As fall colors cover the Missouri S&T campus, RE-CAST has many exciting updates to report.

In this issue we provide some featured project updates, including an exciting field project that took place at the O'Hare International Airport in Chicago as well as some Life Cycle Cost Analysis work that our team is working on.

We are happy to report that our summer internship program was a success. This summer we also sponsored a MoDOT Youth Transportation Conference, which entailed 30 underrepresented students coming to the Missouri S&T campus to learn about transportation engineering and to participate in some hands-on learning.

On Oct. 22, the RE-CAST Center offered a webinar presented by Charles Hanskat, Executive Director of the American Shotcrete Association entitled “Shotcrete for Repair and Rehabilitation of Highway Facilities.”

RE-CAST is offering another webinar on Dec. 1 by Julie Hartell from the University of Oklahoma that will be jointly hosted with Southern Plains Transportation Center. Please watch our website for other upcoming webinars and events.

-Kamal H. Khayat
RE-CAST Director
FEATURED PROJECT
Rapid Repair Method for O’Hare International Airport Runway Light Cans

- David A. Lange, Ph.D., Prof. of Civil Engineering, University of Illinois at Urbana-Campaign
- Jihwan Kim, Ph.D., Post-Doctoral Fellow, University of Illinois at Urbana-Campaign
- Yu Song, Ph.D. Candidate, University of Illinois at Urbana-Campaign
- Ruofei Zou, Ph.D. Candidate, University of Oklahoma

Runway lighting is critical to safe flight operations, so it was a major concern to engineers at the Chicago Department of Aviation when light receptacles embedded in the concrete pavement began to show a tendency to displace downward over time. The problem was found to be related to how the original installation process failed to provide sufficient doweling to transfer shear load between the light cans and the pavement under the vertical loading from airplane wheel loads. Some of the displacements were more than 1 in., thus creating a “small pothole” over which the airplane gear had to travel. The nighttime repair concept required that the light cans be removed and replaced within eight hours, allowing normal airplane traffic at 6:00 am the next morning.

UIUC researchers supported by RE-CAST and the O’Hare International Airport proposed a repair method using pre-packed aggregate that would be grouted to create a solid and durable concrete repair.

Figure 1. A 42 in. diameter core is used to extract the original runway light can.
The pre-packed aggregate method offered advantages of providing reliable early structural support much like ballast supporting rail for trains. The use of a rapid set grout transforms the pre-placed aggregate into a concrete mass. The benefit of this method over the use of other rapid set concrete options is that the entire repair can be installed and positioned, and load carrying at early hours is made reliable by the certain rock-to-rock contact created by the packed ballast.

On October 2, 2015, a team consisting of Chicago Department of Aviation, K-FIVE Construction Corp., and University of Illinois personnel joined in a demonstration project to explore the procedural details required to execute this repair method. A 42 in. diameter core was used to remove the original light can, electricians immediately worked to install conduit to the new light can, the aggregate was placed, and then grout was used to saturate the pre-paced aggregate.

The repair was completed, and the demonstration proved valuable in identifying necessary changes in procedural details.
CONCLUSION:
Overall, the repair was shown viable as an alternative that O’Hare will consider as they face the replacement of about 100 problematic light cans without interrupting flight operations by using nighttime repairs.
Sarah Vanhooser
summer intern at Missouri S&T

Sarah Vanhooser, a senior civil engineering undergraduate student, was involved with research on dynamic segregation with Dr. Feys during her summer internship. Sarah was involved in the experimental work in the laboratory and during the field work at Coreslab Structures. She also attended the 6th Advances in Cement-based Materials Conference with graduate student Margarita, who presented the results.

Heitor Fernandez Oliveira De Melo
summer intern at Missouri S&T

Heitor Fernandez Oliveira De Melo is an undergraduate civil engineering student who visited S&T during the summer semester. During his internship, he participated in the following RE-CAST projects:

- Development of ultra-high-performance concrete for thin overlay
- Eco- and crack-free high-performance concrete with adapted rheology
- High-volume recycled materials for sustainable pavement construction

Alex Harris
summer intern at Missouri S&T

Alex Harris is an undergraduate student in civil engineering at Missouri S&T. As part of his RE-CAST summer internship experience, he assisted graduate students in completing their research in the S&T structures lab and materials lab. He helped setting up beams with external fiber reinforcement to be tested in a two point load configuration. He worked with mixing self-consolidating eco-friendly mortar as well as UHPC containing various supplementary cementitious materials, chemical admixtures, and steel fibers.

