news

MISSOURI S&T

CENTER FOR TRANSPORTATION INFRASTRUCTURE AND SAFETY

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New Director assumes leadership

As we transition from Winter into Spring here in Missouri, we are also undertaking an exciting transition within our Center for Transportation Infrastructure and Safety (CTIS) at Missouri S&T. Our new Vernon and Maralee Jones Chaired Professor, Kamal H. Khayat, has taken over directorship of the CTIS.

Kamal H. Khayat, Director of CTIS

Kamal H. Khayat joined Missouri S&T in August of 2011 as the Vernon and Maralee Jones Chaired Professor of Civil Engineering. He specializes in the development of high-performance cement-based materials for structural applications and rehabilitation, particularly focusing on self-consolidating concrete (SCC) and high-performance concrete (HPC) behavior. His pioneering work in the area of SCC, starting in 1991, has contributed to its acceptance world-wide.

One of his first orders of business as the new CTIS Director has been fostering inter-University partnerships with other leaders in the transportation field.

Dr. Khayat has also been working very closely with personnel at the Missouri Department of Transportation to improve the Center's research capacity and collaborate with them to find novel and cost-effective technical solutions to enhance the state of Missouri's transportation infrastructure.

MoDOT has expressed interest in working on joint projects with other State DOT's, which will be an exciting new venture for the Center. Discussions are underway with possibly projects with the Illinois Department of Transporation as well as the Florida Department of Transportation. The proximity of IL makes this an ideal partnership and the varied climate conditions in FL offer even more opportunity for environmental condition studies.

Over the next months, much time and energy will be focused on organizing the first Annual Missouri S&T Tranportation Infrastructure conference. This will be an opportunity for CTIS researchers to share their research findings with one another and our industrial and governemental partners. This is just one step the new Director is taking to bring CTIS to the next level of excellence, particularly in the area of technology transfer and outreach.

In this issue:

PROJECT:

Design and evaluation of high-volume fly ash concrete mixtures

- Jeffery Volz, Assistant Professor, Department of Civil, Architectural and Engineering (CArE), Missouri S&T
- John Myers, Associate Professor, CArE, Missouri S&T
- Dave Richardson, Associate Professor, CArE, Missouri S&T

Figure 1. Construction of high-volume fly ash concrete full-scale test beams

Sustainability is at the forefront of our society, and concrete is the most ubiquitous man-made material consumed on our planet.

Although concrete has a wealth of sustainable features when examined from a cradle-to-grave or cradle-to-cradle perspective, a significant focus has been placed on the generation of carbon dioxide during the manufacturing of portland cement. For each ton of cement produced, approximately one ton of carbon dioxide is released to the atmosphere. One method of reducing concrete's carbon footprint is by replacing a portion of its cement content with fly ash. In addition to reducing the amount of cement, fly ash can improve the performance of the concrete. However, most specifications limit the amount of cement replacement with fly ash to less than 25% or 30%. With only about 40% of the available fly ash used in concrete and other beneficial applications, increasing the volume of fly ash used in concrete will remove more material from the solid waste stream and reduce the amount ending up in landfills. High-volume fly ash (HVFA) concrete – concrete with at least 50% of the cement replaced with fly ash – offers a potential green solution.

In December 2010, researcher from Missouri S&T embarked on an 18-month study with the Missouri Department of Transportation (MoDOT) and CTIS to design, test, and evaluate HVFA concrete containing aggregate and fly ash indigenous to the state of Missouri. The goal of the research is to develop guidelines on the use of HVFA concrete in infrastructure elements for MoDOT, with the aim of maximizing the amount of cement replacement. One of the key issues involves the behavior of fly ash from different coal-fired power plant sources. Studies have shown that the pozzolanic and cementitious quality of fly ash can vary significantly between sources and even within the same plant. Fly ash samples from a variety of coal-fired power plants in Missouri, including Ameren Corporation's Labadie, Meramec, and Rush Island plants and Kansas City Power & Light's Iatan, LaCygne, and Nearman plants. The researchers also obtained samples of the most common cements used for construction within Missouri. The research team then used semi-adiabatic calorimetry to establish the range of reactivities for different combinations of fly ash, cement, and replacement percentages.

