

PROGRAM PROGRESS PERFORMANCE REPORT #3

GRANT: DTRT13-G-UTC45
Reporting Period: 10/01/2014 – 03/31/2015

RE-CAST:
**REsearch on Concrete Applications for
Sustainable Transportation
Tier 1 University Transportation Center**

Consortium Members:

Missouri University of Science and Technology
Rolla, MO

University of Illinois at Urbana-Champaign
Urbana, IL

Rutgers, The State University of New Jersey
Piscataway, NJ

University of Miami
Coral Gables, FL

Southern University and A&M College
Baton Rouge, LA



TABLE OF CONTENTS

1. ACCOMPLISHMENTS..... 3

1.A - What Are The Major Goals And Objectives Of The Program? 3

1.B - What Was Accomplished Under These Goals? 6

1.C - What Opportunities For Training And Professional Development Has The Program Provided?. 12

1. E - What Do You Plan To Do During The Next Reporting Period To Accomplish The Goals And Objectives?..... 13

2. PRODUCTS 14

2.A - Publications, Conference Papers, and Presentations 14

2.B - Website(s) or Other Internet Site(s) 16

2.C - Technologies or Techniques 17

2.D - Inventions, Patent Applications, and/or Licenses 17

2.E - Other Products, Such As Data Or Databases, Physical Collections, Audio Or Video Products, Software Or Netware, Models, Educational Aids Or Curricula, Instruments, Or Equipment 17

3. PARTICIPANTS & COLLABORATING ORGANIZATIONS..... 17

3.A - What Organizations Have Been Involved As Partners? 17

3.B - Have Other Collaborators Or Contacts Been Involved? 18

4. IMPACT 18

4.A - What Is The Impact On The Development Of The Principal Discipline(s) Of The Program? 18

4.B - What Is The Impact On Other Disciplines? 18

4.C - What Is The Impact On The Development Of Transportation Workforce Development?..... 19

4.E - What Is The Impact On Physical, Institutional, And Information Resources At The University Or Other Partner Institutions? 19

4.F - What Is The Impact On Technology Transfer? 19

4.G - What Is The Impact On Society Beyond Science And Technology? 19

5. CHANGES/PROBLEMS 19

5.A - Changes In Approach And Reasons For Change..... 19

5.B - Actual Or Anticipated Problems Or Delays And Actions Or Plans To Resolve Them 19

5.C - Changes That Have A Significant Impact On Expenditures..... 19

5.D - Significant Changes In Use Or Care Of Animals, Human Subjects, And/or Biohazards 19

5.E - Change Of Primary Performance Site Location From That Originally Proposed 19

6. SPECIAL REPORTING REQUIREMENTS 19

1. ACCOMPLISHMENTS

1.A - What Are The Major Goals And Objectives Of The Program?

The overall goal of this grant is to develop the next generation of cement-based construction materials that are essential to address the growing technical and environmental requirements of the transportation infrastructure. The research program aims to fast-track the acceptance of these technologies and develop national standards and guidelines for their use in the reconstruction of the nation's infrastructure for the 21st Century.

Research Goals

The RE-CAST program goal stated above will be accomplished by performing the following research projects:

- 1-A. Ecological and Crack-Free High-Performance Concrete with Adapted Rheology
- 1-B. Formwork Pressure Measurements and Prediction of High-Performance Concrete with Adapted Rheology
- 1-C. Influence of Casting Conditions on Durability and Structural Performance of High-Performance Concrete with Adapted Rheology
- 2.A. High-Volume Recycled Materials for Sustainable Pavement Construction
- 2.B.1 Rapid Pavement Rehabilitation
- 2-B.2 Rapid Pavement Construction
- 3-A. Performance of Fiber Reinforced Self-Consolidating Concrete for Repair of Bridge Sub-Structures and fiber-reinforced Super-workable Concrete for Infrastructure Construction
- 3-B. Ultra-High Performance Fiber Reinforced Concrete for Infrastructure Rehabilitation
- 3-C. Performance of Reinforced Concrete Decks Strengthened with Fabric-Reinforced-Cementitious-Matrix Composites

Education and Workforce Development (EWD) Goals

The main goal of RE-CAST's Education and Workforce Development program is to develop a workforce trained in the interdisciplinary scholarship needed to understand and address the complex issues facing the implementation of a durable, reliable, and sustainable infrastructure. This is to be achieved by creating multidisciplinary educational opportunities for undergraduate and graduate students in the theme areas of the Center, as well as outreach activities for practitioners.

Education Objectives:

- 1) RE-CAST faculty members will collaborate to create the following courses related to the major thrust areas of the Center:
 - Fundamentals of Rheology and Self-Consolidating Concrete (S&T and UIUC)
 - Structural Health Monitoring Applied to Transportation (Rutgers University and SUBR)
 - Repair Materials and Strategies for Civil Infrastructure (Multiple Universities)
- 2) RE-CAST is to collaborate with national laboratories and DOT research entities, such as NIST and MoDOT-R&D, to host students on scholarly efforts.
- 3) The Center will actively contribute to annual conferences in the transportation field organized by the consortium Universities, including the Transportation and Highway Engineering Conference and the Structural Engineering Conference at UIUC as well as the Transportation Infrastructure Conference at S&T.

Workforce Development / Outreach Objectives:

A. Outreach Activities to Attract New Entrants into the Transportation Field

- 1) RE-CAST members will seek opportunities to invite junior faculty from complementary fields, such as engineering management, mechanical engineering, chemical engineering and chemistry to team up with RE-CAST faculty on various research projects.
- 2) *Graduate Research Assistantship in Transportation Areas (GRATA)* - RE-CAST will provide graduate research assistantships to highly qualified Ph.D. students.
- 3) *Invited Speakers and Field Trip Visits* – RE-CAST will collaborate with the CIES at S&T and student societies at the participating Universities, including ASCE and ACI to organize bi-monthly seminars featuring invited speakers from industry
- 4) *ACI / Portland Cement Association (PCA) / Prestressed Concrete Institute (PCI) Co-Funded Scholarships* – RE-CAST will explore the possibility of providing matching funds to the scholarship programs that these organizations currently offer on a nation-wide basis for Fellowship students
- 5) *Student Competition* – RE-CAST will work with professional student societies to organize a new competition on sustainable construction materials.
 1. Two competitions will be organized at different locations: (a) design of concrete with a minimum of 50% of recycled materials with the highest strength at Rutgers University/SUBR; and (b) development of fiber-reinforced thin elements with minimum fiber content and maximum ductility at UM/S&T.
- 6) *UTC Student of the Year* – Each year, RE-CAST will select a Student of the Year based on scholarly merit and academic achievement.

