

PROGRAM PROGRESS PERFORMANCE REPORT

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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, 2016

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Report Term or Frequency: Semiannual (7/1/14-12/31/14)

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.	No new projects were approved this period.
Education and Workforce Development	Concrete for Kids (July 2014)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT at Virginia Tech encourages young women to succeed in engineering careers.	The camp provided 100 middle and high school students introduction to a wide variety of engineering disciplines.
	Transportation and Dance Program	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT at Delaware taught engineering concepts through interdisciplinary lesson plans that unite the engineering principles with dance.	Fifth grade students were introduced to engineering concepts in a manner that is fun and engaging.
	Designing Roadways for the Aging Population (September 2014)	Generate knowledge and skills to foster a world class workforce for the transportation sectors	CAIT provided this new workshop with the FHWA Resource Center to address aging population issues	30 engineers attended to learn about design with safety in mind for aging drivers and pedestrians
	Big Data Workshop (December 2014)	Generate knowledge and skills to foster a world class workforce for the transportation sectors.	CAIT and UTC partners from Delaware and Virginia Tech organized a workshop examining the current and future roles of big data and analytics in transportation infrastructure management.	Data users and collectors from government, academia and industry examined and proposed solutions to economic, legal and technical barriers that currently hinder big data and analytics to be effectively used by

				transportation agencies.
Technology Transfer	Planning for 2015 CUTC Summer Meeting	Support research projects that have significant and meaningful impacts	This event, hosted by CAIT, will facilitate communication between UTC administrators nationwide, generate cross-country research collaborations, and create new policies and products founded on UTC research	Nearly 200 UTC researchers and administrators will attend the conference to network with other university researchers, learn how to maintain research collectives that align with USDOT goals, and produce meaningful research projects that have national applications
	FHWA EDC2/SHRP 2 Traffic Incident Management Responder Training	Support research products that can make significant and meaningful impacts	CAIT coordinated two Train the Trainer programs for the SHRP 2 product.	As part of FHWA Every Day Counts 2, participated in and hosted the Train the Trainer program in partnership with NJDOT and its partners, to produce 100+ trainers.
	16 th Annual NJDOT Research Showcase (October 2014)	Support research projects that have significant and meaningful impacts	Provides a forum for research on the state and national scale to be showcased and allows for technology transfer of products, processes and best practices.	250+ NJDOT personnel, academics, consultants, and local public agencies attended this event coordinated by CAIT
	Family Resource Network Annual Awards (October 9, 2014)	Support research projects that have significant and meaningful impacts	2014 Community Partner Award	The Family Resource Network/Autism Family Services of New Jersey selected CAIT to receive the 2014 Community Partner Award for research conducted on the transportation

				needs of adults with autism.
	New Jersey Assembly Transportation and Independent Authorities Committee Hearing (October 14, 2014)	Support research projects that have significant and meaningful impacts.	CAIT hosts second in a series of NJ Assembly hearings on funding transportation.	Leaders from labor unions, chambers of commerce and other business organizations, transportation agencies, policy and planning experts, engineers, economists, and private citizens discussed with the committee concerns regarding the condition of the New Jersey infrastructure.

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 (March)

2. PRODUCTS: What has the program produced?

Research projects awarded

No new projects were awarded during this period.

Publications, conference papers, and presentations.