Arnaud Lozachmeur
summer intern at Missouri S&T

Arnaud Lozachmeur is an second year civil engineering student who visited S&T for the summer semester. During his internship, he assisted many RE-CAST graduate students in the laboratory in order to gain practical experience in the area of advanced construction materials.
Meet the 2015 RE-CAST Summer Interns (continued)

Kyrah Williams
summer intern at University of Miami

Kyrah Williams is an undergraduate student at the University of Miami pursuing her bachelor’s degree in Architectural Engineering. She is currently the President of National Society of Black Engineers. After Kyrah graduates, she hopes to pursue her Masters in Architecture.

Catherine Alexis Wells
summer intern at University of Miami

Alexis Wells is pursuing a bachelor’s degree in mechanical engineering at the University of Miami. She participated in the RE-CAST research internship program and her area of focus was FRCM composites as a strengthening material for concrete.

Matthew Kesler
summer intern at University of Miami

Matthew Kesler is an undergraduate student at the University of Miami. Matthew is a member of Chi Epsilon, the civil engineering honor society, where he serves as marshall. Upon graduation, Kesler plans to pursue a M.S. in structural engineering. As a RE-CAST intern, he assisted with the material characterization of novel fiber reinforced composites along with a variety of other research.

- Continued Next Page -
Meet the 2015 RE-CAST Summer Interns (continued)

Nischal Pradhan  
summer intern at University of Oklahoma

Nischal Pradahna, a native of Kathmandu, Nepal, is an undergraduate student studying civil engineering at the National Institute of Technology, Warangal, India. During his internship, Nischal was involved in the design and testing of concrete mixtures for several RE-CAST projects.

Alixandra Bradford  
summer intern at University of Oklahoma

Alixandra Bradford is a female undergraduate civil engineering student at the University of Oklahoma. Alix was involved in the design and testing of concrete mixtures for several RE-CAST projects.

Nanaissa Maiga  
summer intern at University of Illinois at Urbana-Champaign (UIUC)

Nanaissa Maiga is a undergraduate student UIUC. She participated as an undergraduate researcher in Prof. D. Lange's group. She worked on concrete materials testing under the supervision of graduate students sponsored by the RE-CAST UTC funding.
FEATUERED PROJECT


- Kaan Ozbay, Ph.D., Professor of Civil and Urban Engineering, New York University
- Jingqin Gao, Ph.D., Candidate, Civil and Urban Engineering, New York University

The Rutgers-NYU team has been developing a novel probabilistic approach to the life cycle cost analysis (LCCA) in comparing the life cycle cost of conventional and high-performance materials to assist decision-makers in finding optimum investment strategies with budget constraints.

Aging facilities along with growing demand in terms of operational and environmental requirements as well as increasing costs associated with maintaining our transportation infrastructure have led agencies to seek the development of innovative materials and construction technologies. However, reliable decision-making tools for the selection of the best combination of existing and new materials and/or construction methods are needed. Life cycle cost analysis is one of such decision-making tools that take into consideration the life cycle cost of the entire project, including future maintenance and repair costs, vehicle operation costs, work-zone delay cost, and socio-economic impacts resulting from all of these activities.

Clearly, it is not trivial to predict the actual field performance of a brand new construction material or technology that has either being tested in a laboratory environment or underwent a very limited field deployment. Its performance prediction must thus rely on these limited tests or deployment results combined with expert opinions for the most likely values of its behavior under real-world conditions. This approach increases the uncertainty of such predictions. As a result, these uncertainties demand the use of a probabilistic approach to appropriately apply LCCA. Furthermore, the fact that these uncertainties can also vary in time creates the need for a robust stochastic treatment of the individual scenarios that will be evaluated as part of the proposed LCCA methodology.

In the light of all these complications, two different hypotheses are proposed:

1) Apply a hypothesized improvement rate to the deterioration functions of existing and well-known materials to represent the expected enhanced performance of a new material compared with a conventional material with relatively similar characteristics;

2) Utilize the correlation function between the results of laboratory tests and field performance of known materials to predict the expected performance of a new material based only on its laboratory tests.

Figure 1 illustrates the proposed methodology of the two approaches. Stochastic treatment proposed for both approaches is needed to evaluate performance of the new material that has high level of uncertainty. As more information and field data becomes available in the near future, “hypothesized performance functions” will continue to be re-evaluated and improved.

