concrete coloring to create their own custom concrete mixtures. The last ingredient was the water as they worked diligently to mix, explore, and play with their creation. Once completed, the mixtures was placed in a standard 4 inch. diameter concrete cylinder as would be done in the field for strength testing. Finally, an actual concrete cylinder was tested, and they were able to see first the strength of concrete and what a concrete failure looks like.

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OUTREACH/WORKFORCE DEVELOPMENT

"Start Early, Repeat Often" *(continued)*

Remy Gordon, the children's teacher, and several parents were in attendance as Drs. Francisco De Caso and Diana Arboleda, and graduate students Vanessa Pino and Zahra Karim lead the young kids in the experiment, hosted by Dr. Antonio Nanni, Chair of the Civil, Architectural, and Environmental Engineering Department and Associate Director of the RE-CAST University Transportation Center (UTC).

UM is a partner in the RE-CAST UTC, which sponsored the event.

The United Way Center for Excellence in Early Education is an innovative learning, teaching, and training initiative dedicated to elevating the quality of early care and education in Miami-Dade County and beyond.

FEATURED PROJECT

Recycled Fines for Controlled Low Strength Materials

- David Lange, Ph.D., Prof. of Civil Engineering, University of Illinois at Urbana-Champaign
- Yu Song, M.S. student, University of Illinois at Urbana-Champaign
- Jihwan Kim, Ph.D., Visting Scholar, University of Illinois at Urbana-Champaign

The University of Illinois is developing new sustainable materials for infrastructure applications in partnership with the O'Hare International Airport. The study focuses on use of recycled materials, particularly the fine particles that are generated by concrete crushers. While recycled coarse aggregates are readily reused for pavement substructure or for new concrete, the fine particles are generally disposed in landfills. Fine particles are challenging because their high water absorptivity and high fineness pose severe problems for normal concrete mixtures. In contrast, the research is developing mix design strategies for controlled low strength materials (CLSM) that are useful for backfill, such as used for trenching operations for underground utility lines at airports. Another niche application at airports is the use of CLSM materials as a cast-in-place alternative for Engineered Material Arresting Systems (EMAS) that are constructed at the end of runways for the purpose of arresting airplanes that overrun the end of the runways. Arresting systems are one viable option to create safe conditions when land is restricted at the end of runways. When the aircraft overruns the end of the runway, the aircraft landing gear penetrates the EMAS, and drag forces bring the aircraft to a safe halt. The properties of the EMAS need to be tuned so that emergency vehicles can drive on top of the EMAS while the aircraft gear loads are sufficient to punch through the surface. The EMAS strength, fracture energy, and durability need to be considered in the material design. The research is exploring strategies that use fine recycled particles so that the EMAS can be locally produced while advancing sustainability objectives. One novel material design strategy under consideration uses superabsorbent polymer inclusions and foaming strategies to reduce density and strength to more consistently achieves target strengths that may as low as 30-50 psi compressive strength range. **Figure 1** shows how super absorbent polymer beads create opportunity for large voids that reduce density and strength.

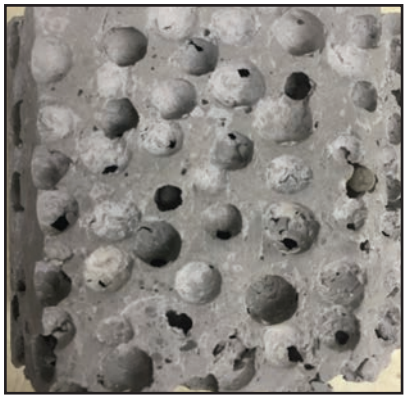

Figure 1. CLSM with large voids created by superabsorbent polymer inclusions

The research is also exploring new ways to characterize moisture in very fine particle systems. Particles that pass the 200 sieve are like dust, and the conventional methods for measuring sand moisture condition do not work because it is very hard to define saturated surface dry conditions.

