Civil, Construction, and Environmental Engineering

2013-2014 Research Projects

Faculty

Sankar Arumugam, Associate Professor (919/515-7700); PhD, Water Resources Engineering, Tufts University (2001); interested in understanding, modeling and forecasting hydrological fluxes at large spatial scales based on land surface and climatic indices. Other topics of research include water resources planning and management and environmental assessment in developing countries. [sankar_arumugam@ncsu.edu]

Tarek Aziz, Teaching Assistant Professor and Coordinator of Advising (919/515-1562); PhD, Civil, Construction, and Environmental Engineering, North Carolina State University (2010); interested in the interface of environmental process engineering and energy. This includes topics such as the conversion of waste materials to fuel (anaerobic digestion, biofuels, waste incineration, gasification, etc.), and sustainability considerations of these, and more traditional, processes. To help explore these research questions he makes use of experimentation, computational fluid dynamics, and life-cycle assessment tools. [tnaziz@ncsu.edu]

Morton A. Barlaz, Professor and Department Head (919/515-7212); PhD, Civil and Environmental Engineering, University of Wisconsin-Madison (1988); interested in refuse decomposition in landfills, integrated solid waste management and anaerobic bioremediation. [barlaz@ncsu.edu]

John W. Baugh, Professor (919/515-7697); PhD, Civil Engineering, Carnegie Mellon (1989); interested in systems engineering and computing applications in civil engineering; concurrent and distributed algorithms and systems; formal approaches for reasoning about computer systems; mathematical modeling, optimization, and support for engineering design; verification of real-time systems. [jwb@ncsu.edu]

Emily Z. Berglund, Assistant Professor (919/515-2338); PhD, Civil Engineering, North Carolina State University (2005); interested in water management; water reclamation and conservation; water security; complex adaptive systems; agent-based modeling; evolutionary computation; human behavior; and social dimensions. [emily_berglund@ncsu.edu]

Chris Bobko, Assistant Professor (919/515-0481); PhD, Structures and Materials, Civil and Environmental Engineering, Massachusetts Institute of Technology (2008); interested in combining small-scale experimental techniques with multiscale modeling of the complex porous composite materials often encountered in civil engineering, including cements, rocks, and fiber-reinforced composites. [chris_bobko@ncsu.edu]

Robert C. Borden, Professor (919/515-1625); PhD, Environmental Engineering, Rice University (1986); interested in remediation of contaminated soil and groundwater. [rcborden@ncsu.edu]

Roy H. Borden, Professor (919/515-7630); PhD, Civil Engineering, Northwestern University (1980); interested in soil and site improvement, grouting, laboratory and in-situ material characterization, behavior of foundations in residual soils, soil-structure interaction, excavation support systems and analysis of the causes of failures. [borden@ncsu.edu]

E. Downey Brill, Jr., Professor (919/515/2352); PhD, Environmental Engineering, The Johns Hopkins University (1972); interested in environmental systems analysis, modeling, optimization. [brill@ncsu.edu]

Francis L. de los Reyes, Professor (919/515-7416); PhD, Environmental Engineering in Civil Engineering, University of Illinois, Urbana (2000); interested in the interface between microbial ecology and environmental engineering. At this interface, molecular techniques are utilized as powerful tools for the analysis of microbial populations in engineered and natural treatment systems. Environmental process engineering is approached from a fundamental standpoint- combining the
insights from molecular (DNA- and RNA-based) approaches with innovative process experiments and modeling. Recent research includes structure-function studies in wastewater treatment systems, landfills, soils, and decentralized sanitation systems. [jdlenkins@ncsu.edu]

Joe DeCarolis, Assistant Professor (919/515-0480); PhD, Engineering and Public Policy, Carnegie Mellon University (2004); interested in the interdisciplinary assessment of energy technology and policy aimed at effecting deep cuts in greenhouse gas emissions. His primary focus is on the development and application of energy system models to derive policy-relevant insight that is robust to future uncertainty. [jdecarolis@ncsu.edu]

Joel Casey Dietrich, Assistant Professor (919/515-5277); PhD, Civil Engineering, University of Notre Dame (2011); interested in the development of computational models for wind waves and coastal circulation, and their application to high-resolution simulations of ocean behavior. [jcdietrich@ncsu.edu]

Joel C. Ducoste, Professor (919/515-8150); PhD, Environmental Engineering, University of Illinois, Urbana (1996); interested in the operation, design, and optimization of drinking water and wastewater treatment processes. He achieves these goals by incorporating novel experimental techniques and validated numerical models in the analysis of unit processes. [jducoste@ncsu.edu]

Billy Edge, Professor (919/515-7387); PhD, Civil Engineering, Georgia Institute of Technology (1968); interested in sustainable engineering practices in the coastal environment, coastal engineering, dredging technology, coastal zone management, hydraulic engineering, modeling of coastal processes. [bledge@ncsu.edu]

H. Christopher Frey, Professor (919/515-1155); PhD, Engineering and Public Policy, Carnegie Mellon University (1991); interested in air pollution emissions, prevention and control; measurement and modeling of activity, energy use, and emissions of on-road and non-road vehicles; exposure and risk analysis; quantification of variability and uncertainty; modeling and evaluation of energy conversion and emission control technologies. [frey@ncsu.edu]

Mohammed A. Gabr, Professor (919/515-7904); PhD, Civil Engineering, North Carolina State University (1987); interested in geoenvironmental Engineering, Geosynthetics, Physicochemical Phenomena of Soils, Groundwater Control, Deep and Shallow Foundation, In Situ Testing, Soft Soils, Use of Waste By Products in Mass Applications, and Waste Containment and Confinement. [gabr@ncsu.edu]

Andrew P. Grieshop, Assistant Professor (919/513-1181); PhD, Mechanical Engineering and Engineering and Public Policy, Carnegie Mellon University (2008); interested in sources and evolution of atmospheric aerosols, characterization of in-use emissions from mobile and stationary combustion sources, linkages between air pollution emissions and climate change, air pollution exposure assessment, technical policy analysis of the environmental impacts of energy systems and energy and environment in developing countries. [agrieshop@ncsu.edu]

N. Murthy Guddati, Professor (919/515-7699); PhD, Computational and Applied Mathematics, University of Texas at Austin (1998); interested in the general area of computational mechanics, ranging from the development of new and efficient computational techniques, to the application of existing methodologies to simulate complex physical systems. [mguddat@ncsu.edu]

Abhinav Gupta, Associate Professor (919/515-1385); PhD, Civil Engineering, North Carolina State University (1995); interested in modeling experimental and analytical behavior of structures, Nonclassically damped primary-secondary systems, Earthquake behavior of electrical instruments and control panels, Buried pipelines, Computer aided engineering. [agupta1@ncsu.edu]

