PROGRAM PROGRESS PERFORMANCE REPORT

Awarding Federal Agency: US Department of Transportation, Office of the Assistant Secretary for Research and Technology

Federal Grant Number: DTRT12-G-UTC16

Project Title: Center for Advanced Infrastructure and Transportation (CAIT) Tier I UTC Consortium Led by Rutgers, The State University of New Jersey

Program Director (PD) Name, Dr. Ali Maher, CAIT Director. **E-mail address:** mmaher@rci.rutgers.edu **Phone number:** 848-445-2951

Name of Submitting Official, Title, and Contact Information (e-mail address and phone number), if other than PD: Dr. Patrick Szary, CAIT Associate Director. **E-mail address:** szary@rci.rutgers.edu **Phone number:** 848-445-2999

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Recipient Organization (Name and Address): Rutgers, The State University of New Jersey, Center for Advanced Infrastructure and Transportation, 100 Brett Road, Piscataway, NJ 08854-8058

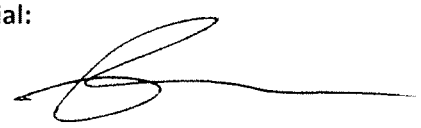
Recipient Identifying Number or Account Number, if any: Rutgers' account #434310

Project/Grant Period: January 1, 2012 through January 31, 2017

Reporting Period End Date: December 31, 2015

Report Term or Frequency: Semiannual (7/1/15-12/31/15)

Signature of Submitting Official:



1. ACCOMPLISHMENTS: What was done? What was learned?

What are the major goals of the program?

The major goal of the CAIT Tier I UTC Consortium is to build a program that will: 1) have a sharp focus on maintaining state of good repair of the nation's infrastructure and the interrelated activities of the Secretary of Transportation's strategic goals where the consortium can make significant impacts, and 2) foster intelligent, effective, and meaningful leveraging between institutions and stakeholders to achieve program goals and objectives.

State of Good Repair (SGR) has been identified as the consortium's **primary area of research** and Safety and Economic Competitiveness as secondary areas in which we believe our team's capabilities, resources, past experience, and track record qualify us to make significant impacts toward reaching the goals of the USDOT. To help fulfill these goals and objectives we will:

- **Sharply focus our research portfolio** to make significant and meaningful impacts during the lifetime of the grant. The UTC designation will be a catalyst for generating relevant and sustainable operations that can aid USDOT in fulfilling the objectives of its strategic plan.
- **Develop effective leveraging** with centers of critical mass and establish networks of researchers, laboratories, test-beds, proving grounds, and all other resources necessary to address the objectives of the strategic plan. Through intelligent leveraging, we will minimize potential duplication of effort and promote and encourage meaningful team work and collaboration.
- **Develop and enhance meaningful relationships with local, regional, national, and international stakeholders** to stay abreast of new problems and best practices; work together to address local challenges and needs; and partner in implementing research results and products.

The consortium will cultivate interest in the transportation industry through a comprehensive **education and workforce development program**. The education and workforce goals are to:

- Develop an educational program that will prepare current and future transportation professionals and researchers to be responsive to changes in the transportation field.
- Develop a strong multidisciplinary component that reflects changes in the organizational, intermodal, and global character of transportation, as well as the use of advanced materials and technologies relative to infrastructure.
- Develop a program that informs high school students about transportation studies and encourages undergraduates to pursue advanced transportation studies.

The consortium supports knowledge sharing and is committed to move research results into practice through its **technology transfer initiatives**. The technology transfer goals are to:

- Ensure all research proposals include feasible implementation plans.
- Provide a forum to discuss the state of practice and innovative new technologies that support State of Good Repair, through conferences and symposiums.
- Continuously post reports and research findings in multiple online repositories and clearinghouses, such as the CAIT website.

What was accomplished under these goals?

Major Goal Area	Major Activities	Specific Objectives	Significant Results	Key Outcomes
Research	Research Selection	Select projects that make significant and meaningful impacts during the lifetime of the grant.	Several projects have cleared the pre-proposal stage and are now being developed by the PI's for full submission and review.	Six new projects were approved this period.
Technology Transfer	FHWA EDC2/SHRP 2 Traffic Incident Management Responder Training	Support research products that can make significant and meaningful impacts	CAIT held an additional four training programs for the SHRP 2 product.	As part of FHWA Every Day Counts 2, offering training programs in partnership with NJDOT. Trained 124 additional responders in this program period.
	Train the Trainer program for Yerevan State University professor in pavements, bridge, and safety asset management.	Support knowledge transfer.	CAIT mentored a Yerevan State University professor for two weeks so that he could bring back technology to Armenia.	Support workforce development and technology implementation.
	Hosted EDC Exchange Webinars	Support research products that can make significant and meaningful impacts	CAIT hosted two EDC Exchange Webinars during this reporting period- GRS-IBS and LPA Stakeholder Partnering.	As part of FHWA Every Day Counts 2, offering training programs in partnership with NJDOT.