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Recycled Fines for Controlled Low Strength Materials *(con't)*

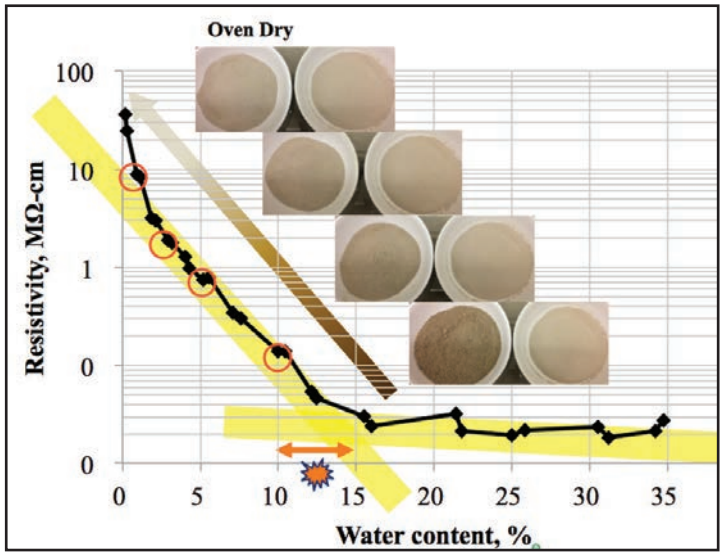


Figure 2. Effect of water content on resistance value of recycled fines

An alternative method being considered defines saturated surface dry condition as a function of electrical resistance across a sample of packed particles. **Figure 2** shows how electrical resistance drops as moisture increases, and a plateau is observed when the particles are saturated. Easy and practical test methods for characterizing fine particles will help establish reliable mixture design methodology for fine recycled materials.

Student Spotlight

RE-CAST Student Awarded ACI Missouri Chapter Honorary Abdeldjelil "DJ" Belarbi Scholarship : *Iman Mehdipour*

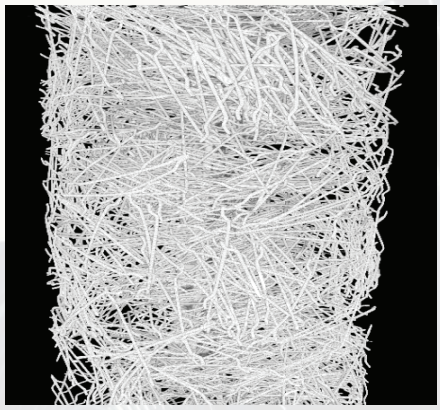
Mr. Iman Mehdipour, Ph.D. candidate at Missouri S&T, was awarded the ACI Missouri Chapter Honorary Abdeldjelil "DJ" Belarbi Scholarship for 2015-2016. The competition was very tough this year, and the RE-CAST Center is proud of this student's achievement.

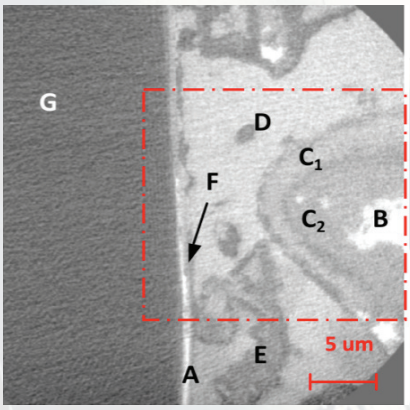
Mr. Mehdipour started his Ph.D. studies under direction of Prof. Kamal H. Khayat in the field of "Ecological and Crack-Free High Performance Concrete" in 2013. His academic achievement, community services experience, and six years of experience working as an engineer made him a good candidate for this scholarship award.