Journal publications

- Higgs, A., Barr, P.J. and Halling M.W. “Comparison of Residual Prestress Forces, Shear and Flexural Capacity of High Strength, Prestressed Concrete Bridge Girders.” Accepted to the ASCE Journal of Bridge Engineering. December 2013.
- Cook, W., Barr, P.J. and Halling M.W. “The Probability of a Bridge Failure.” Accepted to the ASCE Journal of Performance of Constructed Facilities. June 2013. (DOI 10.1061/(ASCE)CF.1943-5509.0000571)
- Cook, W., Barr, P.J. and Brackus, T.R. “Flexure and Punching Shear Capacity Comparison of Full Scale ABC Steel Bridge Girders.” Accepted to the ASCE Journal of Performance of Constructed Facilities. 2013. (DOI 10.1061/(ASCE)CF.1943-5509.0000545)
- Fausett, R. W., Barr, P.J. and Halling, M.W. “Live-Load Testing Application Using a Wireless Sensor System and Finite-element Nodel analysis of an Integral Abutment Concrete Girder Bridge.” Journal of Sensors. October, 2014. (DOI:10.1155/2014/859846)
- Sigurdardottir D.H, Glisic B. (2014). Detecting minute damage in beam-like structures using the neutral axis location, *Smart Materials and Structures*, 23, art. no. 125042 (15pp).
- Shariati, A. and Schumacher, T. (2014). Structural Health Monitoring Using Eulerian-Based Virtual Visual Sensors for Video Analysis. The ISHMII Monitor. International Society for Structural Health Monitoring of Intelligent Infrastructure. Vol. 9(2). December.
- Shariati, A. and Schumacher, T. Oversampling in virtual visual sensors as a means to recover higher modes of vibration. Proceedings of QNDE 2014, Boise, ID. Accepted for publication.
- Shariati, A., Schumacher, T., and Ramanna, N. (2014). Exploration of Video-based Structural Health Monitoring Techniques. Final Report CAIT-UTC-038. Center for Advanced Infrastructure and Transportation University Transportation Center (CAIT-UTC). October.
- Tian, J., Yi, S., Imhoff, P., Chiu, P., Guo, M., Maresca, J., Beneski, V., and Cooksey, S. (2014) Biochar-Amended Media for Enhanced Nutrient Removal in Stormwater Facilities. World Environmental and Water Resources Congress 2014: pp. 197-208. doi: 10.1061/9780784413548.022.
- Tirado, C., Mazari, M., Carrasco, C., and Nazarian, S. (2015). “Simulating Response of Different Light Weight Deflectometer Testing using Finite Element Modeling.” Submitted to and presented at the 2015 Transportation Research Board, 94th Annual Meeting. This paper is available in the Compendium of Papers and is currently under evaluation for being accepted for publishing in the Journal of the Transportation Research Board.
- Tirado, C., Mazari, M., Carrasco, C., and Nazarian, S. (2015). “Evaluating Influence Depth of Light Weight Deflectometer through Finite Element Modeling.” Accepted for the 2015 Airfield and Highway Pavements Conference to be held in June, 2015.

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

“Nothing to Report”

Other publications, conference papers and presentations.

- Halbe, K., Field, C., Joyce, P., Roberts-Wollmann, C., and Cousins, T., “Spliced Connections for Adjacent Precast Member Bridges using Ultra- and Very- High Performance Concrete”, Proceedings of the 2014 PCI Convention and National Concrete Bridge Conference, Sept 6-10, 2014, Washington, DC.
- Higgs, A., Maguire, M., Halling, M.W. and Barr, P.J. “Shear and Flexural Capacity of Salvaged High-Strength, Self-Consolidating Prestressed Concrete Bridge Girders.” Washington DC, PCI-NBC Conference. Sept. 2014.

- Foust, N., Halling, M. and Barr P.J. "Bridge Dynamic Properties and Temperature." Sixth World Conference on Structural Control and Monitoring. Barcelona, Spain. July 2014.
- Foust, N.R., Halling, M.W. and Barr, P.J. "Statistical Models of a Concrete Bridge: Changes in Modal Parameters due to Temperature." Boston, MA, *ASCE Structures Congress*. April, 2014.
- Zolghadri, N. Halling, M.W. and Barr, P.J. "Comparison of Wireless and Wired Structural System Identification." Boston, MA, *ASCE Structures Congress*. April, 2014.
- Sigurdardottir, D., Glisic, B. (2014). Examples of damage detection in real-life settings based on the position of the neutral axis, 7th European Workshop on Structural Health Monitoring (EWSHM), Nantes, France, July 8-11, 2014, paper on conference CD.
- Boccardi, A. and M. LaMotte, "An Interdisciplinary Approach: Integrating Dance and Music in the Elementary Classroom," NDEO National Conference, Chicago, Illinois, November 6, 2014.
- Chu, Pei. "Microbial Nitrate Removal Promoted by Zero-Valent Iron and Black Carbon (Biochar)" Environmental Frontier Seminar Series, University of Delaware. December 8, 2014.
- Greer, Alex, Sue McNeil, and Joseph Trainor, "Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy, An Update," CAIT at UD Brown Bag, December 2014.
- LaMotte, Megan and Lynnette Overby, "Transportation and Dance," CAIT at UD Brown Bag, November 12, 2014.
- LaMotte, Megan, Lynnette Overby and Ali Zimmerman, "The Integrated Approach vs. the Traditional Approach: Analyzing the Benefits of a Dance Integrated Curriculum in Teaching Transportation Concepts," University of Delaware Undergraduate Research Summer Scholars Symposium, University of Delaware, August 9th, 2014
- Ramanna, Nakul, "Static and Impact Load Response of Reinforced Concrete Beams and Slabs with NSM-CFRP Retrofitting", Invited Plenary Session Speaker, International Conference on Recent Advances in Engineering Sciences (ICRAES 2014), Sep 4-5 2014, MSRIT Bangalore, India.
- Ramanna, Nakul, Richard Zabel, Embedment length provisions in ACI 440 2008 for carbon fiber reinforced polymer (CFRP) strips in near surface mount (NSM) retrofitted concrete structures, 2014 PCI Convention & National Bridge Conference, Washington DC, September 6-9, 2014
- Schumacher, T. (2014). Novel Sensing Methodologies for Non-Destructive Testing and Structural Health Monitoring. Structural Engineering Seminar. Portland State University, Portland, OR. October 20. (Invited)
- Shariati, A. and Schumacher, T. (2013). Video-Based Techniques in Structural Health Monitoring. Review of Progress in Nondestructive Evaluation (QNDE). Baltimore, MD. July 21-26.
- Shariati, A. and Schumacher, T. (2014). Oversampling in VVS as a Means to Recover Higher Modes of Vibration. Review of Progress in Nondestructive Evaluation (QNDE). Boise, ID. July 20-25.
- Shariati, A. and Schumacher, T. Video-Based Structural Health Monitoring: A Review. Special symposium session entitled Structural Health Monitoring of Concrete Structures (Serviceability) at the ACI Fall 2014 Convention. Washington, D.C. October 26-30.