Tasnim Hassan, Professor (919/515-8123); PhD, Engineering Mechanics, The University of Texas at Austin (1993); interested in experimental and analytical studies towards understanding and modeling low-cycle fatigue failures of steel structures and welded joints, seismic behavior of steel and concrete structures, sensor development, and constitutive modeling of various steels, high-temperature alloys, concrete and polymeric materials. [thassan@ncsu.edu]

Cassandra Hintz, Assistant Professor (919/515-6411); PhD, Civil and Environmental Engineering, University of Wisconsin-Madison (2012); interested in multi-scale characterization of asphalt
materials, asphalt binder modification, asphalt pavement design, and asphalt pavement distress mechanisms. [cahinz@ncsu.edu]

Edward Jaselskis, Jimmy D. Clark Distinguished Professor (919/515-1158); PhD, Civil Engineering (Construction), University of Texas at Austin (1988); interested in sustainable construction innovation, project management and global construction practices. [ejjasels@ncsu.edu]

N. Paul Khosla, Professor (919/515-7835); PhD, Civil Engineering, Purdue University (1978); interested in bituminous and concrete materials, highways pavements. [khosla@ncsu.edu]

Y. Richard Kim, Professor (919/515-7758); PhD, Civil Engineering, Texas A&M University (1988); interested in pavement Design and Rehabilitation, Bituminous Materials, Pavement Preservation, Nondestructive Evaluation of Pavements, Performance Modeling. [kim@ncsu.edu]

Detlef R. U. Knappe, Professor (919/515-8791); PhD, Environmental Engineering in Civil Engineering, University of Illinois, Urbana (1996); interested in drinking water quality and treatment, water reuse, organic micropollutants, development of water treatment processes for persistent organic pollutants, fate of organic pollutants in solid waste landfills. [knappe@ncsu.edu]

Mervyn J. Kowalsky, Professor (919/515-7261); PhD, Structural Engineering, University of California, San Diego (1997); interested in earthquake engineering design and analysis, behavior of reinforced and pre-stressed concrete structures, development of alternative performance-based seismic design procedures. [kowalsky@ncsu.edu]

Michael L. Leming, Associate Professor (919/515-7823); PhD, Civil Engineering, North Carolina State University (1994); interested in construction materials, concrete, construction. [leming@ncsu.edu]

George F. List, Professor (919/515-8038); PhD, Civil Engineering, University of Pennsylvania (1984); interested in transportation system observability, control, and network planning; sensor design and system instrumentation, wireless technologies, traffic management systems, highway capacity and safety modeling, quality of service assessment, network capacity investment planning; modeling, simulation, and optimization of transport systems and networks; freight logistics; railroad system planning design and operation; multi-objective optimization. [gflist@ncsu.edu]

Min Liu, Assistant Professor (919/513-7920); PhD, Dept. of Civil and Environmental Engineering, Engineering Project Management Program, University of California at Berkeley (2007); interested in performance and Productivity Improvement for Construction Projects. [min_liu@ncsu.edu]

Greg Lucier, Research Assistant Professor and Laboratory Manager (919/513-7322); PhD, Structural Engineering, North Carolina State University (2012); large-scale structural testing. [gwlucier@ncsu.edu]

Kumar Mahinthakumar, Professor (919/515-7696); PhD, Civil Engineering, University of Illinois at Urbana-Champaign (1995); interested in large scale modeling of subsurface flow and transport, parallel and distributed computing, optimization and inverse problems, water distribution system analysis. [gmkumar@ncsu.edu]

Vernon C. Matzen, Professor (919/515-7736); PhD, Civil Engineering, University of California Berkeley (1976); interested in experimental, numerical, and theoretical analysis structures; structural vibrations. [matzen@ncsu.edu]

Brina Montoya, Assistant Professor (919/513-0425); PhD, Civil Engineering, University of California, Davis (2012); interested in bio-mediated soil improvement, cemented sand behavior, liquefaction mitigation, and physical modeling of soils using laboratory and centrifuge testing. [bmmorten@ncsu.edu]

James M. Nau, Professor (919/515-7737); PhD, Civil Engineering, University of Illinois at Urbana-Champaign (1982); interested in structural design, structural dynamics, earthquake engineering, numerical methods. [nau@ncsu.edu]

Roberto Nunez, Lecturer and Senior Construction Extension Specialist (919/515-8408); MBA, General Management, University of North Carolina, Kenan Flagler Business School (1991); project management, project safety. [ranunez@ncsu.edu]

Margery F. Overton, Professor (919/515-7682); PhD, Civil Engineering, Duke University (1981); interested in coastal processes, beach and dune erosion, coastal hazard identification and response
strategies to improve the resilience of coastal environments. Modeling and analysis of both short term and long term impacts due to storms and sea level rise. [overton@ncsu.edu]

Mohammad Pour-Ghaz, Assistant Professor (919/515-2235); PhD, Civil Engineering, Purdue University (2011); interested in durability of reinforced concrete structures, Health monitoring and service life prediction of concrete structures, Non-destructive testing and in-situ sensing, Flow and transport in fractured porous media, Sustainable materials for civil infrastructure. [mpourghaz@ncsu.edu]

M. Shamimur Rahman, Professor (919/515-7633); PhD, Civil Engineering, University of California-Berkeley (1977); interested in geomechanics, soil dynamics, numerical methods, probabilistic analysis, containment transport in groundwater. [rahman@ncsu.edu]

S. Ranji Ranjithan, Professor (919/515-6979); PhD, Environmental Engineering, University of Illinois at Urbana-Champaign (1992); interested in mathematical modeling and optimization, evolutionary computation, systems analysis, computer-based decision support tools, decision making under uncertainty, artificial neural networks; areas of applications include air quality management, watershed management, animal waste management, solid waste management, and transportation engineering. [ranji@ncsu.edu]

William J. Rasdorf, Professor (919/515-7637); PhD, Civil Engineering, Carnegie Mellon (1982); interested in structures, construction, transportation, manufacturing, and computer-aided engineering. Facility design methods. Engineering databases and information processing and technology. Automated representation, use, and management of analysis, design, manufacture, and construction data. Modeling of engineering objects, processes, assemblies, and phenomena. Integration among engineering processes and information systems. Modeling and processing of design, product and process data, material property standards and specifications, design codes, and regulations. Computer-aided design and geometric and spatial modeling and analysis in engineering. Information technology applications in problem solving, design, construction, manufacturing, and transportation. Constructed facility life cycle automation through the integration of software, hardware, sensing, and information and communication technologies. Planning, design, and construction automation. Environmental impacts in construction. [rasdorf@ncsu.edu]

Sami Rizkalla, Professor (919/513-4336); PhD, Civil Engineering, North Carolina State University (1976); interested in design, construction and performance of reinforced and prestressed concrete structures and bridges. [sami_rizkalla@ncsu.edu]

Nagui M. Rouphail, Professor (919/515-1154); PhD, Civil Engineering, The Ohio State University (1981); Dr. Rouphail is interested in traffic flow theory and control. [rouphail@ncsu.edu]