What opportunities for training and professional development has the program provided?
This information has been integrated into the table above for the "what was accomplished under these goals?" section. Please see table above.

How have the results been disseminated?
This information has been integrated into the table above for the "what was accomplished under these goals?" section. Please see table above.

What do you plan to do during the next reporting period to accomplish the goals?

- **RESEARCH ACTIVITIES:**
    - **Ongoing Review of Research projects by the Research Advisory Board:** As previously described.

- **Modify Agreements to Approve expenditure of Research Funds:** No research activities can start until the projects have been reviewed and approved as outlined in the prime proposal submitted to OSTR. CAIT has and will continue to issue modifications to the master agreements with each partner as research projects are approved.
- **Ongoing Research:** Each of the consortium members will continue to perform SGR oriented research.

- **EDUCATION AND WORKFORCE DEVELOPMENT ACTIVITIES:**
  - Continue to work with partner schools in delivering **Traveling Distinguished Lecture Series** presentations.
- **TECHNOLOGY TRANSFER ACTIVITIES:**
  - Continue to host EDC Exchange Webinars.
  - Continue to train in Traffic Incident Management Responder training.

2. <u>PRODUCTS</u>: What has the program produced?

Research projects awarded

Six new projects were awarded during this period.

Publications, conference papers, and presentations.

Journal publications

- "Behavior of 48-Year old, Double-Tee Girders, made with Lightweight Concrete", submitted for publication in the Journal of Bridge Engineering.
- Laurendeau, M., Barr, P.J., Higgs, A., Halling, M.W., Maguire, M. and Fausett, R.W. "Live-Load Response of a 65-Year-Old Pratt Truss Bridge." ASCE Journal of Performance of Constructed Facilities. V(29), No (6). November/December 2015/
- Saquing, J. M., Yu, Y.-H. and Chiu*, P. C. (2016) Wood-Derived Black Carbon (Biochar) as a Microbial Electron Donor and Acceptor, Environmental Science & Technology Letters, in press, DOI: 10.1021/acs.estlett.5b00354 (http://pubs.acs.org/doi/abs/10.1021/acs.estlett.5b00354).
- Shariati, A., Schumacher, T., and Ramanna, N. (2015). Eulerian-Based Virtual Visual Sensors to Detect Natural Frequencies of Structures. Journal of Civil Structural Health Monitoring. Vol. (5)4, pp. 457-468. DOI: 10.1007/s13349-015-0128-5.
- Shariati, A. and Schumacher, T. (2015). SHM Using Eulerian-based Virtual Visual Sensors: Introduction of a New Black-and-white Target for Improved SNR. Structural Health Monitoring 2015 (Proceedings of IWSHM. Palo Alto, CA. September 1-3, 2015). DOI: 10.12783/SHM2015/203.

Books or other non-periodical, one-time publications.

"Nothing to Report"

Other publications, conference papers and presentations.

- McNeil, S.,J.Trainor, A. Greer and K. Mininger, (2015). "Household Residential Decision-Making in the Wake of Disaster: Report Prepared for Oakwood Beach Residents," Disaster Research Center Miscellaneous Report #76. http://udspace.udel.edu/handle/19716/17210
- McNeil, S.,J.Trainor, A. Greer and K. Mininger, (2015). "Household Residential Decision-Making in the Wake of Disaster: Report Prepared for Sea Bright Residents," Disaster Research Center Miscellaneous Report #77. http://udspace.udel.edu/handle/19716/17211

- American Geophysical Union (AGU) 2015 Fall Meeting, San Francisco, CA. "Biochar Addition to Stormwater Treatment Media for Enhanced Removal of Nitrogen."
- Shariati, A. and Schumacher, T. (2015). SHM Using Eulerian-based Virtual Visual Sensors: Introduction of a New Black-and-white Target for Improved SNR. 10th International Workshop on Structural Health Monitoring (IWSHM). Palo Alto, CA. September 1-3.
- Goldschmidt Conference 2015, Prague, Czech Republic. Poster presentation. "Black Carbon (Biochar) as a Rechargeable Electron Donor and Acceptor for Microbial Metabolism."
- Leli, J. (2015). Rural Road Safety Needs. National Local Technical Assistance Program Annual Conference, Savannah, GA. July 20-23.