B. Primary and Secondary School Transportation Workforce Outreach

- 1) RE-CAST will support the *Minority Introduction to Technology and Engineering MITE* summer program.
- 2) *Proposed Activities with Career Technical Education System* – RE-CAST will reach out to local technical trade schools to offer short courses for students in construction-related degree programs to showcase recent developments within their trade.

Technology Transfer Goals

The main goal of RE-CAST related to technology transfer is to work towards advancing transportation proficiency through technology transfer and educational opportunities and to make research results available to potential users in a form that can be implemented.

Technology Transfer Objectives:

A. Partnerships Across Sectors to Move Research into Practice

- 1) RE-CAST will collaborate with MO-LTAP and LA-LTAP to introduce and deliver new materials related to RE-CAST research themes that can be incorporated into workshops and technology transfer activities to service providers and professionals from the transportation industry.
- 2) RE-CAST will work with the Louisiana Transportation Research Center (LTRC) on technology transfer.

B. Technical Assistance to Others in Applying Research Results

- 1) The Center's website will publish detailed documentation of special construction procedures through videos and photos and will also provide data from the research investigations.
- 2) Faculty from RE-CAST as well as technical staff will be available to provide technical assistance to practicing engineers and state and local agencies in the design and construction of the various materials developed by the RE-CAST program.

- 3) RE-CAST faculty will actively disseminate knowledge and develop guidelines and standards through numerous technical committees (TRB, ACI, ASCE, PCI, ACerS, RILEM, and CSA).
- 4) RE-CAST faculty members will also organize sessions at the technical conventions (e.g., TRB, ACI, ASTM, and ASCE) to disseminate the latest findings in the theme areas of sustainable construction materials, NDE and monitoring of infrastructure, service life prediction, and LCCA of transportation infrastructure.
- 5) RE-CAST will also collaborate with various technical committees (e.g., ACI) to develop certification programs on special test methods dealing with the characterization of the materials developed in the research program, including rheological properties, dynamic segregation, and pumpability of HPC-AR.
- 6) RE-CAST will also collaborate with other UTCs working in the State of Good Repair focus area as well as other national/regional centers, including the NSF Industry/University Coop. Research Center for the Integration of Composites into Infrastructure (CICI) at UM and the Infrastructure Monitoring and Evaluation (RIME) Group at Rutgers University.

C. Technology Transfer Mechanisms/Creation of New Business Entities

- 1) The RE-CAST research team will work with the Technology Transfer and Economic Development Center (TTED) at S&T to develop marketing plans and subsequent commercialization of any product(s) and deliverables that can stem from the research program.

D. Information Exchanges

- 1) The team will publish the findings of the proposed research in joint publications involving the different faculty and their students from the partnering consortium members.
- 2) Social media (Facebook and LinkedIn) will be utilized to publicize on-going research, training, and technology transfer events, including field demonstrations, webinars, and educational videos stemming from research activities.
- 3) Research outcomes of the RE-CAST program will be uploaded into the U.S. DOT Research Hub in a timely manner.
- 4) A website with links to a listing of upcoming technology transfer events, educational seminars and workshops, presentations, and project reports.
- 5) Quarterly newsletters highlighting project updates, featured faculty and students, and field implementations of research projects.

Diversity Goals

The main goal of RE-CAST with regard to Diversity is to broaden participation and enhance diversity of the students, researchers, and practitioners involved in transportation-related activities and careers. In the consortium Universities, many initiatives have been created to ensure an inclusive environment related to race, ethnicity, gender, gender identity, sexuality, disability, economic class, religion, and country of origin.

Diversity Objectives:

- 1) Summer Internship for Underrepresented Students - SUBR and Rutgers University, through collaborative projects among faculty members of the Center, will offer summer internship programs to undergraduate students to undertake internship programs at partner institutions.
- 2) RE-CAST will provide support in educational and outreach activities and financial aid in the form of scholarships to bring underrepresented students into transportation engineering-learning opportunities through the following programs:
 - The *Women's Leadership Program* at S&T
 - The *Summer Transportation Institute* at SUBR

- *The Gates Millennium Scholars Program* at UM
- *The Hammond Scholars Program* at UM

1.B - What Was Accomplished Under These Goals?

Research Objectives Accomplished: *Project Updates*

1-A. Ecological and Crack-Free High-Performance Concrete with Adapted Rheology

Missouri S&T

The aim of this project is to develop a new generation of environmentally friendly and crack-free high-performance concrete designated for pavement (Eco-Pave-Crete) and bridge deck constructions (Eco-Bridge-Crete). The first phase of laboratory evaluation carried out at Missouri S&T was undertaken to evaluate the effect of binder type and content on admixture demand, heat flux, rheological properties and thixotropy, development of compressive strength, electrical resistivity, and drying shrinkage of mortars. In total, 24 concrete equivalent mortars made with different types and replacement levels of binary, ternary, and quaternary binder systems were evaluated to optimize the binder type targeted for various applications. Portland limestone cement (PLC) with less than 15% limestone replacement was used for all mixtures. The second phase of laboratory testing was carried out to optimize the combined aggregate blends with high packing density. The research team visited different aggregate quarries in Missouri to evaluate local materials. The influence of physical characteristics of the aggregate, including shape, texture, and particle size distribution on packing density were investigated to optimize aggregate combinations that can secure high packing densities. This step is essential to reduce cement paste and enhance performance, including ecological aspects. Research program is currently underway to develop low shrinkage concrete with high resistance to cracking.

University of Oklahoma

The University of Oklahoma research team investigated potential implementation phases of Projects 1A, 2A, and 3A with the Oklahoma Department of Transportation; Oklahoma City, Norman, and Tulsa, Oklahoma, City Planning Departments; Grand River Dam Authority; and the Oklahoma Turnpike Authority. The team also received a \$100,000 equipment grant from the OU Foundation in support of Projects 1A, 2A, and 3A. The team received donations of 15 tons of coarse aggregate, 15 tons of fine aggregate, 15 tons of recycled concrete aggregate, 5 tons of cement, and 5 tons of fly ash from the Dolese Bros. Co. in support of Projects 1A, 2A, and 3A. The team has completed work on adjusting the mix designs developed on Projects 1A, 2A, and 3A to materials local to the State of Oklahoma in preparation for further laboratory examination of the structural performance of these novel construction materials and their implementation on construction sites.

1-B. Formwork Pressure Measurements and Prediction of High-Performance Concrete with Adapted Rheology

University of Illinois at Urbana-Champaign (UIUC)

The search team at UIUC is advancing a laboratory study of rheological properties that control formwork pressure. This work involves improving measurement methods of formwork pressure using a static column. The team is also analyzing results from the Toronto “SCC Live” study conducted in August 2014 in collaboration with a team from Missouri S&T. The team continues to apply modeling concepts to the data along with past data to propose prediction models to evaluate formwork pressure of high-performance concrete with adapted rheology.