Rudi Seracino, Associate Professor (919/513-1735); PhD, Civil Engineering, The University of Adelaide, Australia (2000); interested in the application of advanced fiber reinforced polymers (FRP) in civil engineering, particularly in the development of FRP systems for the repair or strengthening of existing infrastructure. [rudi_seracino@ncsu.edu]

Tushar Sinha, Research Assistant Professor (919/513-1804); PhD, Agricultural and Biological Engineering, Purdue University (2008); interested in understanding: i) impacts of climate and land use changes on hydrologic cycle, ii) large scale ocean-atmosphere-land surface interactions to improve streamflow and soil moisture forecasting, and iii) surface water and groundwater sustainability under climate change and human interventions. [tsinha@ncsu.edu]

Ben Smith, Lecturer (919/515-1499); M.C.E., Civil Engineering, North Carolina State University (2011); interested in infrastructure repair and re-use, specialty concrete construction, construction management, and sustainable infrastructure design. [bcsmith7@ncsu.edu]

John R. Stone, Professor (919/515-7732); PhD, Civil Engineering, University of Virginia (1981); interested in transportation engineering and systems analysis, urban transportation and land use. [stone@ncsu.edu]

Akhtarhusein A. Tayebali, Associate Professor (919/515-7611); PhD, Civil Engineering, University of California, Berkeley (1990); interested in pavement materials, pavement design and rehabilitation, performance based mix design and analysis systems for conventional and modified bituminous mixes. [tayebali@ncsu.edu]
Billy M. Williams, Associate Professor (919/515-7813); PhD, Civil Engineering, University of Virginia (1999); interested in intelligent transportation systems, travel time reliability, real-time control system optimization, transportation network simulation, applied statistics and time series analysis in transportation, and traffic flow theory. [billy_williams@ncsu.edu]

Jie Yu, Assistant Professor (919/515-7702); PhD, Civil and Environmental Engineering, Massachusetts Institute of Technology (2000); environmental fluid mechanics. [jie_yu@ncsu.edu]

CAREER: Climate Informed Uncertainty Analyzes for Integrated Water Resources Sustainability
Sankarasubraman Arumugam
National Science Foundation (NSF)
$404,351
06/01/10 - 05/31/15
Inability to maintain proper water quality in natural systems could result not just from excessive point and non-point source loadings, but also from ill-conceived water allocation policies. Given that seasonal to interannual climatic variability modulates both precipitation and temperature, streamflow, river water quality and ecological habitats may respond dramatically to the extremes of climate. We argue that by utilizing climate information, an adaptive approach to integrated water quantity and quality management could be developed which on continual application over long-term could result in improved water sustainability. The overarching goal of this career development plan is to exploit the recent advances in climate prediction to promote adaptive water management and to integrate that into undergraduate/graduate education and outreach efforts related to relevant agencies.

Conference: Seasonal to Internannual Hydroclimate Forecasts and Water Management, Portland, OR, July/August 2013
Sankarasubraman Arumugam
National Science Foundation (NSF)
$49,998
07/01/13 - 06/30/14
This conference will convene climate scientists, hydrologists, forecasting agencies, water utilities, reservoir operators and water management agencies together to advance understanding of the challenges and opportunities in developing hydroclimate forecasts relevant to water resources management by answering the following science questions: (1) What are the key sources of uncertainties that challenge development of skillful hydroclimate forecasts at daily, seasonal and interannual time scales? (2) How best do we reduce the uncertainty and improve reliability in downscaling large-scale climate information for developing regional hydroclimate forecasts?

Sankarasubraman Arumugam, Ryan Boyles
The reliability of existing water supply systems are threatened due to increase in water demand resulting from urbanization and population growth. This combined with seasonal to interannual variability in streamflow increase the vulnerability of these systems particularly during prolonged droughts. The objective of the proposed research is to develop experimental reservoir storage forecasts utilizing the monthly/seasonal streamflow forecasts obtained from multimodel climate forecasts using the forecast portal available with the State Climate Office of NC.

Integrated Drought Management and Assessment Portal for the State of North Carolina
Sankarasubraman Arumugam, Tushar Sinha, Ryan Boyles
NCSU Water Resources Research Institute
$60,000
03/01/14 - 02/29/16
The proposed research builds upon the ongoing effort in developing an experimental inflow and storage forecasts portal (http://www.nc-climate.ncsu.edu/inflowforecast) housed at the SCO into an integrated drought management and assessment portal (Figure 1) for NC. Two specific objectives are proposed in this study:  1) Develop operational soil moisture and streamflow forecasts for the entire state of NC by enhancing the existing experimental reservoir inflow and storage forecasts portal with the NASA’s Land Information System (LIS) and distributed modeling framework.   2) Develop adaptive drought management framework that supports monitoring, prediction and drought management including customized drought indices for the entire state of NC.

WSC - Category 3: Collaborative Research: Water Sustainability under Near-term Climate Change : A Cross-Regional Analysis Incorporating Socio-Ecological Feedbacks and Adaptations
Sankarasubraman Arumugam, Kenneth E Kunkel, Gnanamanikam Mahinthakumar, Tushar Sinha, Emily Michelle Berglund
National Science Foundation (NSF)
$890,576
09/01/12 - 08/31/16
Significant variability in hydroclimate across the Sunbelt presents contrasting differences in water infrastructure management, irrigation alternatives, freshwater biodiversity and adaptation strategies. In spite of these cross-regional differences, both regions face two common stressors: (a) uncertainty in available freshwater arising from global climate change and (b) increased human demand due to population growth and consumption. The main objective of this study is to understand and quantify the potential impacts of near-term climate change and population growth on freshwater sustainability by explicitly incorporating the feed-backs from human-environmental systems on water supply and demand in various target basins spanning Arizona to North Carolina.

Sustainable Anaerobic Co-Digestion of Grease Interceptor Waste
Fat, oil, and grease (FOG) generated at food service establishments pose a threat to public health and the environment by reducing the conveyance capacity of our collection systems and causing sanitary sewer overflows. Grease abatement device pumping is a necessary step to maintain system performance. Presently in North Carolina, FOG waste pumped from the food service industry is treated as septage and either land applied or composted as a soil amendment. The anaerobic co-digestion of grease interceptor waste (GIW) provides a value added disposal option whereby GIW can be used to generate electricity at wastewater treatment facilities. No facilities in North Carolina currently utilize the anaerobic co-digestion of GIW. Preliminary research at NC State has shown the addition of GIW to result in increases in biogas production of up to 317%. The proposed research aims to: (1) Explore the limits to anaerobic co-digestion by varying the composition of GIW, (2) Explore bioreactor process and microbial community that is functionally resilient to variations in FOG loading and (3) Evaluate the quality of co-digested biosolids during experimentation for tasks (1) and (2). Findings from this research will provide guidelines for the sustainable disposal of GIW via anaerobic co-digestion and move wastewater treatment facilities towards renewable energy generation.

