Summer break has started on the Missouri S&T campus, which is a good time to look back and reflect on what has been accomplished during the 2014 Academic Year as well as start planning for the upcoming year.

The RE-CAST team has several noteworthy accomplishments to be proud to share. The Advanced Construction Materials Laboratory (ACML) was recently inaugurated by S&T Chancellor Schrader in April 2014. This event was a turning point in the research program for the S&T research team. With nearly $2.8M of newly acquired specialized equipment for the development, manufacturing, and implementation of advanced and sustainable materials for transportation infrastructure, this new lab will be the cornerstone in accomplishing many projects that will be undertaken by the RE-CAST team.

The RE-CAST Director was also selected to lead a Best-in-Class strategic signature area initiative at S&T in the area of Advanced Materials for Sustainable Infrastructure. The goal of this initiative is to position S&T to become a national leader in this critical research area.

As part of the University’s commitment to this strategic initiative, new funding has been made available from campus and the University of Missouri System to support the hiring of additional faculty in this interdisciplinary area, as well as in three other areas of strategic importance. This will prove to be a beneficial investment into research activities related to RE-CAST.

I am pleased to report that the RE-CAST consortium members have several projects underway, which will be outlined in the following pages. The research team has diligently developed the proposed research program into detailed projects and worked with industry and state DOTs to secure matching funds.

Over the past months, RE-CAST has hosted several research seminars to highlight research activities related to the themes of the Center. These seminars have been well attended and broadcast to all partner institutions. This series of seminars will continue over the coming semesters.

-Dr. Kamal H. Khayat
RE-CAST Director
TRANSPORTATION EDUCATION:

Special Workshop:
Fundamentals of Rheology and Applications on Cement-Based Materials

During the week of July 14th, 2014 a group of 40 students, faculty and industry professionals gathered at Missouri S&T for a 4-day accelerated short course on the fundamentals of rheology and applications on cement-based materials. The workshop offered participants classroom lectures and hands-on laboratory experiences, including an introduction to state-of-the-art rheometers. The workshop was led by three faculty members from the RE-CAST team, as indicated below.

Students from the RE-CAST consortium universities attended the workshop, which allowed students working on joint projects to meet face-to-face, as well as network with students from other universities across the country working on similar RE-CAST focus areas.

Attendees came from across the country to participate in this event:

- Burns Concrete Inc., ID
- University of Nebraska Omaha, NE
- Rutgers, the State University of New Jersey, NJ
- University of Illinois, Urbana-Champaign, IL
- Missouri University of Science and Technology, MO
- Durable Concrete, NC
- University of Oklahoma, OK
- Southern University of Baton Rouge, LA
- University of Miami, FL

International attendees:
- Universidad Autónoma de Nuevo León, Mexico
- University of Artois, France

RE-CAST Instructors:

Dr. Kamal Khayat, Vernon and Maralee Jones Professor of Civil Engineering, Missouri S&T
Dr. David Lange, Narbey Khachaturian Faculty Scholar and Professor, University of Illinois at Urbana-Champaign
Dr. Dimitri Feys, Assistant Professor, Civil Engineering, Missouri S&T

“We consider this event a great success for the RE-CAST Center and hope to use it as a stepping stone for offering future workshops for students and transportation professionals.” - K. Khayat, RE-CAST Director
TRANSPORTATION EDUCATION:

Special Workshop: *Fundamentals of Rheology and Applications on Cement-Based Materials* (continued)

**LECTURE TOPICS**

The workshop lectures were divided into three parts:

1. Basic principles of rheology and rheometry and measurement systems.
2. Rheology of cement-based materials.
3. Importance of rheology in concrete research and applications, as demonstrated by different practical studies.

**LAB #1**

This lab involved a demonstration of the concepts of different rheological properties and aggregate packing density and how to measure them. Students determined the rheological properties of ketchup and high-range water reducing admixture and estimated optimal packing density of different aggregate combinations.

**LAB #2**

Participants measured the rheological properties of various flowable concrete mixtures by means of the ConTec Viscometer 5, the ICAR rheometer, the ConTec 4-SCC rheometer, as well as standard workability test methods. The influence of different concrete constituent materials was evaluated.
FEATURED PROJECT:

Repair of Damaged Prestressed Concrete Girder with FRCM and FRP Composites

- Antonio Nanni, Ph.D., Professor of Civil Engineering, University of Miami
- Vanessa Pino, P.E., Ph.D. student, University of Miami