1-C. Influence of Casting Conditions on Durability and Structural Performance of High-Performance Concrete with Adapted Rheology

Missouri S&T

The research team is currently investigating the influence of rheological properties, mix design parameters and placement properties (flow distance, velocity and formwork width) on the dynamic segregation of self-

consolidating concrete by means of the tilting box test. The results confirm theoretical assumptions that dynamic segregation is amplified with a decrease in viscosity and yield stress and increase in flow distance. Reducing formwork thickness (from 8” to 4” in this case), appears to have a positive effect on dynamic stability.

2.A. High-Volume Recycled Materials for Sustainable Pavement Construction

Missouri S&T

Work is currently underway on literature review, development of eco-friendly concrete for single layer pavement, and development of eco-friendly concrete for double layered pavement. Binder type optimization is also underway. Several mortar samples made with different types of binary and ternary binders containing cement, Class C and Class F fly ash, ground granulated blast furnace slag (GGBS), and glass powder are investigated. Results apply for both single-layered and double-layered concrete pavement materials. MoDOT-PCCP concrete mixture proportioned with 323 kg/m³ (545 lb/yd³) of cementitious materials was employed for designing concrete equivalent mortar (CEM) that is used for binder phase optimization. The dosage of the water reducing admixture (WRA) was adjusted to secure a mini slump flow of 140±15 mm (5.5±0.5 in.). Batching of mortar mixtures is completed, and testing of long-term properties and data analysis are underway. Research efforts are focused at the selection of proper combinations of virgin and recycled aggregate sources. This includes optimizing the sand-to-coarse aggregate ratios for both the single and double layered pavements. Three types of coarse recycled concrete aggregates (RCAs) and one fine RCA are investigated. Fine and coarse RCAs are procured from different sources. Initial investigation involves determining key aggregate properties, including specific gravity, absorption, abrasion resistance, dry rodded unit weight, fineness modulus, and particle size distribution. Theoretical models together with laboratory investigation will focus on the selection of aggregate combinations and pavement concrete mix designs that can yield optimum performance and potential cost savings.

University of Oklahoma

The University of Oklahoma research team has investigated potential implementation phases of Projects 1A, 2A, and 3A with the Oklahoma Department of Transportation; Oklahoma City, Norman, and Tulsa, Oklahoma, City Planning Departments; Grand River Dam Authority; and the Oklahoma Turnpike Authority.

See Project 1.A summary for further details on on-going progress.

University of Illinois at Urbana-Champaign

The main contribution of the team at UIUC is in the use of recycled fine materials for controlled low strength materials (CLSM). The very fine material is particularly challenging because these particles are difficult to characterize. Therefore, a new method for measuring moisture content of very small particle systems for which standard methods of obtaining “saturated surface dry” specimens are unsatisfactory is being developed. The new methods use electrical properties to assess moisture content. The team is also advancing experimental studies of Engineered Material Arresting Systems (EMAS) which are used at the end of runways at airports. The researchers believe that CLSM concepts can be used for EMAS applications, providing airports with sustainable and locally constructed options which have potential for cost savings.

2.B.1 Rapid Pavement Rehabilitation

Southern University at Baton Rouge

The literature review is well underway and involves searching the current practice and experience on the rapid joint repair materials and construction techniques of PCC pavements. Field experience on the partial- and full-depth repair materials and construction techniques has been documented and involved interviewing various contractors and material suppliers. Source of early age cracking and related parameters are being identified.

Some of feasible materials to be used in the development of crack-free early strength concrete are identified, and their material properties are measured. Internal curing using recycled aggregate and lightweight aggregate is considered for the mixture design of novel materials that can be employed for rapid pavement rehabilitation. Research will continue to measure self-consolidating concrete (SCC) material properties. The potential of the SCC to be used in rapid repair will be investigated. The mixture design of crack-free early strength concrete will be finalized and casting of successful mixtures will be initiated. Basic material properties (shrinkage and thermal properties, cracking potential in restrained conditions) will be measured. Internal curing benefit will also be investigated. Potential site for field implementation will be discussed with Missouri S&T partners and Louisiana DOTD engineers.

2-B.2 Rapid Pavement Construction

Missouri S&T

Research on Thixotropy and Workability Loss of Vibration-free Concrete in View Accelerating Pavement Construction by Slipforming

The rheological properties, including workability loss and thixotropy of cement-pastes, are investigated using the Anton Paar MCR 302. Preliminary results indicate a significant influence (up to 25% change) of the maximum applied shear rate (between 12.5 and 100 s⁻¹) on yield stress and plastic viscosity values. However, this change is substantially lower than the decrease in (static) yield stress at rest and the dynamic yield stress at 12.5 s⁻¹ maximum applied shear rate. Furthermore, the static yield stress increase with time appears in some cases to accelerate with elapsed time, which is in contrast to what is described in literature.

Roller Compacted Concrete for Rapid Pavement Construction

A comprehensive literature review of previous research progress on roller compacted concrete (RCC) for rapid construction of concrete pavements has been performed. The literature review shows that the selection of proper aggregates combination to achieve high packing density is crucial in optimizing RCC. Such optimization, however, depends on physical properties of aggregate that vary with aggregate source.

Forty aggregate samples were selected from various producers. Aggregate characteristics, including particle size distribution (PSD), specific gravity, bulk density, and absorption were determined. Aggregate quarries were selected from various locations to cover wide range of aggregates available in Missouri. Numerical investigations were performed on various ternary and binary blends of aggregates to select the optimum aggregate combinations. Aggregates were ranked based on the residual error defined as the minimum deviation of aggregate blends from the target grading. In addition to numerical analysis, aggregate combinations were optimized through experimental packing measurements in binary and ternary mixtures. Different packing methods are used and the results are compared with numerical models. The results of this investigation is used to develop a guideline on optimum selection of solid particles in RCC, which should lead to cost savings and enhanced RCC performance.

3-A. Performance of Fiber Reinforced Self-Consolidating Concrete for Repair of Bridge Sub-Structures and fiber-reinforced Super-workable Concrete for Infrastructure Construction

Missouri S&T

The RE-CAST 3A project undertaken at Missouri S&T consists of three Tasks: *Task 1*- literature review, *Task 2*- mixture optimization, with three Subtasks (*2A*, *2B*, and *2C*), and *Task 3*- structural performance of monolithic and repaired beams in flexure. *Tasks 1*, *2A*, and *2B* are completed, and *Task 2C* is 80% completed. *Task 2A* involved the testing of 24 concrete mixtures to optimize fly ash and expansive agent contents. The concrete was tested for key fresh properties, compressive and splitting tensile strengths, and electrical resistivity. Mixtures with Class C 30% fly ash replacement and either 4% Conex or 8% K-comp expansive agent showed good performance.