Collaborative Research: Fluorochemical Signatures in Municipal Waste and Landfill Leachate
Morton A. Barlaz
National Science Foundation (NSF)
$233,882
04/01/11 - 03/31/15
Our first hypothesis is that fluorochemicals are released from municipal refuse by a fast physical process (e.g., leaching) and more slowly due to refuse biodegradation under methanogenic conditions. Our second hypothesis is that carpet, textile, and paper are the primary sources of fluorochemicals in refuse and the resulting leachate will have fluorochemical “signatures”. To test hypotheses 1 and 2, we will measure fluorochemical release to leachate in several sets of laboratory-scale landfill simulation reactors. Reactors containing mixed refuse (collected on a quarterly basis) will be operated under methanogenic and abiotic conditions. Mixed refuse will also be sorted to test separately the paper/textiles/carpet components. Additional reactors will be operated with fresh paper, refuse textiles, and refuse carpet. Fluorochemical data will make it possible to identify the principal classes of refuse that act as sources of fluorochemicals and to rationalize the observed fluorochemicals with known production and uses. Our third hypothesis is that landfills are long-term sources of fluorochemicals and that the mass of fluorochemicals released to engineered wastewater treatment plants and natural environments (e.g., groundwater) will prove important on a national scale. To test our third hypothesis, we will characterize fluorochemical concentrations in leachate in a representative survey of U.S. landfills with a focus on selecting sites so that the effects of climate (arid vs. wet), landfill operations, and refuse age on fluorochemical composition and concentration can be determined. These data, coupled with an inventory of U.S. landfills (lined and unlined), will be used to develop and parameterize a model to estimate on a national scale the mass of fluorochemicals released to wastewater treatment plants and to groundwater.
Development of Methods to Measure Anaerobic Biodegradability Under Simulated Landfill Conditions
Morton A. Barlaz
Plastics Environmental Council
$155,804
08/01/11 - 08/28/13
The objective of this research is to define and execute a modeling program that will result in a basis for projecting landfill biodegradation rates based on laboratory data, with the objective of applying for a standard specification (ASTM or otherwise) that will satisfy regulatory, legislative end commercial requirements for assurance of biodegradability.

Development of Methods to Measure the Hydrogen Sulfide Production Potential of Sulfur-Containing Wastes
Morton A. Barlaz
Environmental Research & Education Foundation
$163,336
08/15/12 - 07/31/15
The presence of hydrogen sulfide (H2S) in landfill gas is problematic for several reasons: (1) it is corrosive to landfill gas treatment systems, (2) it is toxic to humans, and (3) it exerts a bad odor, even at 0.5 “10 ppb. In addition, H2S is toxic to the microorganisms that generate both methane and H2S. As described in this proposal, H2S toxicity has implications for the manner in which we assess the H2S production potential of a waste. Preliminary data from our laboratory suggests that current methods to measure the H2S production potential of a waste may underestimate the true potential because the test is influenced by toxicity. During testing, we often measure H2S concentrations in excess of 20,000 ppm and have recently shown inhibition at 5000 ppm. This suggests that better test methods are required. The overall objective of the proposed research is to develop and document a protocol to assess the H2S production potential of sulfur-containing wastes. Once developed, the protocol will be applied to at least five different fly ashes. The results will include (1) a documented protocol to assess H2S production potential; (2) an understanding of the relationship between a small-scale (serum bottle) test which is cheaper and faster, and a more realistic but slower and more costly reactor test; and (3) an evaluation of whether the H2S production potential of various fly ashes can be predicted from a chemical characterization.

Integrated Solid Waste Management and Its Environmental Sustainability in a Carbon Constrained Environment
Morton A. Barlaz, Sanmugavadivel Ranjithan, Joseph F DeCarolis
Environmental Research & Education Foundation
$268,873
01/01/10 - 12/31/14
The goal of the proposed research is to develop a life-cycle assessment (LCA) model capable of analyzing solid waste management (SWM) performance at both the individual process and integrated system levels, taking into account implications of greenhouse gas (GHG) mitigation
policies and competing SWM objectives (e.g., costs, emissions, and diversion targets). An integrated life-cycle optimization model will be developed to estimate the costs, energy use, emissions, and environmental impacts associated with the processes (e.g., collection, separation, waste-to-energy [WTE], composting, anaerobic digestion, landfilling) that constitute the SWM system.

Life-Cycle Analysis of Alternatives for Food Waste Management
Morton A. Barlaz
Covanta Energy Corporation
$25,000
10/14/13 - 10/31/14
The objective of this research is to evaluate alternatives for the treatment and disposal of food waste by using life-cycle analysis. Management alternatives to be considered include combustion with energy recovery, anaerobic digestion, composting and landfill disposal. Sensitivity analysis will be conducted to explore the effect of critical model parameters on the ranking of the alternatives considered.

Microbial Community Profiling of Anaerobic Refuse Decomposition: Response to Acidic Conditions, Shock Loads and Moisture Addition
Morton A. Barlaz
Waste Management, Inc.
$1,360,969
04/01/04 - 05/16/15
The objective of the proposed research is to develop an improved data set and model to predict methane production from U.S. municipal solid waste landfills. A second objective is to estimate the bioavailability of sulfate in various waste streams buried in landfills.

Modernizing Models and Data on Methane Production from Landfills
Morton A. Barlaz, Joseph F DeCarolis
Environmental Research & Education Foundation
$110,000
08/02/10 - 07/31/13
The objective of the proposed research is to develop an improved data set and model to predict methane production from U.S. landfills.

An Agent-based Modeling Approach to Integrate Social Dimensions and Infrastructure Management for Urban Water Reuse
Emily Michelle Berglund, Andrew Ray Binder PhD
National Science Foundation (NSF)
$345,000
09/01/12 - 08/31/15
This research explores the interplay between social and technical aspects of reclaimed water and will develop new ways for planning municipal water infrastructure and policy. An agent-based modeling approach will be developed to examine interactions among consumers, utility operators, existing water infrastructure, and new water reclamation infrastructure. The project will bridge research in public opinion of unfamiliar technologies, and civil engineering infrastructure management. The Acceptance-Resistance Agent-Based Model will be developed by integrating engineering models and empirical assessments of public opinion to simulate transitions in public attitudes toward accepting or resisting water reuse.

Emily Michelle Berglund, Sankarasubraman Arumugam
NCSU Water Resources Research Institute
$50,000
03/01/12 - 02/28/14
Under population growth and land use change through urbanization, water shortages may become increasingly frequent, and climate change will alter the availability and timing of water from expected levels. The sustainability of water resources depends on the dynamic interactions among the environmental, technological, and social characteristics of the water system and local population. A new integrated framework will be developed to provide critical insights for water utility operators about how the interactions of water shortage response plans with climate change, land use change, population growth, and consumer behaviors impact the long-term water supply sustainability.