TECHNOLOGY TRANSFER

Drs. David Lange and Tyler Oesch give RE-CAST Webinar:

Three-Dimensional Study of Concrete Microstructure using X-ray Computed Tomography





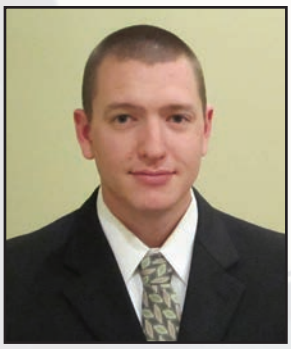
Webinar Abstract:

New technology has made it possible to create three-dimensional images of microstructure to better understand the performance of concrete. X-ray computed tomography (XCT) has been used to study phases — aggregate, paste, air bubbles, porosity and fibers — and discern crack propagation of samples under load. This webinar features recent research that explores how XCT can be applied to concrete materials over a range of scale that encompasses small cement grains on the low end to steel fibers and aggregate on the high end. XCT provides unprecedented opportunities: This advanced technique enables the interrogation of wet samples over time to observe hydration; study distribution of entrained air bubbles; evaluate samples under various levels of loading to study crack propagation and contrast HPC and OPC; and investigate fiber reinforced materials to appreciate how fibers influence fracture. The research community is only beginning to appreciate how these powerful new techniques would lead to profound new knowledge about complex concrete materials.

Prof. David Lange

RE-CAST Assoc. Director

University of Illinois, Urbana, IL



Dr. Tyler Oesch

U.S. Army Engineer Research and Development Center at Vicksburg, MS

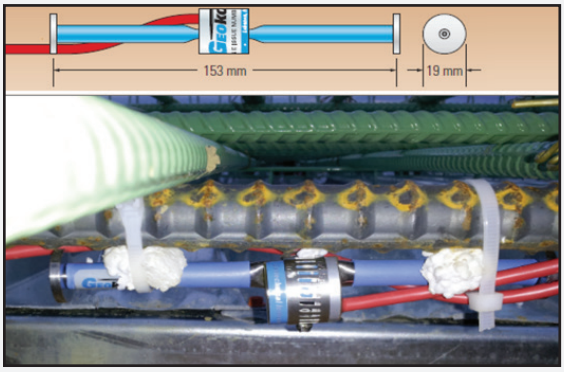
View the Webinar at: recast.mst.edu/webinars

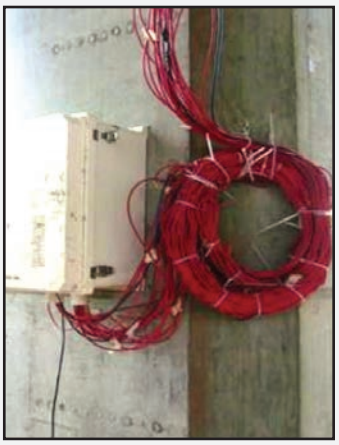
EDUCATION

RE-CAST Graduate Student Summer Workshop:

Structural Health Monitoring of Transportation Infrastructure Facilities

June 1-3, 2015 at Rutgers, The State University of New Jersey





The short course will introduce graduate engineering students and practicitions to the field of structural health monitoring in transportation infrastructures through two-day lectures and half-day field trip to instrumental test beds in New Jersey.

- Lectures: Monday, June 1, 2015 - Tuesday, June 2, 2015
- Field Trip: Wednesday, June 3, 2015

Learning Objectives: by the end of the course, graduate students will be able to:

- Define various aspects of structural health monitoring (SHM) used in transportation infrastructure
- Describe the role and needs of SHM
- Understand sensor technologies and data processing for SHM
- Investigate the difficulties and pitfalls of SHM
- Discuss various SHM case studies
- Application of SHM in concrete bridges, pavement, design, and rehabilitation

This course will be jointly presented by **Dr. Hani Nassif**, RE-CAST Assoc. Director, Professor of Civil Engineering at Rutgers University and **Dr. Alex Hak-Chul Shin**, RE-CAST Researcher, Associate Professor at Southern University. Watch for registration at http://www.recast.mst.edu.