Task 2B involved the testing of eight SCC and eight superworkable concrete (SWC) mixtures to selected efficient fiber types. Six fiber types were investigated with SCC mixtures, including propylene synthetic fiber (PLP), carbon fiber (CA), two different types of hooked steel fibers (ST1 & 3D), a hybrid of crimped Steel fiber and polypropylene multifilament fiber (STPL), as well as a combination of micro and macro steel fibers (STST). Extensive workability evaluation and testing of mechanical properties has been undertaken, including the testing of flexural toughness and flexural crack resistance. The SWC mixtures included one plain SWC and seven FR-SWC mixtures made with propylene synthetic fiber (PLP), four types of hooked steel fibers (ST1, 3D, 4D, and 5D), a hybrid of crimped steel fiber, a polypropylene multifilament fiber (STPL), as well as a combination of micro and macro steel fibers (STST). All of the optimized SCC, FR-SCC, SWC, and FR-SWC mixtures achieved the targeted passing ability criteria, modified J-Ring flow diameter greater than 24 in. (600 mm), and surface settlement less than 0.5%. Properties investigated included compressive strength, splitting tensile strength, modulus of elasticity, flexural strength, flexural toughness (ASTM C1609), fracture energy (RILEM TC-162), as well as surface electrical resistivity. In *Task 2C* four fiber types were selected for further evaluation of FR-SWC: ST1, 5D, STST, and STPL. The fibers were incorporated at 0.75%. The STPL fiber was eliminated. The remaining mixtures with steel fibers ST1, 5D, and STST achieved the targeted fresh and mechanical properties. Work remaining for *Task-2C* involves drying shrinkage, restrained shrinkage, as well as freeze/thaw durability. Future research will also involve extensive evaluation of the structural performance of FR-SCC and FR-SWC mixtures.

Rutgers University

The research team has been evaluating the material performance of FR-SCC with the crimped steel and polypropylene fibers as an infrastructure repair material. The compatibility and the bond strength between the FR-SCC and the substrate concrete were investigated. The team also evaluated the restrained shrinkage performance of the FR-SCC with the polypropylene fiber. The results show that the increase in the steel fiber content provides a higher bond strength and improved compatibility. The addition of polypropylene fiber has a minimal effect on strength; however, it provides lower free and restrained shrinkage strain and delay of the development of the first crack and cracking propagation.

The research team will cast nine full-scale repaired beam to evaluate the flexural behavior under two-point loading. Each beam will have two layers of concrete; typical class A will be used for existing concrete layer, and the FR-SCC will be used as the repair material for the bottom layer. Various sensor technologies, such as foil strain gauges, linear variable differential transformer (LVDT), etc. will be utilized to monitor the overall behavior of the FR-SCC repaired beam.

The team will cast additional full-scale beams to investigate the behavior of the beams prestressed with the combination of bonded/unbonded and steel/CFRP tendons. Similar monitoring setup will be used to monitor the overall behavior of the prestressed beam with bonded and unbonded tendons.

The team will design the testing program to perform the creep test of the FR-SCC. FR-SCC mixtures with various fiber contents will be prepared based on the previous work. For each mix, a total nine vibrating wire strain gages (VWSGs) will be bolt-mounted around three cylinders at 120°. The specimens will be loaded on the creep rigs under the controlled environment to evaluate the creep behavior of the FR-SCC material.

University of Oklahoma

The University of Oklahoma research team has investigated potential implementation phases of Projects 1A, 2A, and 3A with the Oklahoma Department of Transportation; Oklahoma City, Norman, and Tulsa, Oklahoma, City Planning Departments; Grand River Dam Authority; and the Oklahoma Turnpike Authority.

See Project 1.A summary for further details on on-going progress.

3-B. Ultra-High Performance Fiber Reinforced Concrete for Infrastructure Rehabilitation

UHPC is characterized by high compressive strength (22 ksi) and tensile strength (725 psi). UHPC uses a high binder ratio in combination with a low water to cementitious ratio (less than 0.25). UHPC compared to other high-strength concretes (HSC's) can help reduce joint transfer stresses. The main objective of this research program is to evaluate the performance of UHPC versus HSC in girder to girder connections. Another objective of the study is to evaluate the performance of joints when different types of reinforcement detailing is used within the joint. The effect of surface preparation on beam and joint interaction is also one aspect of this research investigation. The experimental test matrix consists of 22 beams of dimensions 8-in. width by 12-in. in depth with a span length of 84-in. which consists of two individual beams of 39-in. length connected using a 6-in. joint cast using either UHPC or HSC.

By using UHPC, the width and cross-section of joint can be considerably reduced and due to high bond development, reduced development lengths of rebars can be used. UHPC, with its SCC like properties, is anticipated to make the structures easier to develop continuity and sustain high stresses. It also possesses high durability, which will make the service life of the structure last longer with reduced maintenance costs at the joint location.

Three different reinforcement detailing (i.e., straight, headed and hairpin) are under consideration to be used in the joint. The beam-joint surface will be prepared before casting joint using three methods (i.e., smooth, lightly sandblasted and roughened). The matrix is divided into three groups or phases of study. Group one consists of four Control beams (no joints), which serve as baseline. Group two consists of nine beams with a HSC joint. Group three consists of nine beams with a UHPC joint.

The beams will be subjected to a four point loading until failure and the loads will be applied near the beam and joint region as shown in the figure. Strain gauges, LVDT's and inclinometers are used to study the strains in rebars, deflection and rotation in the beam due to applied load. The formation of tensile cracks in the beams will also be observed. Another aspect of this research is to evaluate the yielding of rebars prior to the failure load within the UHPC and HSC joint. Once the laboratory testing phase is completed, the performance of UHPC versus HSC will be evaluated.

Another Phase of Project 3-B deals with the development of a novel construction permanent formwork system using UHPC that can be used in fast-track construction of infrastructure. Work is currently underway on *Task I* (literature review), and *Tasks II and III* (development and optimization of HS-SCC, and design of fibrous ultra-high performance concrete (UHPC)). *Task II* includes the selection of fibers for the UHPC, including steel fibers, poly-vinyl alcoholic (PVA) fibers, and their combinations. *Task III* involves the design of UHPC for permanent formwork. The mixture composition processing and rheology are optimized by selecting appropriate material constituents, high-shear mixing of the highly viscous materials, and curing regime to reduce autogeneous shrinkage and maximize strength development. Mix design is optimized using various types of cements, silica fume, fine quartz sand, fibers, and chemical admixtures. The performance characteristics of the UHPC are a min-slump flow consistency of 300 mm (12 in.), a 56-day compressive strength greater than 150 MPa (22 ksi), and a 56-day splitting tensile and flexural strengths of ≥ 8 and 25 MPa (1200-3600 psi), respectively. Fiber-reinforced polymer (FRP) grids are also proposed to reinforce the panel elements to produce light-weight panels of minimum thickness. Bond between the concrete material and reinforcement is investigated by novel pull-out testing. *Task IV* will concentrate on the optimization of fabrication of the material to enhance material performance. A number of experimental techniques will be investigated to evaluate fiber orientation along concrete elements. This includes X-ray techniques, electrical conductivity, and computed axial tomography scanning methods. Proper curing practice, which is critical to the development of the strength and durability for both cast-in-place and precast concrete products, will be considered. Quality control testing will be developed to ensure high tolerances and defect-free construction during fabrication.