Website(s) or other Internet site(s)

CAIT has established two internet sites:

- http://cait.rutgers.edu/cait/research to disseminate research results
- http://cait.rutgers.edu/cait/program-sites to inform about consortium program activities

Technologies or techniques.

- Under the research project entitled "Biochar as a Rechargeable Geobattery to Promote Nitrogen Removal in Stormwater from Roadways" by University of Delaware, nitrate is a major cause of water quality impairment and cannot be effectively removed from stormwater in existing bioretention cells. Biochar has been proposed as a reactive medium to enhance nitrate removal in bioretention systems and recent field tests support that hypothesis. However, how biochar accomplishes this was not understood or experimentally confirmed. This project demonstrates the mechanism for biochar-promoted nitrate removal. We quantified the electron storage capacity (ie. The capacity of biochar to support denitrification) of a commercial biochar – information essential for designing biochar-amended bioretention systems.

Inventions, patent applications, and/or licenses

Nothing to report.

Other products: outreach activities, courses and workshops

Nothing to report.

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

What individuals have worked on the program?

Program Director: Dr. Ali Maher

Project Directors: Dr. Sue McNeil (University of Delaware), Dr. Paul J. Barr (Utah State University), Dr. Raimondo Betti (Columbia University), Dr. Lazar N. Spasovic (NJIT), Dr. Branko Glisic (Princeton University), Dr. Soheil Nazarian (University of Texas at El Paso, Dr. Steven B. Chase (University of Virginia), Dr. Carin Roberts-Wollmann (Virginia Polytechnic Institute).

Consortium Universities Involved:

Rutgers, The State University of New Jersey (Lead)
University of Delaware, Newark, DE
Utah State University, Logan, UT
Columbia University, New York, NY

New Jersey Institute of Technology, Newark, NJ
Princeton University, Princeton, NJ
University of Texas, El Paso, TX
University of Virginia, Charlottesville, VA
Virginia Polytechnic Institute, Blacksburg, VA

What other organizations have been involved as partners?

Organization Name	Location of Organization	Partner's contribution to the project
New Jersey Department of Transportation	1035 Parkway Ave., Trenton, NJ 08625	Financial support; Collaborative research; Personnel exchanges
WTS International	1701 K Street, NW, Suite 800, Washington DC 20006	Female participation in the transportation field
Utah Department of Transportation	4501 South 2700 West, Salt Lake City, UT 84114	Financial support; Collaborative research; Personnel exchanges; Facilities
Virginia Center for Transportation Innovation and Research (VCTIR)	530 Edgemont Road, Charlottesville, VA 22903	Financial support; Collaborative research; Personnel exchanges
Virginia DOT	Richmond, VA	Financial support; Collaborative research; Personnel exchanges
Oregon DOT	Salem, OR	Project customers/managers
Delaware Department of Transportation	Dover, DE	Project customers/managers
TxDOT	Austin, TX	Financial support; Collaborative research; Personnel exchanges
California DOT	Sacramento, CA	Project customers/managers
El Paso MPO	El Paso, TX	Financial support; Collaborative research; Personnel exchanges
Bridge Diagnostics Inc.	Boulder, CO	Collaborative research
The Biochar Company	Berwyn, PA	Collaborative research
Ramaiah Institute of Technology	Bengaluru, Karnataka, India	Personnel exchange
Old Dominion University	Norfolk, VA	Collaborative research
Metropolitan Transportation Commission	San Francisco Bay Area, CA	Collaborative research
Applied Research Associates Inc.	Panama City, FL	Collaborative research
Western Transportation Institute at Montana State University	Bozeman, MT	Collaborative research
reGenesis Consulting Services, LLC	Columbia, SC	Collaborative research
Technologies for Safe and Efficient Transportation	Pittsburgh, PA	Collaborative educational projects
Township of Sea Bright	Sea Bright, NJ	Financial support, in-kind support, facilities, collaborative research, personnel exchanges
Fund for Armenian Relief	New York, NY	Project customers/managers

Have other collaborators or contacts been involved?