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Figure 2. Full-scale beam shear test

The next phase of the research involved testing of HVFA concrete mixtures optimized from the variety of fly ash, cements, and aggregates available in Missouri. Testing included fresh concrete properties (slump, air content, unit weight), hardened concrete properties (compressive strength, modulus of elasticity, modulus of rupture), volume change properties (creep and shrinkage), durability properties (abrasion resistance, freeze-thaw resistance, scaling resistance, and permeability), and structural properties (bond and development, shear strength, flexural strength). Figure 1 is a photo of the construction of the full-scale test beams, and Figure 2 is a photo of one of the full-scale beam shear tests.

Preliminary results indicate that the high-volume fly ash concrete is comparable to conventional concrete in terms of bond and development legnth, shear and flexural strengths, and durability. Furthermore, the creep and shrinkage response of the high-volume fly ash concrete is noticeably less than conventional concrete. The researchers are in the process of completing the long-term durability testing and finalizing the report to MoDOT/NUTC, which will include recommendations and draft specifications on the use of high-volume fly ash concrete in transportation-related infrastructure.

Spring Pre-College Initiative

February 16-19, 2012

The National Society of Black Engineers (NSBE) is the largest student-run, non-profit organization in the country. Its objective is to promote the recruitment, retention, and successful graduation of African-Americans in engineering, science and technology. One of the objectives of the Missouri S&T-NSBE chapter is to encourage high school students to pursue careers in engineering, science, and technology and to consider Missouri S&T as a choice for their college home. The Missouri S&T NSBE chapter hosted its annual Pre-College Initiative (PCI) weekend this past February. Approximately 60 students attended. Students participated in a series of workshops, hands-on activities, and a civil engineering design project.

Minority Introduction to Technology and Engineering

June 3-8, 2012 and
June 17-22, 2012

This program is geared toward rising junior or senior who are interested in a career in science, technology, engineering, or mathematics. The students will become acquainted with the various technological degrees that Missouri University of Science and Technology has to offer and what demands people face in these fields. Minority students for this program include African American, Native American and Hispanic American.

For more details visit: http://precollege.mst.edu/mets/mite/

National Society of Black Engineers 38th Annual Conference

March 28-April 1st, 2012
Pittsburgh PA

The Annual Convention is the premier event for the organization which joins members from around the world. This year's theme was "The NSBE Blueprint: Leadership, Teamwork, and Inspiration." This year's Annual Convention was intended to help provide members with a "blueprint" on how to excel academically, succeed professionally and positively impact the community.

Local Transportation News

The Missouri **Local Technical Assistance Program** is located at Missouri University of Science and Technology (Missouri S&T) and operates on funding provided by the Missouri Department of Transportation (MoDOT), the Federal Highway Administration (FHWA) as well as the CTIS.

Missouri LTAP at Missouri S&T has developed partnerships and processes that deliver the highest quality training and technology transfer to local agencies throughout the state. Missouri LTAP is recognized throughout the state for its training, resources and programs that it provides to local agencies. Over the past few years, the Missouri LTAP program has experienced remarkable growth in the number of agencies served, the number of classes conducted and the variety of training classes offered.

Recently Missouri LTAP started offering a new class titled Pavement Best Practices. Asphalt 101 and chip seal techniques are covered during the four hour class. The discussion of asphalt includes mix design and the manufacturing process, storage and handling, and finally the primary uses of asphalt as well emulsions. The chip seal discussion presents ways to assist in the development and implementation of pavement preservation programs by identifying the benefits of using chip seal as part of a preventive pavement maintenance program. It includes detail on the calibration of distributors and chip spreaders, mix design, maintenance of existing roads before chip sealing, and putting together an effective pavement team.

Pavement Best Practices class in Warrensburg, MO on March 22, 2012.