3-C. Performance of Reinforced Concrete Decks Strengthened with Fabric-Reinforced-Cementitious-Matrix Composites

University of Miami

Experimental evaluation of long-term performance of FRCM strengthened RC beams subject to fatigue loading. Fatigue is a critical issue associated with all transportation related structures. FRCM systems are emerging as a viable strengthening and repair system for concrete structures. Research is advancing on the material characterization and structural application to concrete, but much research focuses on the quasi-static behavior of the concrete-composite members. Not much is known with respect to the long-term fatigue performance of FRCM applied to concrete structures. During the next reporting period, the experimental parameters that most affect fatigue and the performance of FRCM strengthened RC beams subject to fatigue will be investigated.

Education and Workforce Development (EWD) Objectives Accomplished

- 1) RE-CAST hosted its **fifth research seminar** on November 19 – see Attachment A.
- 2) RE-CAST hosted its **sixth research seminar** on January 23 – see Attachment B.
- 3) RE-CAST hosted its **seventh research seminar** on March 30 – see Attachment C.
- 4) Students from the **United Way Center for Excellence Demonstration School** were invited to the University of Miami for a tour of the laboratory facilities and an interesting workshop on concrete scientific discovery. The students were introduced to the large test frames required for structural testing and a discussion of what they knew about concrete. The young students, about 3 to 5 years in age, were set up in groups to make their very own concrete mix. 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 mix compositions. Once completed, the mixtures were used to cast standard 4 in. diameter cylinders as would be done in the field for strength testing. Finally, an actual concrete cylinder was tested, and the young engineers were able to see first the strength of concrete (in terms of number of trucks that a given strength could support) and what a concrete failure surface looks like.
- 5) Graduate Student Workshop on **Structural Health Monitoring of Transportation Infrastructure Facilities**
 - Scheduled for June 1-3, 2015 at Rutgers University
 - By the end of the course, graduate students will be able to:
 - Define structural health monitoring (SHM)
 - Describe the role and needs of SHM
 - Understand sensor technologies and data processing for SHM
 - Investigate the difficulties and pitfalls of SHM
 - Explain SHM case studies
 - Application of SHM in concrete bridges, pavement, design and rehabilitation
 - See Attachment D for details.
- 6) **RE-CAST Student of the Year**: Ms. Vanessa Pino, Ph.D. candidate at the University of Miami, was selected as the 2014 Outstanding UTC Student of the Year for her remarkable academic performance as well as the technical merit and national importance of her research. She was recognized at the 24th Annual Outstanding Student of the Year Awards ceremony that took place as part of the Council of University Transportation Centers (CUTC) annual banquet that took place on Saturday, January 10, 2015 in Washington, D.C. See the newsletter in Attachment F for further details.

Technology Transfer Objectives Accomplished

- 1) Social media (**Facebook and LinkedIn**) pages have been utilized to publicize on-going research, training, and technology transfer events.
- 2) The RE-CAST **website has been updated** to contain links to listing of upcoming technology transfer events, educational seminars and workshops, presentations, and project reports.
- 3) The third quarterly **newsletter** was published in November 2014 – see Attachment E.
- 4) The fourth quarterly **newsletter** was published in January 2015 – see Attachment F.
- 5) The fifth quarterly **newsletter** will be published in April 2015.

Diversity Objectives Accomplished

- 1) A **Summer Undergraduate Research Internship program** was announced for the summer of 2015 to all the RE-CAST partner institutions. The program is aimed at engaging underrepresented students in the research activities of the RE-CAST Center. In total, six applications from undergraduate students were received. The University of Miami will be hosting three students and Missouri S&T will host one student from Southern University of Baton Rouge. This program offered excellent education, training, and research opportunities for underrepresented students at the undergraduate level. The students will work one of the collaborative research projects supported by the Center, which will result in direct interaction with leading researchers and graduate students.
 - See program flyer in Attachment G
- 2) RE-CAST faculty participated in the following outreach programs.
 - **The Gates Millennium Scholars Program at University of Miami** - A working relationship has been established with Christopher Doell, Associate Director of Programs in Office of Academic Enhancement to recruit scholars from both the Gates and Hammond Programs. A link to RE-CAST website was shared with all student scholars to solicit a response if they had any interest in summer employment.
 - **The Hammond Scholars Program at University of Miami** - One Hammond Scholar who showed to be interested in transportation, Catherine Alexis Wells, was interviewed. She is a current junior and will start her research internship on May 15, 2015.

1.C - What Opportunities For Training And Professional Development Has The Program Provided?

The RE-CAST has provided **three research seminars** as professional development opportunities. The topics/dates of those seminars are:

1. Date: Wednesday, November 19, 2014
 - Presenter: Prof. Dimitri Feys, Missouri S&T
 - Topic: *Recent Developments in Evaluating Pumping Behavior of Flowable and Self-Consolidating Concrete*
 - Recording posted on RE-CAST website
2. Date: January 23, 2015
 - Presenter: Prof. Surendra P. Shah, Northwestern University
 - Topic: *Advances in Concrete Science in the last 50 years*
 - Recording posted on RE-CAST website
3. Date: March 30, 2015
 - Presenters: Prof. David Lange (UIUC) and Dr. Tyler Oesch (U.S. Army Engineer, Research and Development Center, Vicksburg, MS)

- Topic: *Three-Dimensional Study of Concrete Microstructure using X-ray Computed Tomography*
- Recording posted on RE-CAST website

1.D - How Have The Results Been Disseminated?

The recordings of the November, January, and March seminars, as well as all previous webinars, are available on the RE-CAST website. A summary of all RE-CAST activities are outlined in the Center's quarterly newsletter, which is distributed to a listserv of approximately 1200 recipients.

Initial findings of various research projects are being compiled to prepare scientific papers and technical presentations at various conventions. Some these findings have already been disseminated at the World of Concrete 2015 in Las Vegas, 2015 TRB Meeting in Washington, D.C., ACI Spring 2015 Convention in Kansas City, and ACI Fall 2014 Convention in Washington D.C., as well as overseas, including the 3rd International Conference on Prescriptive to Performance held in Saudi Arabia in February 2015.