• collaborations with others within the lead or partner universities; especially interdepartmental or interdisciplinary collaborations

- Partner Meeting/Communication: the partners have plenty of communications and virtual meetings through the year.
- Delaware Environmental Institute, University of Delaware

• collaborations or contact with others outside the UTC

- Dr. Toni Nanni, University of Miami: Collaborated with Virginia Tech on the VCTIR repair project.
- Vanessa Pino, University of Miami: Collaborated with Virginia Tech on the VCTIR repair project.
- Charles H. Hegberg, reGenesis Consulting Services
- Applied Research Associates Inc.: On the project entitled "Performance Determination of Precast Concrete Slabs Used for the Repair of Rigid Pavements", ARA collaborated in data collation and through the sharing of historical data.
- Metropolitan Transportation Commission: On the project titled "Multi-objective Sustainable Model for Transportation Asset Management Practices", MTC allowed access to the pavement management system and shared historical data.
- Jason Arndt, Bridge Maintenance Engineer, Delaware Department of Transportation
- Ioannis Koutromanos has served as a Co-PI from the VCTIR matching project for the UTC project "Evaluation of Repair Techniques for Imact Damaged Prestressed Beams", and has served in an advisory role to students performing finite element analysis on this project.

• collaborations or contacts with others outside the United States or with an international organization (country(ies) of collaborations or contacts)

- Dr. Ramappa Prabhakara, Professor and Department Head, Civil Engineering, Ramaiah Institute of Technology, Bangalore, India: Dr. Prabhakara has collaborated on the project titled "Guidelines for Embedment Length of Carbon Fiber Reinforced Polymer (CFRP) Strips in Near Surface Mount (NSM) Retrofitted Concrete Structures".
- Rutgers CAIT is a partner in the project entitled "Sustainable Design and Management of Industrial Assets through Total Value and Cost Ownership" awarded to Politecnico di Milano in collaboration with the University of Cambridge and the Universidad de Sevilla by the MARIE SKŁODOWSKA-CURIE ACTIONS Research and Innovation Staff Exchange (RISE). Rutgers is part of the project academic partnership which includes other institutions of higher education such as the University of Pretoria, South Africa, India Institute of Technology, Pontificia Universidad Catolica de Valparaiso, Chile and Pontificia Universidad Catolica del Peru as well as experts from industrial companies. The involvement will be achieved through the hosting of interviews and workshops related to how life cycle management is possible thanks to total value and cost of ownership with the goal of providing the asset owner with the capability of developing a sustainable factory according to economic and environmental requirements of the local industry.

4. <u>IMPACT:</u> What is the impact of the program? How has it contributed to transportation education, research and technology transfer?

What is the impact on the development of the principal discipline(s) of the program?

PROJECTS SELECTED DURING CURRENT REPORTING PERIOD

Outputs	Expected Outcomes	Impacts
"Modeling of interaction between steel and concrete in continuously reinforced concrete pavements" (University of Texas, El Paso)	The results of this project will be implemented into NYSLAB to expand is capabilities and to be able to analyze CRCPs as well as JPCPs.	The work proposed will lead to the development of better modeling tools providing DOTs with the necessary tools to assess the performance of pavement structures under various loading conditions.
"Prototype development of an piezo-heating array for deicing applications on bridges" (Rutgers University)	The objective of this research is to develop and construct a model prototype that demonstrates how piezo-heating arrays can be embedded in bridge approach slabs, generating sufficient heat for deicing operations.	This technology offers highway departments a new method of mitigating winter conditions with lower annual costs, reduced deterioration of structures and pavements while improving the environment.
"Life Cycle Cost Reduction Study" (Rutgers University)	The objective of this research is the development of a guideline on life cycle cost reduction, which will address the challenge and provision of critical decision0making tools to optimize both network-level and project specific improvements.	Asset owners will be able to gain a better understanding for the techniques being used by industry, familiarize themselves with available methodologies and choose a level that aligns with their agency's philosophy and policy.
"Investigation of Sediment Suspension Technology" (Rutgers University)	The aim of this project is to investigate current existing in-situ sediment suspension measurement technologies and to provide guidance on the scaling up of the technology.	Environmental managers would be able to measure the potential erodability of the sediments in and around harbor systems.
"Collaborative Proposal: Resilience: Definitions, Measurement, Tools and Research Opportunities" (Rutgers University)	The objective of this research is to develop a research roadmap that documents relevant current and ongoing research, key concepts and gaps in our knowledge that require research.	The proposed research will contribute to a safe and economically competitive transportation system by providing a better understanding of the measure of resilience, what is needed to measure resilience, and how to operationalize these concepts.
"Tracking Housing Recover in Sea Bright, NJ and the Relationship to Infrastructure Renewal" (University of Delaware)	The objective of this study is to determine how household decisions evolve over time by resurveying the residents of Sea Bright, NJ.	The results of this project would produce a unique database of housing recovery information following a major storm, which would be of great value to disaster researchers and decision-makers.