Recent CTIS Visitors

Senator Blunt Visits Campus

February 21, 2012

Senator Roy Blunt and his staffers visited the Missouri S&T campus on February 21, 2012. The Center for Transportation Infrastructure and Safety (CTIS) was the focus of his visit. The visit included a tour of the high-bay structures laboratory in the Civil, Architectural and Environmental Engineering Building followed by a presentation by the CTIS Director. The Director took this opportunity to familiarize the Senator with the mission and research theme areas of the Center and the impact its research has had on the State of Missouri, as well as the Nation.

Dr. Kamal Khayat, CTIS Director (left) and Senator Roy Blunt (right)

New UM System President Visits CTIS

February 7, 2012

The new University of Missouri System President, Timothy Wolfe visited the S&T campus on February 7th. The President officially took office on Wednesday, February 15th. He used the campus visit as an opportunity to familiarize himself with the S&T campus and its research capabilities. During the visit, the President was guided through a tour of the testing facilities in Civil Engineering, met with CTIS faculty and graduate students and was introduced to the CTIS, its research capabilities and the economic impact of its research, education and technology transfer activies.

PROJECT:

Lightweight concrete modification factor for shear friction

- Lesley H. Sneed, Assistant Professor, Dept. of Civil, Architectural & Environmental Engineering, Missouri S&T

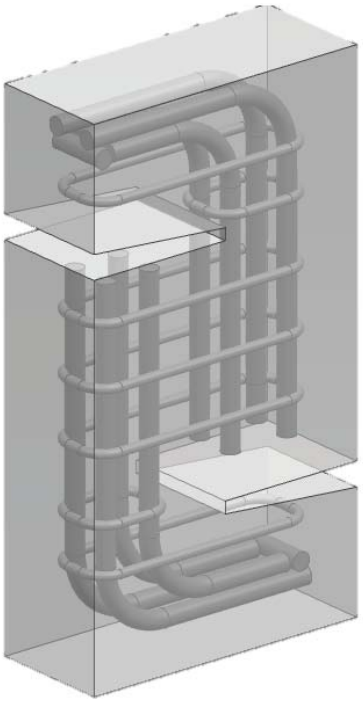

Figure 1. Push-off specimen

This study, initiated in August 2011 by Dr. Lesley Sneed, will investigate the influence of aggregate type on the direct shear transfer across a shear plane at the interface of concrete cast placed against hardened concrete. This direct shear transfer is a function of the friction at the interface, which is related to whether and how the concrete surface has been roughened and the type of aggregate used. Shear friction provisions are commonly used in the design of precast-prestressed concrete structural elements and connections including corbels, dapped double tees, beam bearings, and diaphragms. These types of connections can be critical because there is little or no load redistribution capability if they were to fail.

Current shear friction design provisions are based on experiments performed predominately on test specimens constructed with normalweight concrete. Only a limited number of studies, however, have compared the response of specimens constructed with lightweight concrete, although lightweight concrete is commonly used in practice.

In this project, precast plant practices will first be evaluated to determine procedures commonly used to construct projecting elements such as corbels. Next, 36 push-off specimens (shown in Figure 1) constructed with concrete of different unit weights and compressive strengths will be constructed and tested to examine the influence of aggregate type on the interface friction. Concrete in the test specimens will be placed in two stages so that a cold joint forms along the shear plane to simulate the types of elements that are the focus of this study. Finally, modifications to the Precast/Prestressed Concrete Institute (PCI) shear friction design method will be proposed based upon results from this research.

PROJECT:

Soy-based uv resistant polyurethane pultruded composites

- Chandrashekhara, K., Curators Professor of Mechanical and Aerospace Engineering, Missouri S&T

Pultrusion is considered to be a fast and economical process while producing little waste. Composite parts made by this process are ideal for structural applications because of the high proportion of axial fiber reinforcement. The polyurethane pultrusion process will require an injection box, component metering unit, and redesign of the preforms. In our previous study at Missouri S&T, the pultrusion process has been modified to meet these demands (Figure 1). PU and Soy-PU composites have been manufactured using aliphatic and aromatic PU resin systems.