1. E - What Do You Plan To Do During The Next Reporting Period To Accomplish The Goals And Objectives?

- 1) First annual student competition
 - This activity is under discussion amongst the RE-CAST team.
- 2) Publish fifth and sixth newsletters
- 3) Schedule eighth, ninth and tenth bi-monthly research seminars
 - The following webinars are scheduled for May 2015:
 - Date: May 5, 2015
 - Presenter: Elizabeth Birriel, P.E., FLDOT
 - Topic: Connected Vehicle Technology: Current Efforts, Demonstration and Future Plans of FLDOT
 - *Webinar will be broadcast in Spanish (for the first time for our Center) to reach out to a wide-range of Spanish speaking population. The seminar will have English Closed-Captioning.*
 - Date: May 13, 2015
 - Presenter: Prof. W. Micah Hale, The University of Arkansas
 - Topic: Alkali-Silica Reaction (ASR) and ASR Mitigation
 - *Webinar is being co-sponsored with the Southern Plain Transportation Center at the University of Oklahoma in an effort to collaborate with other UTC Centers that are working on similar Strategic Goals of the U.S.DOT.*
- 4) **Summer Transportation Institute at SUBR** - Southern University and A&M College will host National Summer Transportation Institute (NSTI) during **June 1 - 26, 2015**. The College of Engineering will serve as the housing facility for the institute's classroom based activities and construction projects. Up to 20 high school participants (9th and 10th grades) will be selected from parishes in Louisiana. Dr. H. Shin from RE-CAST will participate in the NSTI as the speaker on June 4, 2015. He will present the Center's on-going research on rapid pavement repair and related subjects. RE-CAST will support \$2,333 to purchase laboratory experiment set-up and supplies for the NSTI activities.
- 5) **S&T Transportation Infrastructure Conference**
 - October 3, 2015 at St. Louis University, in collaboration with MoDOT, with a RE-CAST faculty and a member of the RE-CAST Research Advisory Committee members giving invited lectures.

2. PRODUCTS

2.A - Publications, Conference Papers, and Presentations

- 1) November 2014 seminar: see Appendix A
- 2) January 2015 seminar: see Appendix B
- 3) March 2015 seminar: see Appendix C
- 4) Fall 2014 Newsletter: see Appendix E
- 5) January 2015 Newsletter: see Appendix F
- 6) Journal Publications:

Feys, D., Khayat, K.H., Prediction of Pumping Pressure by means of a New Tribometer for Highly-Workable Concrete, *Cement and Concrete Composites*, **57**, March 2015. pp. 102-115.

Aïssoun, B., Hwang, S.D., and **Khayat, K.H.**, Influence of Aggregate Characteristics on Workability of Superworkable Concrete, *Materials and Structures*, Jan., 2015. <http://link.springer.com/article/10.1617/s11527-015-0522-9>.

Esmaeilkhani, B., **Khayat, K.H.**, Yahia, A., and **Feys, D.**, Effects of Mix Design Parameters and Rheological Properties on Dynamic Stability of Self-Consolidating Concrete *Cement and Concrete Composites*, **54**, Nov. 2014, pp. 21-28.

Feys, D., **Khayat, K.H.**, Perez-Schell, and A., Khatib, R., Development of a Tribometer to Characterize Lubrication Layer Properties of Self-Consolidating Concrete, *Cement and Concrete Composites*, **54**, Nov. 2014, pp. 40-52.

Billberg P.H., Roussel N., Amziane S., Beitzel M., Charitou G., Freund B., Gardner J.N., Grampeix G., Graubner C.-A., Keller L, **Khayat, K.H.**, Lange D.A., Omran A.F., Perrot A., Proske T., Quattrocioni R., and Vanhove Y. Field Evaluation of Models for Predicting Lateral Form Pressure Exerted by SCC, *Cement and Concrete Composites*, **54**, Nov. 2014, pp. 70-79.

Mueller, F.V., Wallevik, O.H., and **Khayat, K.H.**, Linking Solid Particle Packing of ECO-SCC to Material Performance, *Cement and Concrete Composites*, **54**, Nov. 2014, pp. 117-125.

Kassimi, F., El-Sayed, A.K., and **Khayat, K.H.**, “Performance of Fiber-Reinforced Self-Consolidating Concrete Used in Repair of Reinforced Concrete Beams,” *ACI Structural Journal*, Vol. 111, No. 6, pp. 1277-1286, 2014.

Zhang, K., Z. Fang, **A. Nanni**, J. Hu, and G. Chen, “Experimental Study of a Large-Scale Ground Anchor System with FRP Tendon and RPC Grout Medium,” *ASCE J. Compos. Constr.*, [10.1061/\(ASCE\)CC.1943-5614.0000537](https://doi.org/10.1061/(ASCE)CC.1943-5614.0000537), 04014073, Dec. 2014.

Babaeidarabad, S., G. Loreto, and **A. Nanni**, “Flexural Strengthening of RC Beams with Externally-Bonded Fabric-Reinforced-Cementitious-Matrix (FRCM).” *ASCE Journal of Composites for Construction*, Vol. 18, No. 5, Sept.-Oct. 2014, 04014009-1 to 12

Loreto, G., L. Leardini, D. Arboleda and **A. Nanni**, “Performance of RC Slabs Strengthened with Fabric-Reinforced-Cementitious-Matrix (FRCM) Composite,” *ASCE Journal of Composites for Construction*, Vol. 18, No. 3, Special Issue, March 2014, A4013003-1 to 9.

Looney, T.J., Arezoumandi, M., and **Volz, J.S.**, “Effect of Fly Ash Replacement Level on the Bond Strength of Reinforcing Steel in Concrete Beams,” *Journal of Cleaner Production*, V. 87, Jan. 2015, pp. 745-751 (published, federal support yes).

Arezoumandi, M., **Volz, J.S.**, Ortega, C.A., and **Myers, J.J.**, "Shear Behavior of High-Volume Fly Ash Concrete versus Conventional Concrete: Experimental Study," *Journal of Structural Engineering*, V. 141, No. 3, Mar. 2015, B4014006(11) (published, federal support yes).

7) Conference Papers:

Khayat, K.H., Self-Consolidating Concrete – A Novel Performance-Based Material, 3rd P2P Technical Conference – Khobar, Riyadh, Jeddah, February 16-18, 2015 (invited).

Khayat, K.H., SCC Research and Benefits of New Form Pressure Guidelines, Annual Minnesota Concrete Conference, Dec. 2014. (invited)

Khayat, K.H., Advances in Form Pressure and Pumping of Self-Consolidating Concrete, Concrete Conference, Iowa State University, Nov. 2014. (invited)

Khayat, K.H., High-Performance Concrete for the 21st Century, Oklahoma University, Department of Civil Engineering, Oct. 2014. (invited)

Khayat, K.H., Evaluation of Thixotropy of SCC and Influence on Performance, Oklahoma Transportation Conference, Oct. 2014. (invited)

R. Serpell, J. Henschen, J. Roesler, and **D.A. Lange**, "Relative Proportioning Method for Controlled Low Strength Material," *ACI Mat. J.*, Vol. 112, No. 2, 2015.