The University of Miami is working with Virginia Polytechnic Institute and State University (Virginia Tech) and the Virginia DOT to design, strengthen, test and analyze the behavior of damaged AASHTO Type III prestressed concrete girders using three repair methods. The repair methods that will be used are: strand splicing, fiber reinforced polymer (FRP) strengthening, and fabric reinforced cementitious matrix (FRCM) strengthening. Currently there is no design specification outlining the evaluation and design procedure for the strengthening and repair of damaged prestressed concrete girders specifically using FRP or FRCM materials. Thus, our work will focus on the design, application, and material characterization of the FRP and FRCM systems and repair methods. The work combined with the girder testing performed at Virginia Tech will allow the determination of the damaged and strengthened girder behavior specific to each type of repair method. Currently, progress has been made on the FRP and FRCM material characterization. FRP and FRCM materials have been received and specimens have been prepared for the material characterization. One ply and two ply FRP specimens were prepared for direct tension, interlaminar shear, and tensile bond tests. Additional specimens were prepared and placed in sea water, water vapor, and alkaline environments (Figure 1). One ply and two ply FRCM specimens were also prepared for direct tension, bond, interlaminar shear, and bond over repair mortar tests as well as compression of matrix mortar in ambient and limewater conditions (Figure 2). Additional specimens were also prepared and placed in sea water, water vapor, and alkaline environments. The material characterization of FRP and FRCM will allow for a firm understanding of the material behavior and performance capabilities. Accordingly, the results from the material characterization will be useful in the design and application of FRP and FRCM as a strengthening material for damaged prestressed concrete girders.

Figure 1. Externally Bonded Fiber Reinforced Polymer Application to Concrete

Figure 2. Fabric Reinforced Cementitious Matrix Specimen Preparation
DIVERSITY AND OUTREACH:
Summer Transportation Institute at Southern University, Baton Rouge
- Alex Hak-Chul Shin, Ph.D., Assoc. Professor of Civil Engineering, SUBR

As a support of the academic enhancement program of communities underrepresented in transportation, Dr. Shin presented the RE-CAST center and research project to the Summer Transportation Institute (STI) participants on June 26, 2014. The STI is organized by the College of Engineering at Southern University every year. This year, 18 students participated in the STI program from June 9 to 27. The participating students were sophomore or junior high school students in the metro Baton Rouge area. During the three week program of STI, students had a hands-on experience focused on the behavior of various novel construction materials and characterization techniques in transportation engineering. The students also had several field trips to LA DOTD and construction sites, and visited several colleges in the Southern University campus to expose themselves to the college campus life. These activities should help in attracting the interest of underrepresented high school students in the transportation area and help recruit them into engineering in the near future.

During the presentation, Dr. Shin discussed the mission and research activities of the RE-CAST Center. He emphasized the importance of sustainability in transportation and the need to develop and implement novel construction materials. During the workshop, the students were exposed to history and scale of roadway construction, as well as other transportation infrastructure.

Current research on the rapid full-depth repair of concrete pavement sponsored by RE-CAST and Louisiana Transportation Research Center (LTRC) was discussed in great details.
DIVERSITY AND OUTREACH:
MoDOT 2014 Annual Youth Transportation Conference

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

The Missouri Department of Transportation (MoDOT) sponsors an annual Youth Transportation Conference each summer. Thirty students are selected from across the state to attend this conference in Jefferson City, Missouri. The six-day conference is free to 9th, 10th, 11th, and 12th graders.

The conference exposes students from across Missouri to the numerous career opportunities in the field of transportation and is packed with fun and exciting academic, career development, and social activities. Students apply math, science, and computer concepts learned in school to transportation related problems. The academic curriculum includes sessions on math modeling, applied physics, magnetic levitation, public administration, and safety. Other activities include field trips, office/site tours, and speakers from various divisions within MoDOT and related organizations.

RE-CAST is providing financial support to this activity as well as providing graduate student assistants to help with a hands-on activity that will take place during the field trip to Missouri S&T on July 21st. This Youth Transportation Conference is a great outreach opportunity for the RE-CAST Center to attract new entrants into the transportation field from local secondary schools and highlight the numerous opportunities of a STEM education.

“As Center Director, I am excited to support this youth conference. I believe opportunities such as these are essential for generating excitement at an early age for the next generation of transportation leaders.”

- K. Khayat, RE-CAST Director
DIVERSITY and OUTREACH:
RE-CAST Summer Internships for Underrepresented Students

During the month of July, several undergraduate students from Rutgers University and Southern University undertook summer internships at Missouri S&T. This program offers excellent education, training, and research opportunities for underrepresented students at the undergraduate level. The students worked on one of the collaborative projects supported by the Center.

UPCOMING TECHNOLOGY TRANSFER EVENTS

Save the Dates:

2014 Missouri S&T Transportation Infrastructure Conference

Date: October 3, 2014           Location: Havener Center, Missouri S&T campus
Overview: The purpose of this year’s event will be to showcase recent transportation-related research findings in the areas of advanced construction materials and non-destructive testing and monitoring of transportation infrastructure and act as a vehicle for technology transfer to practitioners.