Figure 2 is the representation of the life cycle of analysis approach and its corresponding costs of two different types of materials, namely conventional and new. As seen in this figure, an assumption about the performance of novel and sustainable materials similar to those under development by RE-CAST researchers will have to be made.

The proposed approaches to predict the performance of new materials are further described on the following page to illustrate the way they will be adopted in this study.

1) Improvement rate approach

Normally, estimated values or models based on historical data are used as input to life-cycle analysis when quantifying costs. However, for a new material or construction technology, there may not be adequate data to describe its real-world performance. An interim solution is to define metrics for the new material / technology as a percent improvement rate with respect to a current conventional material with a known performance function. Then, this percent improvement rate is applied deterministically or probabilistically to this known performance function. Figure 3 shows an hypothetical example of the life cycle of a traditional versus new material in terms of maintenance and replacement actions. Both deterministic and stochastic approaches are illustrated in Figure 3 for the same hypothetical example.

2) Correlation approach

There have been considerable amount of research efforts conducted to develop “performance tests” that can link performance of parameters measured in the laboratory to actual in-situ pavement or bridge performance. This proposed approach is focused on such a correlation methodology between laboratory results and the available correlation values from published data based on actual field performance. If a correlation function between laboratory and field performance of a well-known material exists, one can assume that this relationship remains the same for the new material as well. This same correlation methodology can be used to estimate the field performance of new material. This correlation function may include coefficient of thermal contraction, Poisson’s ratio, complex modulus, resilient modulus, relaxation modulus and so on.
In addition to the probabilistic LCCA methodology described above, a web-based software tool that can access state-wide infrastructure data is being developed. This tool is able to automatically extract road and traffic data for each link. This data is needed to calculate life cycle costs of each individual link using the proposed LCCA methodology for different scenarios. We will incorporate a flexible interface to define performance functions specific to the construction materials/technologies used. This will be in addition to default performance functions for conventional construction materials/technologies. This tool is also envisioned to serve as a database of performance functions.

Moreover, the advantage of a web-based tool is that it can be used by any user without having to install additional software (and possibly data) on their own computers. This simplifies the process of using the developed software by a large number of users who just need to have access to a web browser.

In the near future, the research team will start testing the proposed LCCA approach using real-world and laboratory data.
DIVERSITY AND OUTREACH

MoDOT 2015 Annual Youth Transportation Conference

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.

RE-CAST sponsors this activity by providing assistance with a bridge building activity, shown below, that took place during the field trip to Missouri S&T on July 22nd. 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.

“RE-CAST is very pleased to support this annual 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. H. Khayat, RE-CAST Director

Pictured below:
Iman Mehdipour, RE-CAST Ph.D. student, with camp participants

Pictured center:
Jason Cox, RE-CAST technician, helps students test bridge structures

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LEADERSHIP SPOTLIGHT

RE-CAST Director named RILEM Fellow

Dr. Kamal H. Khayat, RE-CAST Director, has been named a Fellow of RILEM, the International Union of Laboratories and Experts in Construction Materials, Systems and Structures.

“The award of a RILEM Fellowship is a rare honor,” says RILEM president Mark Alexander. “It is given for exceptional contributions to the work of RILEM and includes aspects such as scientific contributions and developmental contributions.”

Khayat is one of only 64 named Fellows in the RILEM organization.

RE-CAST Associate Director invited to present in Bogota

Dr. Antonio Nanni, RE-CAST Associate Director, was invited to present “Case Studies on Strengthening of Concrete and Masonry Structures” by the ACI Columbian Chapter and Columbia Association of Seismic Engineering during their seminar entitled “Strengthening of Concrete and Masonry Structure with FRP”. The seminar took place in Bogota, Columbia on July 23, 2015.

“We below that your participation will lead to the success of the seminar given your recognized expertise on this topic and active participation in the ACI 440 Committee “Fiber Reinforced Polymer Reinforcement”, one of the most prominent technical groups in the world working on the development of guidelines for the use of FRP for strengthening of concrete and masonry structures.” - Pedro Nel Quiroga and Juan Francisco Correal, seminar organizers
Full-depth precast concrete deck systems have several advantages over traditional cast-in-place (CIP) concrete decks in bridge construction, such as improved construction quality, reduced construction time and impact on traveling public, possible weight reduction, and lower bridge life-cycle cost. Existing full-depth precast concrete deck systems use either open channels or open pockets at 2 ft spacing for connecting to supporting girders to achieve a composite system. These channels and pockets are typically grouted and then overlaid to cover the exposed surface, which negatively affect construction duration and cost.