FEATURED PROJECT

Economical and Crack-Free HPC with Adapted Rheology: *Packing Density Approach to Select Aggregates*

- Kamal H. Khayat, Ph.D., Professor of Civil Engineering, Missouri S&T
- Iman Mehdipour, Ph.D. Candidate, Missouri S&T

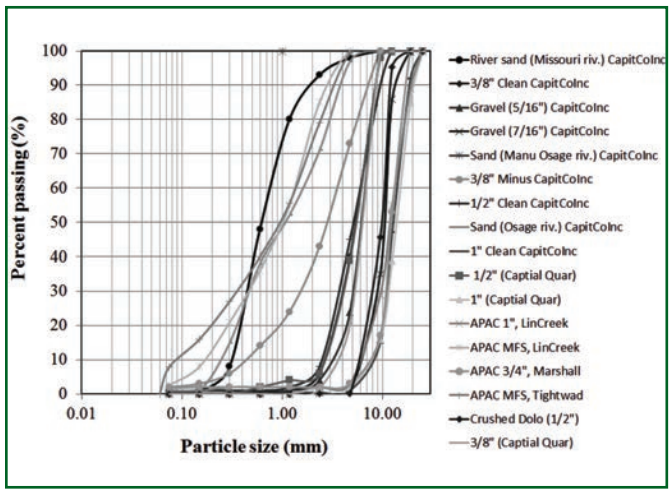


Figure 1. PSD of investigated aggregates

An essential step of producing ecological and environmentally friendly concrete (Eco-Crete) is to enhance the packing density of the aggregate skeleton. For a given workability, an increase in packing density can reduce paste volume, hence leading to greater resistance to cracking and reducing cost and emissions.

As part of RE-CAST project 1A, an experimental program was undertaken to evaluate the influence of physical characteristics of fine and coarse aggreagates including shape, texture, and particle-size distribution (PSD), on packing density. In total, 17 aggregate samples from different aggregate quarries in Missouri were sampled. The PSD of investigated aggregates (fine, intermediate, and coarse aggregates) is shown in **Figure 1**. The packing density of aggregate blends was determined using the loose packing approach (ASTM C29), dense packing approach using rodding (ASTM C29), and dense packing approach with an intensive compaction tester (ICT), as shown in **Figure 2**.

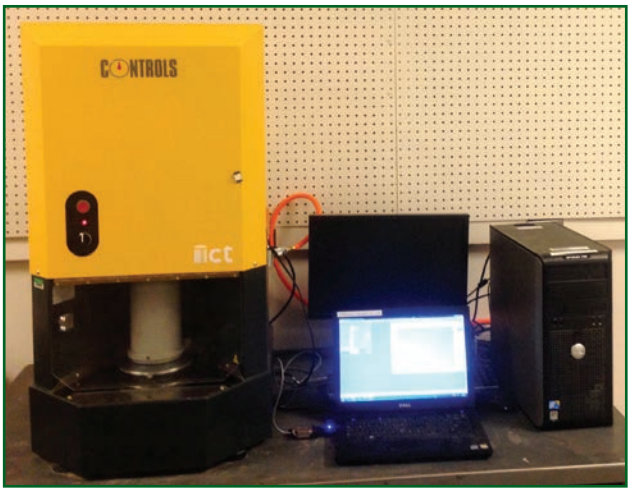


Figure 2. Packing density measurement using ICT

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Economical and Crack-Free HPC with Adapted Rheology:
Packing Density Approach to Select Aggregates (con't)

The packing density of the tested aggregates determined using the ICT is plotted in **Figure 3**. Depending on the shape, texture, and PSD of aggregate, the packing density of mono-sized aggregates varied from 0.59 to 0.73. Typical results for ternary aggregates combination shown in **Figure 4**. Given different types and replacement rates of aggregate, the packing density of ternary systems varied from 0.70 to 0.82. The spread between the minimum and maximum packing densities of 0.12, corresponds to void volume that should be filled with cement paste.