DO 2 Task 3.7 - Berglund
Emily Michelle Berglund
Laboratory for Analytic Sciences
$52,550
09/13/13 - 09/30/14
DO 2 Task 3.7 activities

LAS DO3 Task Order 2.8 Analytic Workflow - Berglund
Emily Michelle Berglund
Laboratory for Analytic Sciences
$50,000
05/31/14 - 12/31/14
Modeling and simulation of analytic workflow dynamics will be investigated within the operational domain. Within fixed organizational contexts, predictive models of performance will be based on two complementary scenarios: (1) people and their mutual relationships and (2) an analyst and tools. Research will investigate the influence on success and productivity of (1) the cognitive processing of individual analysts, or human-centric modeling and (2) social networks within teams of analysts, or social network-centric modeling of analytic workflows. The development of a modeling framework will create insight about the use of social network
analysis, human-tool interaction semantics, and agent-based modeling for simulating the effects of communication among individuals in analysis of workflow and for simulating the learning process and network effects of knowledge sharing on the analysis of workflow. A scientist-tool interaction workflow for knowledge extraction will be represented within an agent-based modeling framework to extend traditional scientific workflow simulation. An agent-based modeling approach will simulate a scientist as an agent that interacts with environmental data to create hypotheses and update results through a feedback process. The agent-based modeling framework will be coupled with an existing scientific workflow tool, and a team of scientists will be represented as agents to use the workflow tool, communicate, and update an external knowledge base.

EAGER: Submicron Fracture Toughness Measurements for Cement Paste Using Focused Ion Beam (FIB) and Nanoindentation
Christopher P Bobko
National Science Foundation (NSF)
$79,974
05/15/14 - 04/30/15
The research objective of this EAGER proposal is to measure the fracture toughness of cement paste at submicron length scales using nanoindentation experiments with Focused Ion Beam (FIB) milled sample structures. Fracture and strength measurements made at the typical scales of concrete laboratory testing are often explained and modeled by introducing the idea of microcracks, small material flaws within the cement paste matrix. Current experiments, however, are unable to reveal how fractures are generated within the microstructure. As a result, modeling the initiation, propagation, interdependence, and coalescence of microcracks for macroscopic material failure is a formidable challenge because basic input data is missing. New, small scale experimental techniques are required to quantitatively assess the complex material behaviors that lead to microcracking in cement paste. In support of the primary research objective, FIB milling techniques will be applied to cement paste and used to fabricate micropillars, microbeams, and micro-wedge-splitting samples of cement paste. These FIB milled structures will be tested using nanoindentation to assess strength and fracture properties. The research outcomes will lead to significant broader impacts in the study of failure of cementitious materials. The production, transportation, and use of concrete accounts for between 5-9% of total CO2 emissions worldwide. If the fundamental mechanics mechanisms behind failure of cement can be better understood, rationally designed engineering solutions can be deployed to provide tougher materials for civil infrastructure, reducing consumption of natural resources and production of CO2. The research outcomes will transform the concrete industry by continuing our move away from â€œmake-and-breakâ€ testing and towards the study and design of concrete materials for specific applications. They will also have a significant impact on study of any concrete deterioration mechanism that involves formation of internal stresses in the material.

Measuring Mechanical Properties of Tantalum Powder and Tantalum Power Granular Composites Using Nanoindentation
Christopher P Bobko
Global Advanced Metals USA, Inc.
The research objective of the proposed agreement is to demonstrate that nanoindentation methods are useful experimental tools for measuring mechanical properties of Tantalum powders and powder composites. In particular, we will seek to understand relationships between powder processing steps and behavior of Tantalum during compaction that is relevant to the capacitor manufacturing processes. This research is in support of an overall, longer term research goal to reveal a fundamental unifying model capturing the link between powder properties and performance after the manufacturing process.

Nanotechnology for Shales and Polymers in Australia's Energy Sector
Christopher P Bobko
Commonwealth Scientific and Industrial Research Organization (CSIRO)
Unfunded
08/16/13 - 08/14/14
Fulbright award - Conduct atomic force microscopy and other microscale techniques within materials science on two types of materials, shale and thin-filmed polymers.

Development and Field Evaluation of Colloidal Mg(OH)2 Buffer
Robert C. Borden
Savannah River Nuclear Solutions, LLC (formerly Washington Savannah River Company)
$198,000
06/20/11 - 06/19/14
Increasing the pH of groundwater and aquifer material is a major challenge due to the high buffering capacity of these materials. In this project, we will develop and evaluate colloidal Mg(OH)2 buffers for increasing aquifer pH. This will include laboratory studies to evaluate transport and geochemical properties followed by field testing to evaluate performance.

Generation of Biodegradation - Sorption Barriers for Munitions Constituents 11 EB-ER1-079 (formerly ER1-038)
Robert C. Borden, Detlef R. Knappe
US Army - Corps of Engineers
$639,000
03/30/11 - 03/30/15
The overall objective of this proposal is to further develop and demonstrate a process to enhance the sorption and/or degradation of TNT, RDX, HMX and perchlorate in soils by spray application of an amendment solution containing waste glycerol and a soluble humic material to the soil surface, followed by irrigation to carry the amendments deeper into the soil profile. The readily biodegradable glycerol will stimulate anaerobic biodegradation of the target contaminants and will reduce naturally occurring Fe(III) oxides and hydroxides to Fe(II). This Fe(II) will provide a reservoir of reducing power to maintain anoxic conditions in the soil and will enhance abiotic degradation of RDX and other contaminants. The humic materials will also maintain reducing conditions by consuming oxygen, enhance hydrophobic sorption, enhance covalent
binding of TNT, and may potentially serve as electron shuttles, enhancing abiotic degradation by Fe(II).

Numerical Modeling of Post-Remediation Impacts of Anaerobic Bioremediation on Groundwater Quality
Robert C. Borden, Detlef R. Knappe
Strategic Environmental Research and Development Program (SERDP)
$506,874
03/22/11 - 03/22/15
Electron donor addition can be very effective in stimulating enhanced reductive dechlorination (ERD) of chlorinated solvents and anaerobic biodegradation/immobilization of other groundwater contaminants. However, electron donor addition can result in the release of a groundwater “plume” with reduced levels of O2, NO3-, SO42-, and elevated levels of dissolved Mn2+, Fe2+, CH4, organic carbon, salts, and naturally occurring hazardous compounds (As, etc.). There is growing concern about these “secondary impacts” of anaerobic bioremediation processes. Objective: The overall objective of this research is to develop an improved understanding of the near- and long-term impacts to groundwater quality after implementation of in situ anaerobic bioremediation processes. This will include development and application of a general modeling approach for describing the natural attenuation of important secondary water quality impacts associated with electron donor addition. Specific objectives to be achieved during the three year duration of this project include. A. Formulate a general modeling approach appropriate for simulating the natural attenuation of electron donors and associated secondary impacts for a wide range of sites. The model approach and validation will be based on data from three intensively studied field sites -- Bemidji Crude Oil Spill, Cape Cod Wastewater Plume, and NAWC - West Trenton Chlorinated Solvent Spill. B. Assemble a database of secondary water quality impacts at ERD sites. Analyze the secondary plumes to determine a range of characteristics and natural attenuation mechanisms. Identify a set of representative Case Studies illustrating important aspects of secondary plume behavior. C. Use the validated model approach to simulate a series of synthetic plumes corresponding to end-member cases important to SWQI assessment. Use the simulation results to assess the potential for significant SWQIs at ERD sites based on site characteristics and remediation system design. D. Use the advanced model simulations and ERD parameter database to develop a draft protocol for estimating the likely extent and duration of secondary impacts at typical ERD sites. The protocol would address extent and duration of impacts, sampling needs, and modeling approaches.