ONGOING RESEARCH PROJECTS

Outputs	Expected Outcomes	Impacts
"Impact of Gradation and Moisture Content on Stiffness Parameters of Base Materials" (University of Texas at El Paso)	The goal of this study is to evaluate the behavior of the base materials with different gradations and moisture contents for the construction of pavements.	This research provides a cost-effective solution for selection of sustainable and durable material for construction of a stable pavement foundation, and contributes in the reduction of repair and maintenance work during the operation phase of the pavement.
"Traffic Safety Measures Using Multiple Stream Real Time Data" (Rutgers University)	The main objective of this project is to build advanced analytics to estimate a composite traffic safety risk measure that change temporally and spatially, and take into account driver behavior, roadway quality conditions and historical safety characteristics of roadways.	The proposed analytics opens up a new frontier for the connected vehicle and smart car technologies by creating an environment where drivers and vehicles act in a closed loop in the roadway and externalities and allows for these drivers to respond to traffic risks that may be ahead.
"Development of an Online Platform for Streamlining Highway LIDAR Data Collection, Sharing, and Processing" (Rutgers University)	This project aims to develop an online platform for sharing, visualizing, and analyzing lidar data to support typical DOT data needs.	An effective data infrastructure for lidar technology offers potential to drastically improve state DOTs' design, operation, and maintenance practices.
"Nondestructive Evaluation of Four Sister Bridges in Virginia Using Manual NDE Technologies and Robotic Platform RABIT" (Rutgers University)	Four sister bridges will be tested using manual NDE technologies and the robotic platform RABIT to quantify the influence of bridge design and traffic on the performance of concrete bridge decks and to evaluate the performance of the RABIT platform in relation to manual NDE technologies.	The utilization of automated platforms for non-destructive evaluation can streamline to process of bridge condition evaluation, and could lead to the adoption of automated platforms in numerous other applications.
"Cookbook for Rheological Models – Asphalt Binders" (University of Delaware)	The goal of this effort is to develop a guidebook that provides guidelines for using appropriate rheological models of asphalt binders.	This guidebook will present the effective practices for using rheological (binder) models in pavement analysis and design, and will identify the key advantages/disadvantages of each model.
"Environmental Assessment of Airport Pavement Design and Construction Alternatives" (Rutgers University)	The proposed research is to develop an environmental assessment tool to quantify the emission during the construction and maintenance phases of airport pavement.	This environmental assessment tool can help airport authorities incorporate environmental sustainability into their decision-making process.
"Addressing the Issue of Insufficient Information in Data-Based Bridge	The goal is to develop, investigate and validate, through numerical and	Through this new approach, bridge engineers will be able to create

Health Monitoring" (Columbia University)	experimental test data, techniques to address the issues and consequent limitations related to scarcity of measured data in data-based bridge health monitoring.	more reliable data-based models using the same amount of recorded data.
"Evaluation of Uncertainty in Determination of Neutral Axis and Deformed Shape of Beam Structures" (Princeton University)	The overall objective is to research and develop universal SHM methods based on strain monitoring using series of parallel long-gauge fiber-optic sensors.	The creation of robust data analysis algorithms for damage identification and structural identification will be useful to (1) owners or managers of structures that implement and benefit from SHM system (e.g., FHWA, DOTs); (2) providers of SHM solutions (e.g. companies that provide instrumentation and data analysis solutions for SHM) and (3) researchers in the area of SHM.
"Performance Life of HMA Mixes" (University of Texas at El Paso)	This project focuses on evaluating and validating the performance lives of common mixes.	The product of this research will provide a comprehensive tool relating the HMA mix to performance by means of linking the mix type, design and construction information, and pavement management information data.
"Evaluating the Effectiveness of Traffic Diversion and Managed Lanes on Highway Work Zones" (NJIT)	The objective of the proposed study is to develop an analytical model that can be used to quantify effects of the planed traffic diversion and managed lanes (i.e., the use of road shoulders) for work zones on multi-lane highways.	The findings of this research will help determine a guideline on selecting strategies to mitigate traffic congestion and GHG emission as well as accidents that deteriorates the highway infrastructure performance.
"Evaluation of Repair Techniques for Impact Damaged Prestressed Beams" (Virginia Polytechnic Institute)	The objectives of this research are to evaluate existing methods of repair of impact damaged precast, prestressed bridge beams, and develop guidelines for best methods for evaluation and repair.	It is envisioned that the policy developed will be adopted by VDOT for their use in evaluating and repairing impact damaged prestressed concrete bridge beams.
"Guidelines for Embedment Length of Carbon Fiber Reinforced Polymer (CFRP) Strips in Near Surface Mount (NSM) Retrofitted Concrete Structures" (University of Delaware)	Research outcome includes new technical guidelines for the use of NSM-CFRP strips and MATLAB code to capture experimental bond behavior of strengthened member.	NSM-CFRP strengthening technique has a huge potential for considerably increasing the service life of structures.
"Understanding the Relationships between Household Decisions and	The focus of this exploratory project is to connect the qualitative data	A workshop with representatives of impacted communities, Federal and

Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy" (University of Delaware)	provided by adult members of households that sustained substantial damages from Hurricane Sandy to the quantitative data that are used in the planning and infrastructure decision making process.	state Emergency Management Agencies, the relevant MPOs, and state DOTS will be held to better explore the integration of the qualitative data into the household decision making process.
" Asphalt : Rheology and Strengthening through Polymer Binders" (University of Delaware)	The goal of this project is to work cross-discipline (pavement engineering and mathematical science) to carry out experiments (laboratory and field studies) and couple those results with mathematical modeling to better understand the properties of polymer modified asphalts.	An attempt will be made to introduce the proposed methodology as part of a mechanistic pavement design approach. A series of numerical and design examples will be provided to guide engineers in selecting the inputs for analysis.
"Defining and Quantifying State of Good Repair (SGR) for the Pedestrian Network" (University of Delaware)	The primary goal of this proposal is to propose guidelines as to what constitutes a SGR for the pedestrian network, with priority placed on the contextual setting more so than the adjacent roadway classification.	The result of the research is expected to provide state and local governments with a better understanding of the concept of SGR and how it may be applied to pedestrian and bicycle infrastructure at the state and local government levels.
"A Multi-objective Sustainable Model for Transportation Asset Management Practices" (University of Texas at El Paso)	This research will provide a holistic multi-objective asset management approach integrating environmental related measures with traditional indicators in order to provide a robust framework for implementation.	The multi-objective asset management model will improve the current decision making process of local and state agencies.
"Development of a Comprehensive Hot Mix Asphalt Pavement Specification" (Rutgers University)	The major goal of this study is to search and critically evaluate the literature to determine how the HMA quality characteristics can best be incorporated into the existing NJDOT HMA pavement specification to produce a comprehensive and effective multi-characteristic acceptance specification.	Improve the state-of-good repair of multimodal transportation infrastructure systems.
"COLLABORATIVE PROPOSAL: Big Data: Opportunities and Challenges in Asset Management" (Rutgers University, University of Delaware and Utah State University)	The overall objectives of this project are to define "big data" for asset management purposes and to identify opportunities for data integration, data mining,	The product of this research will be a catalog of tools and techniques to support asset management.

	visualization, meta data and other techniques for data aggregation.	
"COLLABORATIVE PROPOSAL: Evaluation of Biotechnologies for Flexible Pavement Applications" (Rutgers University, University of Delaware and University of Texas at El Paso)	The main goal of the project is to conduct an evaluation/approval of bio-based materials that will enhance the performance of flexible pavements or used in substitution of current materials at a considerable cost reduction that is environmentally beneficial.	A Best Practices document describing the benefit of bio-based materials in the construction of flexible pavements and a Technical Brief, presenting the mathematical model development and its potential use/application will be generated for distribution.