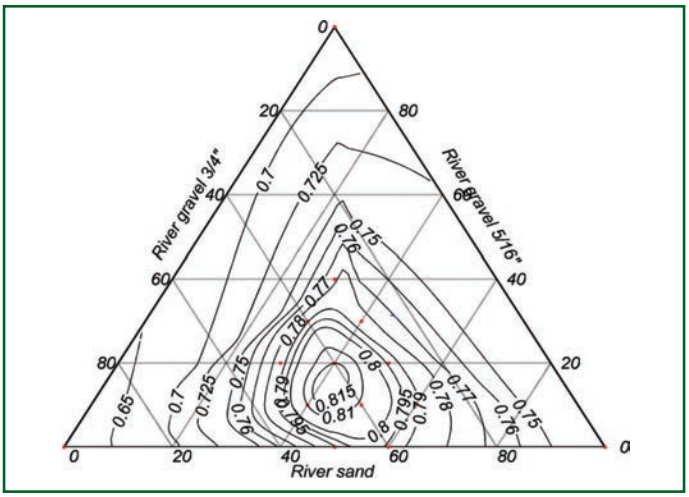

Figure 4. Ternary packing diagram for investigated aggregates

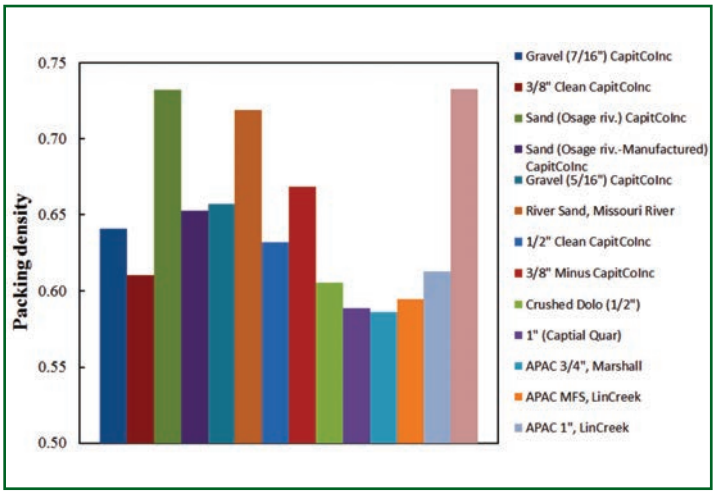

Figure 3. Packing density of investigated aggregates using ICT

Research is underway to optimize binder and aggregate combinations and to incorporate fibers and expansive admixtures/shrinkage reducing admixtures to develop a new generation of environmentally friendly and crack-free high-performance concrete (Eco and crack-free HPC) designated for pavement (Eco-Pave-Crete) and bridge desk constructions (Eco-Bridge-Crete).

DIVERSITY AND OUTREACH

RE-CAST Offers Undergraduate Summer Research Internships

RE-CAST is excited to be offering an Undergraduate Summer Research Internship program at Missouri University of Science and Technology and the University of Miami. Undergraduate civil engineering students from the consortium institution are eligible to apply for an 8-week internship to work on RE-CAST research projects. This program will offer excellent education, training, and research opportunities for students at the undergraduate level. Preference will be given to populations that have been historically underrepresented in engineering. The students will have two options to choose from, as elaborated below.

OPTION A: UNIVERSITY OF MIAMI	
Project Title	Use of Composites in Repair of Transportation Infrastructure
Research Advisor	Dr. Antonio Nanni, RE-CAST Associate Director
Brief Description of Project	Student/s will be engaged with experimental characterization and certification of innovative construction composites. All aspects of research will be covered, including experiment and specimen development, testing, data collection and analysis, and reporting. The student/s will be in a laboratory environment and will learn how to use different advanced test equipment.