Design of Temporary Slopes and Excavations in NC Residual Soils
Roy H. Borden, Mohammed A. Gabr
NC Department of Transportation
$328,080
08/16/12 - 12/31/15
The main objective of the proposed project is the more economical design of temporary slopes and retaining structures in North Carolina (NC) residual soils. In general, the current design methods and procedures for temporary slopes and temporary excavation support systems do not consider the short-term characteristics of NC residual soils, and therefore may result in overly
conservative designs and unnecessary construction costs. Even though the geotechnical engineers are aware of the over conservatism of the current design methods and procedures, they do not have rational means by which to improve the design cost effectiveness. It is the development of these rational design procedures that is the heart of the proposed research.

STRIDE - University of Florida Consortium
Earl D. Brill, Nagui M. Rouphail, Henry C. Frey, Bastian Schroeder, Joseph Huey, James B. Martin, Daniel Findley, Leigh B. Lane, Thomas J. Cook, Jeffrey C. Tsai
University of Florida
$727,217
01/01/12 - 01/30/16
The Center for Transportation and the Environment at NCSU proposes eight outreach activities that will incorporate LEGO Mindstorms NXT robots into workshops in two locations in North Carolina. These workshops will provide a hands-on experience that will encourage students to look at science, technology, engineering and math (STEM) topics in a new light and foster interests in transportation engineering as a career choice.

Inducing Aerobic Granulation in Continuous-Flow Reactors using Shear Variability
Francis Lajara De Los Reyes III, Joel J. Ducoste
National Science Foundation (NSF)
$299,764
08/15/13 - 07/31/16
We propose to prove that aerobic granulation in lab-, pilot-, and full-scale activated sludge systems can be induced by engineering the bioreactor to have variable shear distribution. This project will thus impact wastewater treatment plant design and operation by increasing settling, improving organic contaminant removal efficiencies, decreasing reactor volume, and increasing organic and nutrient loading.

Research Study on a Potentially Cost Saving Wastewater Treatment Additive
Francis Lajara De Los Reyes III
NC Rural Economic Development Center
$108,546
02/23/11 - 08/31/14
This is a supplement to extend the previous project, to include assessment of kenaf addition in full scale wastewater treatment plans. The partners include the Mebane WWTP and CH2M Hill.

GCE Phase 2: Reliable and Hygienic Pit Emptying System Using Modified Power Augers
Francis Lajara De Los Reyes III
Bill and Melinda Gates Foundation
$250,000
10/09/13 - 01/31/15
Building on our Phase I results, we will continue to improve and develop a low-cost, portable auger-based technology that can reliably and hygienically empty a wide variety of pit latrines and septic tanks (pits) containing wastes with a range of moisture contents. Thus one machine can be used in watery, low solids pits (e.g., as occur in Malawi), and high solids and trash pits (e.g., as occur in eThekwini municipality in South Africa). We envision that a successful device will be used by local entrepreneurs or local governments in emptying pits all over the world, thus reducing the dangerous, unhygienic, and undignified practice of manual pit emptying.

Francis Lajara De Los Reyes III
Washington University - St Louis
$5,000
05/01/12 - 09/01/13
A workshop on microbial ecosystem services conducted with WUSL, Univ. of Maryland, and UC Merced.

CAREER: Modeling for Insights with an Open Source Energy Economy Optimization Model
Joseph F DeCarolis
National Science Foundation (NSF)
$400,795
01/15/11 - 12/31/15
Energy economy optimization (EEO) models enable optimization-based analysis of energy systems over multiple decades, allowing analysts to quantify how particular actions may affect outcomes of interest, particularly economic and environmental impacts. This proposal has four main goals: (i) institute a transparent process for EEO model development and application, (ii) generate new insights into energy system development at the national and global scale through the rigorous application of uncertainty analysis, (iii) involve analysts, decision-makers, and students in the modeling effort through participation in a joint cognitive process of discovery, and (iv) use EEO models as a tool to teach students ranging from high school to graduate school to think critically about energy systems and environmental sustainability from a systems perspective.

The Environmental Sustainability of Integrated Solid Waste Management in a Carbon Constrained World
Joseph F DeCarolis, Morton A. Barlaz, Sanmugavadivel Ranjithan
National Science Foundation (NSF)
$299,575
06/30/12 - 07/31/15
The goal of the proposed research is to investigate the cost and environmental implications of emerging greenhouse gas (GHG) reduction policies on the solid waste management (SWM) sector, and to outline alternative ways in which municipal solid waste (MSW) managers may optimally respond through changes to material flows and choice of process-technologies in SWM systems. A mathematical programming model is being developed to consider cost, GHG
and other emissions, energy consumption, and environmental impacts to identify optimal integrated SWM strategies.

Strengthening the Hurricane Wave and Surge Forecast Guidance Provided to Coastal Communities in North Carolina
Joel Casey Dietrich
NCSU Sea Grant Program
$70,770
02/01/14 - 01/31/16
This proposal seeks funds to expand the utility and accuracy of wave, storm surge and flooding forecast guidance that is available to emergency managers in North Carolina using a high-resolution modeling system. Through discussions with them, the guidance from the forecast system will be targeted to their needs, so they can better utilize it while also understanding its strengths and limitations. In addition, the modeled representation of the North Carolina coastal waters will be enhanced to increase accuracy in specific regions of interest. North Carolina is particularly sensitive to waves, storm surge and flooding, given its geographic location and the protrusion of its coastline into the Atlantic. Severe storms such as hurricanes and nor-easters can devastate the natural and built environment along the complex system of barrier islands, bays and estuaries, and communities that comprise our coast. Several powerful storms have caused extensive flooding in recent years, including but not limited to Bertha and Fran (1996), Floyd (1999), Isabel (2003), Irene (2011) and Sandy (2012). Other, smaller storms have caused localized flooding in specific regions. The accurate prediction of waves, storm surge and flooding is essential for evacuation and protection of life and property. A computational modeling system for North Carolina has been established for forecasting of waves, surge and flooding at high resolution using high-performance computing resources. The models have been validated extensively and applied recently for the analysis of the levee protection system near New Orleans, the transport of oil following the destruction of the Deepwater Horizon drilling platform, and the development of new flood risk maps for the Gulf and Atlantic coasts. Within North Carolina, these models are utilized operationally to provide forecast guidance every day for coastal waves and inundation (http://nc-cera.renci.org/). In this proposed research, the forecast guidance from this modeling system will be expanded beyond Web-based delivery to include additional formats that are targeted to the needs of users within the state. These new formats will represent the guidance at high levels of geographic resolution and will be portable to the systems of these users, so they can combine and compare the forecast guidance with information from other sources. The resulting guidance will be more powerful because it will be placed directly into the hands of stakeholders who will have participated in its development, and who will be trained how to use it. In addition, by identifying regions of interest to them, the models will evolve to improve accuracy in their description of the coastal environment.