Objectives: In Task 1, PU resin will be forumulated with higher soy content. In Task 2, nano-engineered soy PU composites will be synthesized. Task 3 will inolve the manufacturing and performance evaluation of pultruded composites.

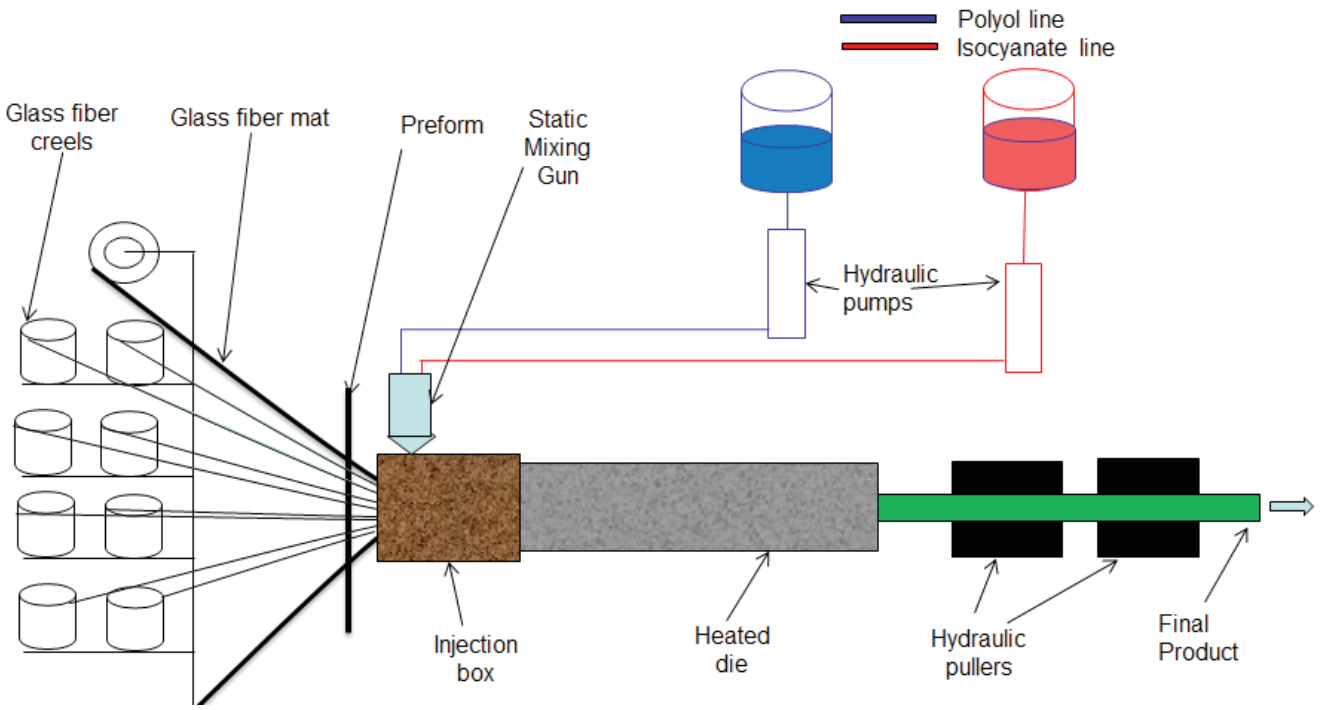

Figure 1. Schematic of the Pultrusion Process

Approach: Aliphatic and aromatic soy-PU resin systems are being studied in this project. Differential scanning calorimetry (DSC) studies are conducted on these resin systems to study cure kinetics and reaction rates.