SCC2016

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, the Center for Advanced Cement-Based Materials (ACBM), NRMCA as well as RILEM and ACI.
High-performance concrete (HPC) is typically characterized by high binder content. Using high binder contents can lead to higher cost and greater risk of cracking due to thermal and drying shrinkage, thus reducing service life of the structure. Early-age shrinkage cracking of concrete bridge decks is a common problem in U.S. The risk of early-age cracking in bridge decks increases the risk of freeze-thaw damage, corrosion of reinforcing steel, and ingress of various deleterious substances that can lead to premature deterioration and potential structural deficiencies of concrete infrastructure.

The aim of the project is to develop a new generation of environmentally friendly, high-performance concrete (HPC) with relatively low cement and paste contents: Eco-HPC. Such concrete should be designed with relatively low binder content of 350 kg/m³ (590 lb/yd³).

This project will develop two classes of Eco-HPC for the following applications: HPC for pavement construction (Eco-Pave-Crete) and HPC for bridge desk construction (Eco-Bridge-Crete). Eco-Bridge-Crete can be used in cast-in-place girders, cast-in-place piers and piles, and other bridge elements. The rheological properties of these advanced materials will be designed to facilitate construction operations and reduce labor and cost. The Eco-HPC will also be designed to ensure high durability and high resistance to cracking. Low cracking potential can enhance structural performance and cracking resistances, properties leading to prolonged service life of the infrastructure.

This two-year project will involve collaboration between the following four Universities:
- Kamal H. Khayat
  *Missouri S&T*
- Hani Nassif
  *Rutgers, The State Univ. of NJ*
- Kaan Ozbay
  *New York Univ. Polytechnic*
- Jeffery S. Volz
  *University of Oklahoma*

The RE-CAST team will work in conjunction with the following non-federal sponsors at this project:
- MO Dept. of Transportation
- NJ Dept. of Transportation
- Dolese Brothers Co.
Dr. Kamal H. Khayat, RE-CAST Center Director, visited the Rutgers Infrastructure Monitoring and Evaluation (RIME) Group on May 8-9, 2014 and held a seminar entitled "Design and Performance of Fiber-reinforced Self-Consolidating Concrete in Infrastructure Repair". The presentation highlighted previous research work into this novel repair technology and discussed the various tasks of the collaborative work that will be undertaken by the RE-CAST team, including the RIME Center and research at NYU, University of Oklahoma and Missouri S&T.

Drs. Hani Nassif, Elsayed A Elsayed, Najm Husam from Rutgers, Dr. Kaan Ozbay from NYU, Dr. Giri Venkiteela, Mr. Smmamunar Rashid, and David from NJDOT, and post-docs and students from Rutgers joined this meeting and discussed various topics related to the fiber-reinforced self-consolidating concrete. A total of 25 attendees participated in the event.
INFRASTRUCTURE EXPANSION:
Missouri S&T inaugurates new Advanced Construction Materials Laboratory (ACML)

Figure 1. Missouri S&T Chancellor Cheryl Shrader and Dr. Kamal H. Khayat officially inaugurate ACML

Figure 2. Missouri S&T research group at new concrete batch plant with 1 yd$^3$ output

Missouri S&T celebrated the inauguration of the Advanced Construction Materials Laboratory (ACML) on Friday, April 25, 2014. The renovated laboratory showcases over 35 recently purchased pieces of specialized equipment. This laboratory will enable the development, manufacturing, and implementation of innovative and sustainable materials for civil infrastructure, with an emphasis on cement-based materials. Examples of the type of studies this facility will allow include projects on the design and performance of a number of innovative materials, including self-consolidating concrete (SCC) for cast-in-place bridge superstructure and substructure elements, high volume fly ash concrete (HVFAC) for infrastructure construction, and roller compacted concrete (RCC) for rigid concrete pavement for highways, rural roads, and airfield pavements.

Figure 3. Visitors are introduced to rheology testing equipment during Inauguration Laboratory Tour given by RE-CAST faculty, Dr. Dimitri Feys

Figure 4. Dr. Kenneth Hover from Cornell University speaks with students during Inauguration Open House
WORKFORCE DEVELOPMENT and TECH TRANSFER:
RE-CAST Seminar Series

As part of the workforce development and technology transfer missions of the RE-CAST Center, bi-monthly seminars featuring invited speakers from industry, and academia, highlight on-going and recent projects involving the design, implementation, and construction of sustainable infrastructure materials that are of interest to the Center are organized. Campus-based seminars will be telecast through video conferencing to enable participation of students from the various consortium universities. The seminars are designed to enhance interaction between the students, industrial partners, guest speakers, and faculty members.

March 5, 2014
Presenter: Dr. John Myers, Missouri S&T
“In-situ load testing and instrumentation for advanced construction material applications”

April 25, 2014
Presenter: Dr. Kenneth Hover, Cornell University
“There is more to concrete than meets the eye”

June 17, 2014
Presenter: Dr. Antonio Nanni, University of Miami
“Extending the life of concrete structures: FRCM technology”
LEARN MORE ABOUT RE-CAST:

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