RESEARCH PROJECTS COMPLETED

Outputs	**Expected Outcomes**	**Impacts**
"Performance Determination of Precast Concrete Slabs used for the Repair of Rigid Pavements" (University of Texas at El Paso)	The goal is to provide a better understanding of the mechanical behavior of the precast concrete panels considering the temperature variation in the field.	Rapid repair of damaged rigid pavements is important for the safety of users of transportation facilities. Proper characterization and construction of precast panels is in line with the sustainable repair objective identified by the USDOT.
"Aerodynamic Flow Deflector to Increase Large Scale Wind Turbine Power Generation by 10%" (Rutgers University)	A proposed aerodynamic flow deflector has been proposed to increase the power generation of wind turbines.	The results of this project could have greatly impact the energy industry, and could lead to the increased adoption of energy harvesting using wind turbine technology. Thus, this aids in the reduction of society's dependence on fossil fuels and moves us further toward an adoption of cleaner energy practices.
"Effects of Temperature on Bridge Dynamic Properties" (Utah State University)	The goal of this study is to rigorously determine the effect that changes in temperatures throughout a bridge have on the dynamic properties of the bridge.	The data provided by all these bridges will make it possible to advance toward a true smart bridge by providing a methodology for detecting changes in the bridge condition.

Final research reports for projects completed during this reporting period will be posted on Center's websites and distributed to designated repositories.

RESEARCH PROJECTS REPORTED PREVIOUS PERIODS

- "COLLABORATIVE PROPOSAL: Numerical Simulation of Intelligent Compaction Technology for Construction Quality Control" (University of Texas at El Paso and Rutgers University)
- "COLLABORATIVE PROPOSAL: Multi-Sensor Sheets Based on Large-Area Electronics for Advanced Structural Health Monitoring of Civil Infrastructure" (Princeton University, University of Delaware, and Columbia University)
- "COLLABORATIVE PROPOSAL: Feasibility of Bridge Structural Health Monitoring Using Short Term, Data Acquisition System" (Utah State University, Virginia Polytechnic Institute and Columbia University)
- "Highly Efficient Model Updating for Structural Condition Assessment of Large-scale Bridges" (University of Texas at El Paso)
- "Forensic Testing of Post Tensioned Concrete Girders" (Utah State University)
- "Bridge Responses Due to Temperature Variations" (Utah State University)
- "Combining Model Based and Data Based Techniques in a Robust Bridge Health Monitoring Algorithm" (Columbia University)
- "Exploration of Video-Based Structural Health Monitoring Techniques" (University of Delaware)
- "Forensic Testing of a Double Tee Bridge" (Utah State University)
- "COLLABORATIVE PROPOSAL: Analyzing Asset Management Data Using Data and Text Mining" (Rutgers University and Utah State University)
- "Mixing and Compaction Recommendations for Warm Mix Asphalt (WMA) with Recycled Asphalt Shingles (RAS)" (Rutgers University)
- "Development of a Real-Time Vibrator Tracking System for Intelligent Concrete Consolidation" (Rutgers University)
- "3D Laser Scanning for Quality Control and Assurance in Bridge Deck Construction" (Rutgers University)
- "Quantifying Impact of Port Truck Traffic on Highway Operations Using GPS-Based Speed Data" (NJIT)
- "The Effects of Network Characteristics on Traffic Flows and Emission" (Rutgers University)
- "COLLABORATIVE PROPOSAL: Analysis of Interactions between the Marine Terminal and Highway Operations" (Rutgers University and NJIT)
- "Railroad Operations Research and Training" (Rutgers University)
- "Life Cycle Assessment of Asphalt Pavement Maintenance" (Rutgers University)
- "Mathematical Modeling and Experimental Responses of Polymer Modified Asphalt" (University of Delaware)
- "Multi-Resolution Information Mining and a Computer Vision Approach to Pavement Condition Distresses" (University of Delaware)
- "Better State-of-Good-Repair Indicators for the Transportation Performance Index" (University of Delaware)
- "Virginia Bridge Information Systems Laboratory" (University of Virginia)
- "Development for Transportation Asset Management Inventory & Management Tools" (Utah State University)
- "Improved Connection Details for Adjacent Prestressed Bridge Beams" (Virginia Polytechnic Institute)
- "ABC Deck Panel Testing" (Utah State University)
- "Forensic Testing of Prestress Concrete Girders after Forty Years of Service" (Utah State University)
- "Fiber Optic Monitoring Methods for Composite Steel-concrete Structures Based on Determination of Neutral Axis and Deformed Shape" (Princeton University)

- "Correlation between Hurricane Sandy Damages along NJ Coast with Land Use, Demographic and Other Local Characteristics" (Rutgers University)
- "Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges" (University of Delaware)
- "Elevated Temperature Properties of Weathering Steel (Princeton University)
- "Warehouse Location and Freight Attraction in the Greater El Paso Region" (University of Texas at El Paso)
- "Development of a Bridge Resource Program for the New Jersey Department of Transportation" (Rutgers University)
- "COLLABORATIVE PROPOSAL: Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation" (University of Delaware and Rutgers University)

What is the impact on other disciplines?