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Soy-based uv resistant polyurethane pultruded composites (continued)

Also, nano-engineered fillers are incorporated in the soy-based polyol to achieve improved mechanical performance and to reduce cost. The exfoliation of the nano-fillers in the soy-based polyol are studied using X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR). Neat resin coupons are manufactured to assess tensile, flexure, and impact resistance. Pultruded composite parts are manufactured using PU resin system with nano-fillers and their performance is compared to soy-based PU composites without nano-fillers (Figure 2). The effect of UV exposure on mechanical properties of the composites is evaluated (Figure 3).

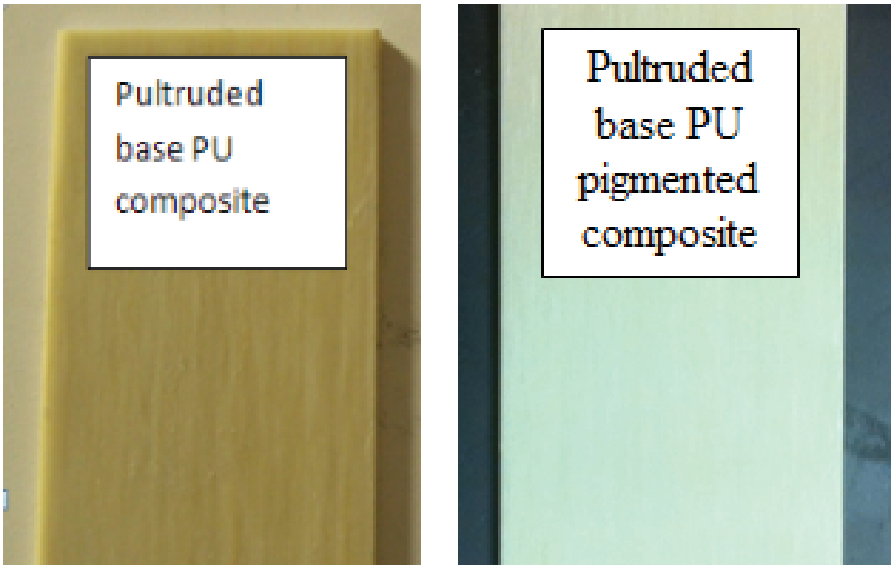

Figure 2. Manufactured Samples of Base and Pigmented Aromatic PU Composites

Benefits: The soy-based pultruded PU composites will find applications in the housing industry (wall, roof, floor, and window lineal systems), modular shelters, automotive, bridge decks, civil infrastructure and armor systems. This will open huge market for soy-based composite structures and will provide economic benefits for soybean farmers. Successful completion of the proposed research will aid in developing low cost, UV resistant and durable soy-based PU composites. The soy-based polymer is poised to move from the laboratory to high volume applications and will generate new markets for agricultural products.

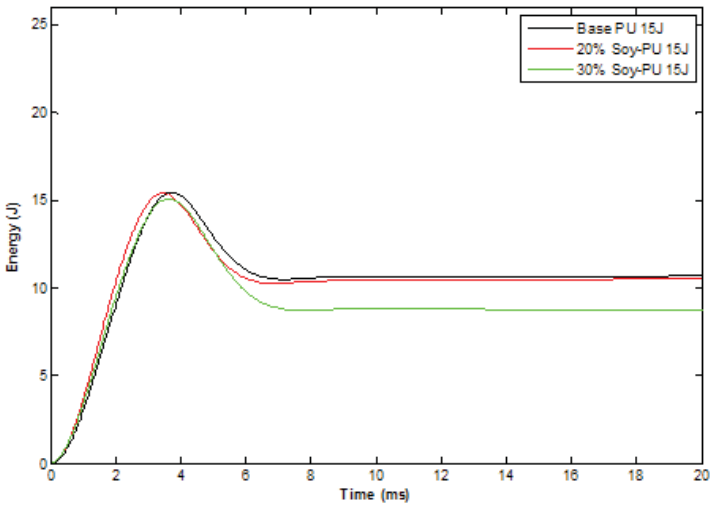

Figure 3. Energy vs. Time of Base-PU and Soy-PU Composites