Recent development in full-depth precast concrete deck systems allowed using covered individual pockets at 4 ft spacing to simplify fabrication and eliminate the need for deck overlays, which speeds up construction and enhances deck durability and economy. However, this development requires the use of specially proportioned flowable concrete to completely fill the blind pockets as well as the gap between precast concrete deck panels and supporting girders. A research project was conducted with researchers at Missouri S&T, in collaboration with University of Nebraska-Lincoln to develop a self-consolidating concrete (SCC) mixture for this specific application and to experimentally investigate its constructability using small-scale and full-scale mock ups. Results indicated the excellent performance of the developed...
mixture in both fresh and hardened conditions in addition to its economy, which led to the implementation of this new generation of full-depth precast concrete deck systems in the construction of Kearney East Bypass bridge project in Kearney, NE.

The project consists of twin bridges over US-30 and Union Pacific rail road: south bound bridge constructed using conventional CIP deck; and north bound bridge constructed using the new precast concrete deck system. Each bridge is 41 ft 8 in. wide and 332 ft long and has two equal spans with five prestressed concrete girders in each span at 8 ft 6 in. spacing. The bridge deck consisted of 28 full-width panels, each panel is 12 long and 8 in. thick. After installing the deck panels, grouting transverse joints, and post-tensioning deck panels longitudinally, a total of 120 cubic yards of the developed SCC was placed through 4 in. diameter grouting/inspection holes located at 4 ft spacing on the deck surface using an innovative process to ensure the complete filling of the shear pockets and the gap between the deck and girders in an efficient manner. Figures 2 and 3 show the slump flow of the SCC (averaged 28 in.), placing apparatus used to funnel the pumped SCC into the holes, sand buckets used to cover the filled pockets and force SCC to flow to the next ones, and the completed deck. This process was very successful and efficient as it resulted in a continuous placement that took approximately 1 hour for each girder line. A video of SCC placement process can be watched at: https://www.youtube.com/watch?v=wFC8zxpVDp8. The use of workability retaining admixtures and 3/8 in. nominal maximum aggregate size assisted in maintaining concrete flowability for over an hour and ensured full encapsulation of reinforcing bars and strands in very tight spaces. This successful implementation has proven that SCC can be used as an economical and superior alternative to commercial grouts in bridge construction.
WEBINAR SERIES

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

October 22, 2015 at 11am CDT
Presenter: Charles Hanskat, P.E.
Executive Director, American Shotcrete Association
“Shotcrete for Repair and Rehabilitation of Highway Facilities”

This seminar, presented by the American Shotcrete Association (ASA), will give the owner, design engineer, project specifier, field inspector, and general contractors an overview on how shotcrete can be efficiently, and cost effectively used for structural repair and rehabilitation of concrete bridges and associated structures. We will provide a basic overview of the shotcrete process, cover the design, specifying and detailing considerations for shotcrete repairs. Next, we use specific project case studies from a variety of projects across the USA to illustrate field considerations and the sustainability benefits gained when using shotcrete for repair including reduced formwork needs and scheduling advantages. We also discuss achieving quality of shotcrete addressing field inspection, specific placement techniques, nozzlemaster certifications, and contractor qualifications. We wrap up with a discussion of new ASA programs for shotcrete inspector training, and contractor qualification as well as providing a listing of appropriate references and resources on use of shotcrete for structural concrete repair.

December 1, 2015 at 11am CDT
Presenter: Julie Hartell, Assistant Professor
Civil and Environmental Engineering
Oklahoma State University
Topic Coming Soon

Presented in partnership with Southern Plains Transportation Center (SPTC) at University of Oklahoma
UPCOMING TECHNOLOGY TRANSFER EVENTS

4th Annual Transportation Infrastructure Conference
Date: Friday, December 4, 2015
Location: St. Louis University

SCC2016 - “Flowing Towards Sustainability”
Dates: May 15-18, 2016
Location: Washington, DC

Overview: The conference combines the 8th RILEM Symposium on SCC and the 6th 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
Contact Information:

Website: http://recast.mst.edu

Email: re-cast@mst.edu

Director: Kamal H. Khayat - khayatk@mst.edu

Coordinator/Newsletter Editor: Abigayle Sherman - abigayle@mst.edu

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