- "Biochar as a Rechargeable Geobattery to Promote Nitrogen Removal in Stormwater from Roadways" (University of Delaware): The study demonstrates for the first time the ability of black carbon to serve as a microbial electron donor and acceptor. Through its redox cycling black carbon may promote microbial transformation in sediments and anaerobic systems. Given its high global emission rate, black carbon may play an important role in biogeochemistry and may impact the fate of contaminants in subsurface environments.
- "Tracking Housing Recovery in Sea Bright, NJ and the Relationship to Infrastructure Renewal" (University of Delaware): This project has assembled a unique data base of housing recovery following a major storm. This database would be of exceptional value to any researcher in disaster recovery, which is inherently a multi-disciplinary effort such as environmental science.
- "Evaluation of Uncertainty in Determination of Neutral Axis and Deformed Shape of Beam Structures" (Princeton University): This work is likely to make an impact in structural design and construction. Improved knowledge of structural behavior and better understanding of the uncertainties in key parameters could lead to improved designs and safer construction practices. These disciplines can take advantage of the results from this project in two ways. First, by implementing the technology and directly applying the algorithms and analysis techniques, and second, by exploring the knowledge in this expanding database of real structural behavior and indirectly applying it to the design and construction. Other disciplines that would likely be impacted by the results of this research are mechanical engineering including aerospace engineering, where structural health monitoring is frequently performed.
- "Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation" (conducted at University of Delaware): This study impacts disciplines including environmental engineering and geo-microbiology. It produces empirical evidence to support the underlying hypothesis; i.e. black carbon such as biochar can serve as an electron donor and acceptor to support/enhance microbial transportation reactions. This new finding has important implications for not only stormwater treatment but (bio)remediation of a broad range of contaminants in groundwater and sediment.
- "Aerodynamic Flow Deflector to Increase Large Scale Wind Turbine Power Generation by 10%" (conducted by Rutgers' CAIT): This project develops a new aerodynamic flow deflector that will increase power generation by 10%. This project is mechanical engineering in nature, but the effects will be felt throughout a variety of different fields. This would encourage the implementation of wind turbine generation which would greatly affect the infrastructure, requiring the involvement of civil engineers and systems engineers. Additionally, electrical engineering would be required to restructure the electrical infrastructure to assimilate the developing technology into society.
- "Laboratory for Energy Smart Systems (LESS)" (conducted by Rutgers' CAIT): The foundation of this laboratory is inherently interdisciplinary, and aims to involve all disciplines working in energy and

infrastructure to come together to progress the assimilation of new energy technologies into society. At minimum, this would include civil engineers, electrical engineers, mechanical engineers, and systems engineers working together to solve society's energy problems.

- "Research Challenges Toward the Implementation of Smart Cities in the United States" (conducted by UTEP): The adoption of technological advances into the cities would require the collaboration among numerous fields. In addition to civil engineers, this study would require the inclusion of concepts from fields such as computer science, electrical engineering, and systems engineering.

What is the impact on the development of transportation workforce development?

Outputs	Outcomes/Impacts
Educational events for pre-collegiate students	Spreading awareness of opportunities in transportation to students, and encourage their pursuit of transportation as a viable career possibility through engagement in activities and events.
FHWA EDC2/SHRP Training	As part of FHWA Every Day Counts 2, participated in and hosted EDC related events to promote implementation

What is the impact on physical, institutional, and information resources at the university or other partner institutions?

"Nothing to Report"

What is the impact on technology transfer?

- It is anticipated that all projects will lead to the adoption of new practices or inform policy.

What is the impact on society beyond science and technology?

Outputs	Outcomes/Impacts
Results of ongoing research projects	Increased safety of structures and saving of public funds through sustainable preservation and maintenance planning of existing infrastructure made possible by knowledge and understanding of true structural behavior.

5. <u>CHANGES/PROBLEMS</u>

Changes in approach and reasons for change

"Nothing to Report"

Actual or anticipated problems or delays and actions or plans to resolve them

"Nothing to Report"

Changes that have a significant impact on expenditures

"Nothing to Report"

Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards

"Nothing to Report"

Change of primary performance site location from that originally proposed

"Nothing to Report"

6. <u>SPECIAL REPORTING REQUIREMENTS</u>

"Nothing to Report"