Research on Concrete Applications for Sustainable Transportation

RE-CAST

MISSOURI S&T

Vol. 3 :: Issue 4 :: FALL 2016

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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

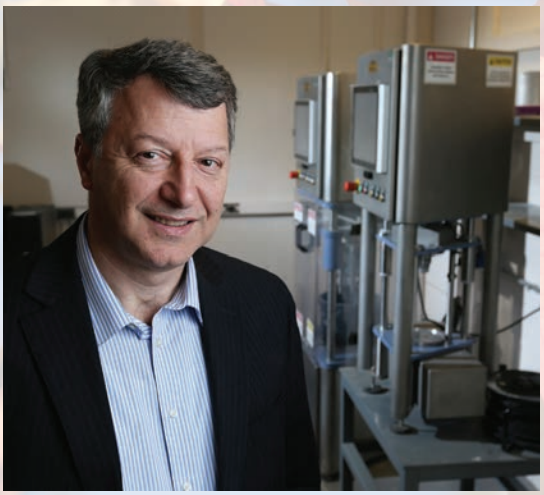
Director's Message

As the leaves fall and temperatures grow colder, we invite you to grab a mug of hot apple cider and catch up on some activities happening at RE-CAST.

We have two research project updates to report on and invite any questions our readers may have about them. Our research team's contact information is available on our webpage and we invite your feedback.

We are co-hosting a joint online webinar with the Center for Environmentally Sustainable Transportation in Cold Climates (CESTiCC) and the ACI Alaska Chapter on Nov. 9. Dr. Antonio Nanni of RE-CAST will present "The Role of Cementitious Materials in the Next Decade." We invite you to vist our webinar library for additional details and to register.

We also have the 5th Annual Missouri S&T/MoDOT Transportation Infrastructure Conference taking place on the Rolla campus on Friday, November 18. We invite our viewers to register for this event.



We would also like to share with you a recent student success, which we feel is a great recognition of her hard work and the importance of our research. See our Student Spotlights for more details.

Kamal H. Khayat
RE-CAST Director

FEATURED PROJECT

Field Implementation of Crack-Free Concrete: A case study using High-Early Strength (HES) High Performance Concrete (HPC)

- Hani Nassif, Ph.D., Professor of Civil Engineering, Rutgers University
- Chaekuk Na, Post-Doctoral Associate, Rutgers University

Figure 1. Bridge Overview for Field Implementation

Bridge re-decking in urban areas always requires the application of the staged construction process due to the heavy traffic. The presence of heavy truck traffic in lanes adjacent to freshly poured concrete would increase the potential of cracking at early age (i.e., 6-8 hours) prior to the concrete gaining sufficient strength. Based on a detailed finite element analysis using data form Weigh-In-Motion (WIM) and structural health monitoring sensors, it was shown that in order to minimize the cracking potential due to trucks in adjacent lanes, a minimum compressive strength of 1100 psi at 6 hours. Therefore, partial traffic closure for lanes adjacent to the freshly poured concrete was mandated to help minimize the cracking potential at early-age. The state Maintenance and Protection of Traffic (MPT) specification allows closing after 7 PM and then opening again before 6 AM, and in order to meet the MPT and strength requirement, the designed strength should be achieved at 6 hours. The two main challenges for this field implementation were how to ensure the strength of 1100 psi at 6 hours while maintaining low shrinkage for the HPC, and how to implement an acceptance criterion in the specification for the target compressive strength.

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FEATURED PROJECT

Field Implementation of Crack-Free Concrete *(continued)*

The research team, with funding from New Jersey Turnpike Authority (NJTA) and RE-CAST, performed a detailed research program to develop and implement a special HES-HPC mix design, similar to HPC mixes currently used on NJTA projects. The best mixture developed under laboratory conditions were also by two concrete producers in their batching plants.

For implementing this HES-HPC mixture in a field project (shown in Figure 1), special technical specifications for HES-HPC utilizing the maturity method for estimating the strength within the first 24 hours (in lieu of concrete cylinders) for the entire project was developed. Additionally, the research team developed a detailed specification for curing of the HES-HPC using heat blanket between 6-12 hours to help attain the target strength during cold weather.

The specifications consist of three phases, 1) development, 2) verification and 3) production for the implementation of HES-HPC into the bridge deck reconstruction.