Aljazaeri, Z., **Myers, J.J.**, "*Strengthening of Reinforced Concrete Beams in Shear with Fiber Reinforced Cementitious Matrix*," 2nd International Conference on Performance-based Lifecycle Structural Engineering (PLSE 2015), Sydney, Australia, Dec. 9-11, 2015, Abstract Accepted.

Aljazaeri, Z., **Myers, J.J.**, "*Fatigue and Flexural Behavior of Reinforced Concrete Beams Strengthened with Fiber Reinforced Cementitious Matrix*," 7th International Conference on Advanced Composites in Construction (ACIC15), University of Cambridge, Cambridge, UK, Sept. 9-11, 2015, Paper Submitted.

Mela, D., Z. Karim, M. Di Benedetti, and **A. Nanni**, "Durability Evaluation of Shear Bond Strength of Carbon and Glass FRP laminates Using Small Plain Concrete Beams," CAMX 2014, Orlando FL, October 13-16, 2014, No. 47730, pp. 7654-7664, CD-ROM.

Arboleda, D., S. Babaeidarabad, C. Hays and **A. Nanni**, "Durability of Fabric Reinforced Cementitious Matrix (FRCM) Composites," 7th International Conference on FRP Composites in Civil Engineering, R. El-Hacha, Ed., Vancouver, Canada, August 20-22, 2014, pp. 384-390.

Babaeidarabad, S., G. Loreto, D. Arboleda and **A. Nanni**, "Flexural Behavior of RC Beams Strengthened with Fabric-reinforced-cementitious-matrix (FRCM) Composite," 7th International Conference on FRP Composites in Civil Engineering, R. El-Hacha, Ed., Vancouver, Canada, August 20-22, 2014, pp. 386-392.

Nanni, A., M. Ekenel and J. Jones, "Fabric-Reinforced Cementitious Matrix (FRCM) Composites in North America: Institutional Documents," 7th International Conference on FRP Composites in Civil Engineering, R. El-Hacha, Ed., Vancouver, Canada, August 20-22, 2014, pp. 372-378.

Arboleda, D., and **Nanni, A.**, "Caracterización y Durabilidad de Materiales Compuestos a Base de Matriz Cementicia Reforzada con Tejido (FRCM)," REHABEND 2014: Congreso Latinoamericano sobre Patología de la Construcción, Tecnología de la Rehabilitación y Gestión del Patrimonio: Santander (Spain) 1-4 April, 2014. Eds.: L. Villegas, I. Lombillo, C. Liano, and H. Blanco, pp. 1504-1511.

Bianchi, G., Carozzi, G., Poggi, C., **Nanni, A.**, "Fabric Reinforced Cementitious Matrix (FRCM) per la Riabilitazione Strutturale: Aderenza al Supporto," REHABEND 2014: Congreso Latinoamericano sobre Patología de la Construcción, Tecnología de la Rehabilitación y Gestión del Patrimonio: Santander (Spain) 1-4

April, 2014. Eds.: L. Villegas, I. Lombillo, C. Liano, and H. Blanco, pp. 1156-1163.

Leardini, L., Loreto, G., Poggi, C., **Nanni, A.** "Studio Sperimentale del Comportamento a Taglio di Travi in Calcestruzzo Armato Rinforzate con FRCM (Fabric-Reinforced-Cementitious-Matrix)," REHABEND 2014: Congreso Latinoamericano sobre Patología de la Construcción, Tecnología de la Rehabilitación y Gestión del Patrimonio: Santander (Spain) 1-4 April, 2014. Eds.: L. Villegas, I. Lombillo, C. Liano, and H. Blanco, pp. 1693-1700.

Nassif, H., Montemarano, J., and Na, C.K., (2015) "Investigation of High Performance Concrete Containing Slag Under Restrained Shrinkage Conditions," *Transportation Research Board*, 94th Annual Meeting, Washington, D.C., January 11-15.

Albhaisi, S., **Nassif, H.** (2015) "Simple Approach to Calculate Displacements and Rotations in Integral Abutment Bridges," *Transportation Research Board*, 94th Annual Meeting, Washington, D.C., January 11-15.

Su, D., **Nassif, H.**, and Hwang, E.S. (2015) "Probabilistic Approach For Forecasting Long Term Performance of Girder Bridges," *Transportation Research Board*, 94th Annual Meeting, Washington, D.C., January 11-15.

M. Beltran and **Nassif, H.**, "Structural Health Monitoring of Reinforced Bar Debonding in Concrete Bridge Decks due to Traffic-Induced Vibrations", **ACI Fall 2014 Convention**, Washington D.C., Oct.26, 2014

Nassif, H., "Field monitoring of rebar vibrations in concrete bridge decks under traffic loads", **56th Brazilian Congress of Concrete**, Natal, Brazil, Oct. 8-11, 2014.

Arezoumandi, M., Ortega, C.A., and **Volz, J.S.**, "Flexural Behavior of High-Volume Fly Ash Concrete Beams – Experimental Study," *Proceedings of the 94th Transportation Research Board Conference*, Washington, DC, January 2015, Paper No. 15-1655, 22 pp.

8) Keynote/Invited Presentations:

Kamal H. Khayat

K.H. Khayat gave the keynote address at the 2014 Oklahoma Transportation Research Day, October 21, 2014.

K.H. Khayat was invited speaker at the Concrete Conference, Iowa State University, Nov. 2014.

David Lange

D.A. Lange, D.I. Castenada, J.A. Koch, R.H. Ewold, K.A. Riding, "Stability of Air Bubbles in Bingham Fluids Under Vibration," ACI Fall Convention, Washington, D.C, October 27, 2014.

D.A. Lange and T. Oesch, "Three-dimensional Study of Concrete Microstructure using X-ray Computed Tomography," Re-CAST Webinar, March 30, 2015.

Hani Nassif

Structural Health Monitoring for the Assessment of Cracking Potential in Concrete Structures", 3rd Annual Transportation Infrastructure Conference, Missouri S&T, Rolla, MO, Oct. 3, 2014

"Structural Health Monitoring for the Assessment of Cracking Potential in Concrete Structures", 56th Brazilian Congress of Concrete, Natal, Brazil, Oct. 8-11, 2014.

2.B - Website(s) or Other Internet Site(s)

A **website** was created for the RE-CAST University Transportation: <http://recast.mst.edu>. This website is the central location for listing all activities related to the grant. In this reporting period, the following tab has been added:

- **Internships**

In addition to the main website, RE-CAST utilizes Facebook and LinkedIn Group for announcements.