OPTION B: MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY	
Project Title	Project A: Strengthening and Repair of Structural Concrete with a Fabric-reinforced-cementitious-matrix Project B: Ultra-high Performance Fiber-Reinforced Concrete for Infrastructure Rehabilitation
Research Advisor	Dr. John Myers, RE-CAST Focus Area Leader
Brief Description of Project	Project A: The overall objective of this project is to evaluate existing methods of repair of bridge girders, subjecting a new FRCM system to environmental studies, and a practical field strengthening implementation project. Project B: This study aims at developing sustainable concrete materials for infrastructure applications. The main idea is to develop a cost effective and sustainable ultra-high performance fiber-reinforced concrete (UHPC) to be used in concrete infrastructure applications where enhanced durability and extended service life are key. This study examines UHPC performance in varied bridge joint details and panels.

FEATURED PROJECT

Rapid Pavement Repair

- Alex Hak-Chul Shin, Ph.D., P.E. Associate Professor, Southern University and A&M College
- Denita Walker, Graduate Student, Southern University and A&M College

Cracking in Full-Depth Repair

Instruments to Measure Thermal Properties of Concrete

Portland cement concrete (PCC) pavements have been used with great success in many locations across the U.S. and the world. The main detriment to PCC pavement is rapid repair using hydraulic cement based material: the pavement can develop strength quickly, but in doing so, it generally shrinks and can lead to shrinkage cracking.

The main objective of the research is to determine the feasibility of producing cost effective materials for rapid pavement repair. The study will evaluate mixture optimization as well as fresh and hardened properties and durability aspects of such novel materials through laboratory tests. Two types of pavement technologies will be applied in this project:
1) crack-free early strength concrete, and
2) self-consolidating concrete mixture for repair.

Several methods are being considered to minimize stresses caused by shrinkage and temperature changes. Internal curing using the lightweight aggregate (LWA), recycled concrete aggregate (RCA), expanded slate (shale), and superabsorbent polymer are being investigated. Internal curing can reduce substantial autogenous shrinkage at early age and increase long term strength in high-performance blended cement mortars. The effects of absorption and deception capacity of the aggregate with the size of materials are being investigated. Following these studies, use of synthetic fiber and shrinkage-reducing admixtures (SRA) of repair concrete will be considered.

Field implementation will also be carried out to investigate in-situ performance of the proposed concrete in different geographic locations in the U.S. (e.g., Louisiana and Missouri). The project will also evaluate life cycle cost analysis (LCCA) to determine the economic impact of using such novel material in infrastructure applications.

This project is sponsored by the Louisiana Transportation Research Center (LTRC) and Southern University in partnership with RE-CAST.

UPCOMING WEBINARS

Visit our Webinar Library at: recast.mst.edu/webinars

May 5, 2015 at 2pm ET

Presenter: Elizabeth Birriel, Florida DOT

"*Connected Vehicle Technology: Current Efforts, Demonstration and Future Plans of FLDOT*"

Will be presented in Spanish with English Closed-Captioning

May 13, 2015 at 11am CDT

Presenter: W. Micah Hale, Professor of Civil Engineering
The University of Arkansas

"*Alkali–Silica Reaction (ASR) and ASR Mitigation*"

Being presented in conjunction with the
Southern Plains Transportation Center at University of Oklahoma

UPCOMING TECHNOLOGY TRANSFER EVENTS

Save the Dates:

SCC2016 - "Flowing Towards Sustainability"

Dates: May 15-18, 2016 **Location: Washington, DC**

Overview: The conference combines the RILEM Symposium on SCC and the North American Conference on the Design and Use of SCC and will be held jointly with the National Ready Mix Concrete Association (NRMCA) International Concrete Sustainability Conference The conference is supported by Missouri S&T, the RECAST Center, NRMCA, the Center for Advanced Cement-Based Materials (ACBM), as well as RILEM and ACI. For more information, visit: www.scc2016.com.

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