An Integrated Approach to Understanding and Reducing Fat Oil and Grease (FOG) Deposit Formation for Sustainable Sewer Collection Systems
Joel J. Ducoste
Environmental Protection Agency (EPA)
$569,568
The proposed project seeks to understand and reduce the FOG deposits formation that lead to environmentally detrimental sanitary sewer overflows (SSO) in sanitary collection systems by achieving the following objectives: 1) perform detailed bench scale experimental tests that attempts to recreate FOG deposits and determine parameters that influence their formation rate, 2) develop numerical models that describes the FOG deposit formation kinetics, 3) perform bench scale tests to explore treatment methods to improve FOG deposit chemical precursor removal with grease interceptors, and 4) perform pilot scale experiments on a sewer collection system that includes common piping structures. This study results are expected to provide new tools to assist utilities in meeting CWA requirements and provide better management of sewer collection systems.

CREATIV Dynamic Regulatory Modeling of the Iron Deficiency Response in Arabidopsis thaliana
Cranos Williams, Joel J. Ducoste, Terri Long, James Tuck
National Science Foundation (NSF)
$999,758
08/15/12 - 07/31/17
In this proposal, we present a novel paradigm for identifying putative cis-regulatory promoter targets that control the regulation of stress responses in plants. This paradigm will also be used to identify critical regulatory components that differentiate the regulatory stress response across different cell types. We first develop the computational and analytical infrastructure needed to build a dynamic model of the gene regulatory network from time-course transcription profile data that quantifies the stress response. Novel analytical model refinement techniques are proposed to reduce the space of feasible solutions, generate specifications for model validation experiments, and test functional redundancy in the response. Parallel computing architectures will be used to scale the implementation of these model refinement approaches to the size and complexity associated with gene regulatory networks. The dynamic model of the gene regulatory network will be used to identify relationships between genes, build corresponding functional modules, and identify putative cis-regulatory promoter targets and regulatory components that can be used to alter responses to biotic and abiotic stresses in plants. Previous cell-specific transcription profiling has indicated that cell types have distinct expression profiles and respond differently to stress. We will generate cell-specific time-course transcription profiles using experiment specifications derived from the dynamic gene regulatory network. These data will be used to create a cell-specific dynamic gene regulatory network for identifying regulators that are key in differentiating the stress response between cell types.

EFRI-PSBR: Closing the Loop- Towards a PSBR Design Framework for Self-Sustained Marine Microalgal-Based Fuel Production
Amy M. Grunden, Heike W. Sederoff, Joel J. Ducoste, Sanmugavadivel Ranjithan, Francis Lajara De Los Reyes III
National Science Foundation (NSF)
$1,999,985
09/01/13 - 08/31/17
NC State's EFRI PSBR program will model, develop, implement, and evaluate a scalable photosynthetic biorefinery (PSBR) that uses transformational nutrient recycle processes and supports efficient conversion of CO2 to lipid (oil) in a marine microalgal-based system. Algal oils are an ideal feedstock for biofuels production, offering high production density and the ability to use marginal water (municipal wastewater, brackish water, etc.) and reuse CO2 in flue gases. However, there are a number of technical challenges associated with culturing algae in current generation PSBRs. Using a tightly coupled synergistic approach employing both Engineers and Biologists, the team will: a) genetically engineer a marine microalgal species (Dunaliella spp.) with enhanced CO2 uptake/fixation and the capability to recycle N and P from microalgal biomass; b) design a small-scale PSBR informed by our kinetic model which will be used to develop a scalable dynamic reactor model based on computational fluids dynamic simulation of the PSBR; c) develop innovative, scalable approaches for algal harvesting and lipid extraction; and d) develop an analytical framework for the LCA of our microalgal PSBR system to include creation of flexible and scalable cost and LCI process models that will ultimately lead to generation of a robust PSBR life-cycle decision tool that can be applied to this and other PSBR systems.

**Evaluation of Continuous Flow Ultraviolet Light Emitting Diode Reactors**
Joel J. Ducoste  
National Science Foundation (NSF)  
$356,795  
09/01/09 - 08/31/14  
The proposed research plan seeks to integrate bench-scale and pilot-scale experimental and numerical techniques for comprehensive characterization of an ultraviolet light emitting diode (UV LED) continuous flow reactor. Data from bench and pilot scale experiments will provide the necessary information to develop and validate a computational fluid dynamics (CFD) model of a UV LED disinfection system. The validated CFD model will be combined with a heuristic optimization routine to develop an efficient continuous flow UV LED system based on a desired optimality criterion. Overall, this research will allow engineers to determine whether UV LED based continuous flow UV reactor systems can achieve high disinfection system efficiencies and offer an alternative technology that replaces mercury vapor UV lamps.

**Modeling of Cellulose, Hemicellulose and Lignin-Carbohydrate Complex Formation and Regulation to Understand Plant Cell Wall Structure**
Vincent Chiang, Ronald R. Sederoff, Hou-min Chang, David C. Muddiman, Cranos Williams, Fikret Isik, Joel J. Ducoste, Christopher P. Smith  
US Dept. of Energy (DOE)  
$2,249,825  
09/01/11 - 11/30/14  
Plant cell walls are the essential components of feedstocks for biomass based liquid fuel alternatives to petroleum. The secondary cell walls of woody plants contribute greatly to biomass and are targets for improving potential feedstocks. In the application of systems biology to development of new biofuels, as in any complex biological process, predictive modeling is the central goal. We propose to use a systems approach with genome based information and
mathematical modeling to advance the understanding of the biosynthesis of the plant secondary cell wall. To do this, we will use multiple transgenic perturbations and measure effects on plants using advanced quantitative methods of genomics, proteomics, and structural chemistry. The combination of quantitative analysis, transgenesis, statistical inference and systems modeling provide a novel and comprehensive strategy to investigate the regulation, biosynthesis and properties of the secondary cell wall.