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 research project entitled “Numerical Simulation of Intelligent Compaction Technology for Construction Quality Control”, the researchers developed a numerical model of soil response due to roller compaction and light weight deflectometer testing that incorporates the MEPDG constitutive model for base and subgrade. This model advances towards a better representation of the compaction process as it considers contact models and provides a step further by considering the material nonlinearity.
- Under the project “Exploration of Video-based SHM Techniques”, the research introduced and promoted a novel approach to video-based monitoring, using so-called Eulerian-based virtual visual sensors. This is different than traditional approaches such as digital image correlation (DIC). Advantages include: simplicity, robustness, and speed. It has been shown that we can very accurately measure frequencies of vibration using standard off-the-shelf digital cameras with the same accuracy achieved with expensive monitoring systems. The research has progressed to the point of being applicable to actual bridges. The method has been tested on a bridge in Princeton, NJ which allowed for the verification of the accuracy of the proposed method.

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
ArtsBridge		Personnel exchange, Collaborative educational projects
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

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
 - ArtsBridge, University of Delaware: The transportation and dance program integrates transportation knowledge with dance. The information is transformed into classroom lessons for

5th grade students, and allows the students to gain knowledge from two disciplines simultaneously.

• **collaborations or contact with others outside the UTC**

- Toni Nanni, University of Miami: Collaborated with Virginia Tech on the VCTIR repair project.
- Charles H. Hegberg, reGenesis Consulting Services
- Dr. Marianne Walch, Environmental Scientist of the Delaware Department of Transportation: Dr. Walch has collaborated on the project entitled “Enhancing Removal in Stormwater Treatment Facilities for Transportation”.
- 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.
- Dr. Zia Razaq, Professor, Civil Engineering, Old Dominion University
- Jason Arndt, Bridge Maintenance Engineer, Delaware Department of Transportation

• **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. IMPACT: 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

No new projects have been selected during this period.

ONGOING RESEARCH PROJECTS

Outputs	Expected Outcomes	Impacts
“Utilization of a Pneumatic Tube Mixing Technique for Processing and Stabilization of Contaminated Dredge Material” (Rutgers University)	The primary goal of this proposal is to demonstrate the viability of a pneumatic tube mixing method for the processing and handling of contaminated navigational dredged materials from the NY/NJ harbor system.	The results should demonstrate 1) that pneumatic tube mixing is a cost effective, repeatable, and more consistent method for the amendment of dredged materials and 2) to document how the process is best conducted in the field.
“Cloud-based Federation and Fusion of Distributed Geospatial Data Sources for Supporting Hurricane Response: Requirements, Challenges and Opportunities” (Rutgers University)	The objective of this project is to explore the potential of cloud-based federation and fusion of distributed geospatial data sources to support hurricane response.	The outcome of this research will contribute to improving the security and resilience of the critical infrastructures.
“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 Health Monitoring” (Columbia University)	The goal is to develop, investigate and validate, through numerical and experimental test data, techniques to address the issues and consequent limitations related to scarcity of measured data in data-based bridge health monitoring.	Through this new approach, bridge engineers will be able to create 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.
“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.
“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 planned 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 Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy” (University of Delaware)	The focus of this exploratory project is to connect the qualitative data 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.	A workshop with representatives of impacted communities, Federal and 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	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

	understand the properties of polymer modified asphalts.	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.
“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.
“COLLABORATIVE PROPOSAL: Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation” (University of Delaware and Rutgers University)	The objective of this project is to conduct laboratory-based studies that will enable to elucidate the mechanisms by which biochar mixed with soil is able to reduce nutrients in a pilot-scale system.	New treatment technologies, like the one considered in this project, are needed that significantly reduce the footprint required for stormwater systems treating roadway runoff - which would result in significant cost reductions for State DOTs.
“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.
“Highly Efficient Model Updating for Structural Condition Assessment of Large-scale Bridges” (University of	The objective is to propose a high-speed, highly efficient model updating technique for structural	Reliable condition assessment is important to make decisions on timely maintenance or repair, which