Development Phase: A number of mixtures, including those with various supplementary cementitious material, set-accelerating admixture and slump retaining admixture, were prepared and cured at different curing temperatures (blanket, heat-blanket, hot water) to simulate different field conditions. By the end of this phase, the HES-HPC mix design was developed to fulfill the strength and shrinkage requirement and a corresponding strength-maturity (S-M) relationship was also developed. It was found that the concrete initial temperature should be 75°F+, and the concrete temperature at 6 hours should be 100°F to fulfill the strength requirements.

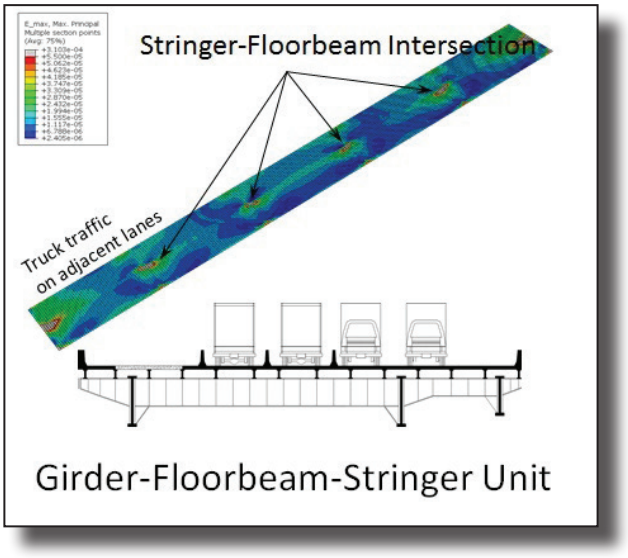

Figure 2.
Finite Element Model and Analysis with Site Specific WIM Data and Staging

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FEATURED PROJECT

Field Implementation of Crack-Free Concrete *(continued)*

Figure 3. Verification Phase - Trial Slab

Verification Phase: Two trial slabs were cast (as shown in Figure 3) to replicate the field conditions and to validate the pre-developed S-M relationship. Maturity probes and thermocouples were installed in the slab at mid-depth at several locations to estimate strength. Results showed that the S-M relationship matched the pre-determined relationship.

Production Phase: The HES-HPC mixture was utilized for the bridge deck reconstruction (as shown in Figures 4 and 5) with the maturity requirement. Three maturity probes were instrumented in the slab at every 50 cubic yard for the estimation of concrete strength based on the predetermined and validated S-M relationship. It was found that the majority concrete pours obtained the target compressive strength at 6 hours based on the maturity index of each pour.

Figure 4. Production Phase: HES-HPC Pouring

Figure 5. Production Phase: Maturity Probe Installation

FEATURED PROJECT

Field Implementation of Crack-Free Concrete *(continued)*

The specifications included research efforts to develop and implement in the field a new mix design, monitoring of traffic pattern using a WIM system to develop live load model at service, development and calibration of a detailed finite element model, and implementation of the new specifications. Throughout the project, the specification provided a good guidance for the success of the deck replacement project as well as a good quality of concrete. The HES-HPC has been used on similar NJTA projects and is planned to be sued on the additional projects where concrete deck staging is required.

STUDENT SPOTLIGHT

RE-CAST student/faculty recieve outstanding paper award

Zena R. Aljazaeri: Outstanding Paper Award at SCMT4

Ms. Zena R. Aljazaeri, Missouri S&T Ph.D. Candidate/RE-CAST Student and Professor **John J. Myers**, Ph.D., P.E., F.ACI, F.ASCE, F.TMS received the Outstanding Paper Award at the 4th International Conference on Sustainable Construction Materials and Technologies (SCMT4) held recently in Las Vegas, NV, USA. The title of the paper was: "***Strengthening of Reinforced Concrete One-Way Slabs for Flexure Using Composite Materials: Evaluation of Different Composite Materials***" which investigated new innovative composite material techniques for structural strengthening of RC slabs. The technology is expected to be transferred into the rehabilitation of a load posted bridge in Howell County, Missouri within the next year extending laboratory work into practice.

Congratulations to Zena and Dr. Myers for this recognition of thier RE-CAST work.