Facebook: <https://www.facebook.com/pages/Re-Cast-University-Transportation-Center/628790710502751>

LinkedIn: https://www.linkedin.com/groups/RECAST-University-Transportation-Center-6626216?trk=anet_ug_hm&gid=6626216&home=

2.C - Technologies or Techniques

Nothing to Report.

2.D - Inventions, Patent Applications, and/or Licenses

Nothing to Report.

2.E - Other Products, Such As Data Or Databases, Physical Collections, Audio Or Video Products, Software Or Netware, Models, Educational Aids Or Curricula, Instruments, Or Equipment.

Nothing to Report.

3. PARTICIPANTS & COLLABORATING ORGANIZATIONS

3.A - What Organizations Have Been Involved As Partners?

The main consortium members of this University Transportation Center remain the same as the proposal:

- Missouri University of Science and Technology, Rolla, MO - LEAD
- University of Illinois at Urbana-Champaign, Urbana, IL
- Rutgers, The State University of New Jersey, Piscataway, NJ
- University of Miami, Coral Gables, FL
- Southern University and A&M College, Baton Rouge, LA

As stated in the proposal, the RE-CAST team is also partnered with Dr. H. Celik Ozyildirim, as a consultant, from the Virginia Center for Transportation Innovation and Research, Charlottesville, VA. Dr. Ozyildirim's main implication is to provide input for field implementation and development of specifications and standards.

In addition to the main consortium members, two additional universities are collaborating with with RE-CAST, due to faculty moving to those universities after the proposal was submitted. Those new partners are:

- The University of Oklahoma, Norman, OK (Dr. Jeffrey Volz)
- New York University Polytechnic School of Engineering, Brooklyn, NY (Dr. Kaan Ozbay)

Several state governments and industrial partners are involved in various on-going RE-CAST projects and are providing financial and in-kind support to the research program. Those agencies are listed below. The highlighted agencies are new in this reporting period:

- Bowman, Barrett and Associates, Chicago, IL, financial support
- **Coreslab Structures Inc., Marshall, MO**
- Dolese Bros. Co., Oklahoma City, OK financial support
- **Grand River Dam Authority, Vinita, OK**
- Louisiana Transportation Research Center (LTRC), Baton Rouge, LA, financial support
- Missouri Department of Transportation, Jefferson City, MO, financial support
- Missouri University of Science and Technology, Rolla, MO, in-kind support
- New Jersey Department of Transportation Research Division, West Trenton, NJ, financial support
- New York University Polytechnic School of Engineering, Brooklyn, NY, financial support

- O'Hare Modernization Program, Chicago, IL, financial support
- **Oklahoma Department of Transportation, Oklahoma City, OK**
- **Oklahoma City, Norman, and Tulsa, OK, City Planning Departments**
- **Oklahoma Turnpike Authority, Oklahoma City, OK**
- Small Modular Reactor Research and Education Consortium, financial support
- Structural Technologies, Hanover, MD, financial support
- University of Illinois, Urbana-Champaign, Champaign, IL, in-kind support
- University of Miami, Coral Gables, FL, financial support
- University of Oklahoma, in-kind support
- Virginia Center for Transportation Innovation and Research (via VirginiaTech) Charlottesville, VA, financial support

3.B - Have Other Collaborators Or Contacts Been Involved?

The Research Advisory Committee (RAC) has been established and is composed of the following individuals:

William Stone, Research Administrator, P.E. (RAC President)

Missouri Department of Transportation, Jefferson City, MO

Ross Anderson, Senior Vice President

Bowman Barrett & Associates, Chicago, IL

Casimir Bognacki, Chief of Materials Engineering

Port Authority of New York and New Jersey, New York, NY

Harvey DeFord, Ph.D., Structural Materials Research Specialist

Florida Department of Transportation State Materials Office, Gainesville, FL

Chiara "Clarissa" Ferraris, Ph.D., Physicist

National Institute of Standards and Technology, Gaithersburg, MD

Jim Myers, P.E., Senior Staff Engineer

Coreslab Structures, Inc., Marshall, MO

Karthik Obla, Ph.D. P.E., Vice President, Technical Services

National Ready Mix Concrete Association, Silver Spring, MD

Zhongjie "Doc" Zhang, Ph.D., Pavement Geotechnical Research Administrator

Louisiana Transportation Research Center, Baton Rouge, LA

The objectives of the RAC to advise the Center's Director and Associate Directors on management and activities of the Center and to contribute to the Center core mission. The Center will interact with state DOTs, public agencies, and three primary industry components through the RAC.

A meeting took place with the RAC on November 11, 2014 at 11am CST via WebEx. The RAC Director, Mr. William Stone led the meeting. The group will meet again to discuss this report in May or June of 2015.

4. IMPACT

4.A - What Is The Impact On The Development Of The Principal Discipline(s) Of The Program?

Nothing to report at this time.

4.B - What Is The Impact On Other Disciplines?

Nothing to report at this time.

4.C - What Is The Impact On The Development Of Transportation Workforce Development?

Several graduate and undergraduate students have been recruited to staff the RE-CAST projects for FY2014 and FY2015. For the undergraduate students, working with graduate students and world-renown faculty helps them with experiential learning activities and raise their interest in the transportation field.

4.E - What Is The Impact On Physical, Institutional, And Information Resources At The University Or Other Partner Institutions?

Nothing to report at this time.

4.F - What Is The Impact On Technology Transfer?

Several invited speakers/keynote speaker lectures are scheduled for the Summer/Fall of 2015, many of which will report on some of the research findings of RE-CAST projects.

SCC2016, an international conference focusing on the Design and Use of Self-Consolidating Concrete, is being sponsored by RE-CAST. This event will attract engineers, architects, government officials, researchers, academics, students, contractors, and industry professionals from around the world.

4.G - What Is The Impact On Society Beyond Science And Technology?

The RE-CAST projects are developing the next generation of cement-based construction materials to address the growing technical and environmental requirements of the nation's transportation infrastructure. The ultimate goal of the RE-CAST program is to fast-track the acceptance of these technologies and develop national standards and guidelines for their use in the reconstruction of the nation's infrastructure for the 21st Century, which will have a lasting impact on our nation's society. This research theme addresses a Grand Challenge for our society and has been recognized recently at Missouri S&T as one of four strategic areas for future growth in education and research on campus.

5. CHANGES/PROBLEMS

5.A - Changes In Approach And Reasons For Change

Nothing to report at this time.

5.B - Actual Or Anticipated Problems Or Delays And Actions Or Plans To Resolve Them

Nothing to report at this time.

5.C - Changes That Have A Significant Impact On Expenditures

Nothing to report at this time.

5.D - Significant Changes In Use Or Care Of Animals, Human Subjects, And/or Biohazards

Not Applicable.

5.E - Change Of Primary Performance Site Location From That Originally Proposed

No Change to Report.

6. SPECIAL REPORTING REQUIREMENTS

Nothing to Report.