Texas at El Paso)	condition assessment of large-scale bridges.	ensures the integrity of bridges and improves the safety for the public, and significantly reduces the life-cycle costs of bridges.
“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)	The research team will develop and evaluate a prototype of a novel multi-sensor sheet that is inexpensive, can be equipped with a variety of different sensors, easy to fabricate and deploy, and which provides densely spaced quantitative measurements from large areas of a structure.	Potential future implementations of this sensing approach include: an integrated monitoring system for bridges and other structures with similar problems; a research tool for better understanding the damage mechanisms leading to catastrophic failure; and a method for estimating remaining service-life of structures.
“COLLABORATIVE PROPOSAL: Numerical Simulation of Intelligent Compaction Technology for Construction Quality Control”(University of Texas at El Paso and Rutgers University)	The primary goal of this project is to better understand the process of accepting compacted materials to ensure quality, performance and durability using IC technology.	The deliverable of this project will be recommendations to implementation of IC based on numerical model results that can be used with confidence to evaluate the effectiveness of the existing and future instrumented rollers.
“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, visualization, meta data and other techniques for data aggregation.	The product of this research will be a catalog of tools and techniques to support asset management.
“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.
“COLLABORATIVE PROPOSAL: Feasibility of Bridge Structural Health Monitoring Using Short Term, Data Acquisition System” (Utah State University, Virginia Polytechnic Institute and Columbia University)	The goal of the research is to develop a self contained, structural health monitoring system that tracks critical bridge behavior over a period of four to six weeks.	In the long term, results from this research could aid DOTs in making better quantified decisions in terms of maintenance strategies or bridge replacement. Currently the data to make these decisions is not sufficient or available.

RESEARCH PROJECTS COMPLETED

Outputs	Expected Outcomes	Impacts
“Forensic Testing of Post Tensioned Concrete Girders” (Utah State University)	The goal of this project is to obtain better estimations of the condition of a state's bridge inventory by studying the behavior of in service prestressed concrete bridges.	It is expected that the research findings will result in design recommendations that will directly impact operation and maintenance practices as well as new construction planning.
“Bridge Response Due to Temperature Variations” (Utah State University)	The goal of this research is to quantify the effects of daily temperature variations on the behavior of concrete bridges.	Analysis of data on the effects of temperature variations will have direct implications for operation and maintenance practices as well as new design procedures.
“Combining Model Based and Data Based Techniques in a Robust Bridge Health Monitoring Algorithm” (Columbia University)	The primary objective of this proposed research is to develop a continuous health monitoring strategy applicable to real life bridges.	The robustness of the final unified scheme will be in its ability to address the practical constraints of incomplete instrumentation, unobserved/weakly excited vibration modes, unknown scaling in output-only situations, and effect of model uncertainty induced by environmental variations of the structural parameters.
“Exploration of Video-Based Structural Health Monitoring Techniques” (University of Delaware)	The objective of this research is to evaluate advanced video-based techniques for SHM of civil infrastructure.	Research products include novel remote monitoring techniques for capturing the dynamic response of structures. Once the algorithm has been implemented and evaluated, it can be deployed to monitor critical structures, e.g. bridges, in the field.
“Forensic Testing of a Double Tee Bridge” (Utah State University)	By studying the behavior of in service prestressed concrete double tee bridges, better estimations of the condition of a state's bridge inventory can be quantified.	This research has direct implications for operation and maintenance practices as well as new construction planning. It is anticipated that the results of this research will be used to help engineers make informed decisions in terms of capacity of in-situ prestressed concrete bridges made with double tee girders.

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: 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"
- "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)

What is the impact on other disciplines?

- "Effects of Temperature on Bridge Dynamic Properties" (conducted at UTEP): The aim of this project is to isolate the effects temperature has on the dynamic properties of several bridge types. By determining the correlation between temperature and dynamic properties, the effects due to temperature can essentially be removed from the structural analysis, and the effects of damage to the bridge can be isolated. This analysis can be applied to model structures in other fields, such as mechanical engineering and aerospace engineering.

- “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.

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

Outputs	Outcomes/Impacts
Designing Roadways for the Aging Population	Educated public agency professionals on design and safety issues for aging drivers and pedestrians.
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.

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.
Big Data Workshop	Data users from government, academia and industry examined and proposed solutions to economic, legal and technical barriers that currently hinder big data and analytics to be effectively used by transportation agencies.
Designing Roadways for the Aging Population	Public agency professionals were educated on design and safety issues for aging drivers and pedestrians which would potentially lead to safer roadways and fewer instances of incidents.

5. CHANGES/PROBLEMS

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. SPECIAL REPORTING REQUIREMENTS

“Nothing to Report”