FEATURED PROJECT

Mechanical and Durability Performance of Reinforced Concrete One-Way Slabs Strengthening In Flexural: *Evaluation of Different Composite Materials*

- John J. Myers, Ph.D., P.E., Professor of Civil and Architectural Engineering, Missouri S&T
- Zena R. Aljazaeri, Ph.D. Candidate, Missouri S&T

Figure 1. Strengthened slabs inside the environmental chamber at Missouri S&T

Researchers from Missouri S&T are investigating new sustainable composite materials targeted for rehabilitation and repair of existing aging infrastructures. The study focused on three different composite materials in term of the reinforcing fibers and the bonding agents. The composite material systems that were investigated included: polyparaphenylene benzobisoxazole (PBO) fabric with a cement based curing agent (FRCM), carbon fiber grid with a polymer curing agent, and steel reinforced polymer (SRP). Particularly, the research was undertaken with two key objectives in mind. The first aim was to examine the effectiveness of composite materials on the flexural enhancement of one-way slabs. The second aim was to evaluate the durability performance of the composites on the flexural behavior of the strengthened RC slabs exposed to environmental conditioning. In total, fourteen (14) RC one-way slabs were designed, cast, and strengthened with one of the aforementioned composite strengthening systems. **Figure 1** shows representative slabs specimens in an environmental chamber being exposed to cycles of freezing and thawing, high temperatures, and high relative humidity that were intended to simulate severe weather conditioning. The flexural test results increased strengthened slabs' ultimate load carrying capacity by approximately 1.3 to 2 times that of the unstrengthen slab. Testing of the conditioned strengthened slabs resulted in very similar flexural strength results compared to the unexposed strengthened slabs. It was noted that the high temperature cycles inside the environmental chamber had a benefit of improved curing the FRCM composite which resulted in improved displacement ductility. In the case of the SRP or CFRP-grid composite systems, the sensitivity of the epoxy curing agents to high temperatures resulted in lower displacement ductility compared to the FRCM system.The anticipated next phase of work will involve the rehabilitation of a four span load posted bridge in Howell County, MO in cooperation with RE-CAST partner, University of Miami.

UPCOMING TECHNOLOGY TRANSFER EVENTS

Save the Dates:

5th Annual
Missouri S&T/MoDOT Transportation Infrastructure Conference

Date: November 18, 2016

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.

REGISTER: http://cies.mst.edu/conference

UPCOMING WEBINARS

CESTiCC, RE-CAST and the Alaska Chapter of ACI present:

The Role of Cementitious Materials in the Next Decade

Wednesday, November 9, 2016 - 9:00AM Alaska Time

REGISTER: http://cem.uaf.edu/cesticc/webinars.aspx

Presenter: Antonio Nanni

This webinar presents a personal perspective on the potential impact of cementitious materials in the construction industry over the next decade. While it is true that today concrete and its derivatives are ubiquitous, their presence and use can only grow as academia and industry address the challenges of sustainability and resilience. The webinar briefly discusses some of the topics that will fuel this growth and can be considered low-hanging fruits. They include: a) new classes of binders complementing portland cement; b) non-corrosive reinforcement resulting in concrete without chloride limits; c) use of saltwater and recycled/alternative aggregates; and, d) brittle matrix composites for repair.

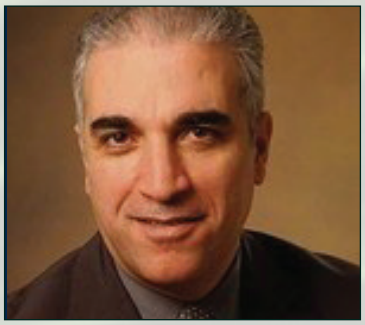
Engineering, smart, stimuli-responsive cementitious composites

Thursday, November 17, 2016

Presenter: Dr. Raissa Ferron, Assistant Professor, University of Austin at Texas

WEBINAR SERIES

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



October 11, 2016

Presenter: Hani Nassif, Professor of Civil Engineering

Rutgers University

"Structural Health Monitoring (SHM) of Corrosion Potential in Concrete Bridge Decks"

August 12, 2016

Presenter: Kaan Ozbay, Professor of Transportation Engineering

New York University

"An Overview of a Network-wide Probabilistic Life Cycle Cost Analysis Methodology and Implementation Framework for New Concrete-based Materials and Construction Techniques"

Extending the Service Life of New Reinforced Concrete Structures by Using Advanced Composite Materials Workshop

- Joint workshop offered with University of Bath (UK)

July 29, 2016

RE-CAST Presenter: Antonio Nanni, Professor of Civil Engineering, Univ. of Miami

STAY INFORMED
STAY CONNECTED

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