Regulation and Modeling of Lignin Biosynthesis
Vincent Chiang, Ronald R. Sederoff, Joel J. Ducoste, Fikret Isik, David C. Muddiman, Cranos Williams, Christopher P. Smith, Reza A Ghiladi
National Science Foundation (NSF)
$3,722,841
09/15/09 - 09/30/15
Lignin is a unique and complex phenylpropanoid polymer, important in plant development and response to environment. We propose to advance our knowledge of lignin biosynthesis by developing a comprehensive pathway model of regulatory and metabolic flux control mechanisms. Our primary tool will be systematic gene specific perturbation in transgenic Populus trichocarpa. We will perturb all 34 known lignin pathway and regulatory network genes in P. trichocarpa using artificial microRNA (amiRNA) and RNAi suppression. From each independent transgenic perturbation, we will obtain quantitative information on transcript and protein abundance, enzyme kinetics, metabolite concentrations, and lignin structural chemistry. Using statistical correlation and path analysis, we will integrate this information to develop a mechanistic-based signaling graph and metabolic flux model for the pathway and its regulation leading to specific lignin structures.

Henry C. Frey, Nagui M. Rouphail
National Science Foundation (NSF)
$326,627
05/15/08 - 09/30/14
This is request for international travel supplemental support on an existing NSF grant. The proposed project collaboration is between the NCSU project team and the Transport, Energy and Environment Division (DTEA) of the Research Group on Sustainable Energy Development at the Instituto Superior Tecnico (IST) in Lisbon, Portugal and the Center for Mechanical Technology and Automation (TEMA) at the University of Aveiro in Aveiro, Portugal. The collaboration is in the area of measurement and modeling of vehicle activity, energy use, and emissions.

Evaluating Air Emissions and Fuel Efficiency of Solid Waste Collection Vehicles
Henry C. Frey
University of Nebraska - Lincoln
$89,900
The goal of this proposed project is to evaluate emissions from solid waste collection vehicles and to evaluate fuel economy during solid waste collection. Currently, there is very limited data available regarding air emissions from conventionally fueled or natural gas fueled solid waste collection vehicles. In this proposal we intend to collect information from various types of solid waste collection vehicles during actual operation. Collection of these data is important as they can be used in future studies to develop strategies to reduce CO2 emissions from solid waste collection and in life-cycle analyses of the environmental and economic impacts of solid waste management systems. This proposal is responsive to several parts of the EREF strategic research plan, The proposed project is directly relevant to several of the 2011-2012 EREF Research Agenda topics including Global Warming, Greenhouse Gases/Carbon Sequestration and Equipment/Safety/Ergonomics.

Framework for Mobile Source Emission Inventories
Henry C. Frey, Nagui M. Rouphail
Environmental Protection Agency (EPA)
$500,000
05/16/10 - 09/30/14
We will use field measurements, analyses of existing data, and novel approaches based on linking traffic simulation models to micro-scale emissions models for onroad vehicles to improve emissions inventories. This research will include a combination of measurement, modeling, and analysis techniques. We will develop and demonstrate new analysis techniques that can be generalized to state, regional, or national emission inventories. We will use field measurements to determine whether emission inventories represent real-world conditions. We will conduct multi-pollutant field studies to elucidate interactions between co-emitted pollutants that must be considered in emission inventories. We will use field data to characterize spatial and temporal variability of emissions from onroad vehicles at scales that support project-level assessments as well as area-wide inventories.

Locomotive Biofuel Study
Henry C. Frey, Alexander O. Hobbs
US Dept. of Transportation (DOT)
$395,189
01/03/11 - 09/30/14
For the biofuel study, the Federal Railroad Administration wishes to consider (1) the energy intensity of various biofuel blends compared to diesel fuel; (2) environmental and energy effects of using various biofuel blends compared to diesel fuel, including emission effects; (3) the cost of purchasing biofuel blends; (4) whether sufficient biofuel is readily available; (5) any public benefits derived from the use of such fuels; and (6) the effect of biofuel use on locomotive and other vehicle performance and warranty specifications. Locomotive engine performance and emissions shall be determined through locomotive testing, using various biofuel blends and diesel fuel. This research shall be done so that recommendations can be made for premium locomotive biofuel blends.
Multiple Tiered Methodology For Micro- to Macro-Scale Assessment of Plug-In Hybrid Electric Vehicles (M4-PHEVs)
Henry C. Frey, Joseph F DeCarolis
National Science Foundation (NSF)
$470,036
10/01/09 - 09/30/14
We will develop a new methodology for real-world field data collection and analysis of second-by-second activity, energy use, and emissions of PHEVs using portable emission measurement systems (PEMS). The models will allocate energy use and tailpipe emissions in time and space. The microscale models will enable comparison of PHEVs with previously developed microscale models for conventional vehicles in order to quantify the marginal impact of PHEVs under specific real-world conditions. The macro-scale approach will feature the use of a MARKet ALlocation (MARKAL) energy systems model with a 9-region representation of the U.S. in order to assess how the demand for electricity and fuels by PHEVs affects choices among vehicle and power generation technologies, end-use electricity demand across the economy, resource utilization, and regional emissions.

Spatial-temporal Modeling and Analysis of Health Effects Associated with Source Contributions and Speciation of Fine Particulate Matter
Montserrat Fuentes, Henry C. Frey, Yang Zhang
Environmental Protection Agency (EPA)
$902,349
05/15/08 - 11/30/13
Objectives: The overall objectives of this proposed nationwide spatiotemporal analysis are to investigate the adverse health outcomes associated with population exposure to fine particulate matter (PM2.5) and speciation and to characterize geographic differences, sources, and population heterogeneity in the putatively PM2.5 mediated health effects, combining different sources of data with atmospheric models. We aim to answer the following research questions:
What is the recommended framework to integrate atmospheric models with monitoring data and other sources of information to obtain a better spatial and temporal characterization of fine PM components and sources? Can we improve the PM component-based epidemiologic studies by using atmospheric models? How to integrate the atmospheric models in this epidemiologic framework, while characterizing uncertainties in the models (epiemicologic and numerical)? How to use source apportionment approaches in national epidemiologic studies, while characterizing different sources of uncertainty in models and data? Approach: In this work we will develop and implement a statistical hierarchical Bayesian framework that provides a very broad, flexible approach to studying the spatiotemporal associations between mortality and morbidity and population exposure to daily PM2.5 mass and its components, while characterizing its sources. In Stage 1, we will map ambient PM2.5 air concentrations using all available monitoring data (Supersites, IMPROVE, STN and FRM), an air quality model (CMAQ), and satellite data (MODIS), at different spatial and temporal scales. In Stage 2, we will conduct space-time dynamic source apportionment analysis to characterize the PM sources. We will introduce space-time source and receptor models, and we will also run source sensitivity simulations using CMAQ 12-km runs with 7-10 source categories. We will characterize uncertainties in the
different models (stochastic and deterministic) and the data. In stage 3, we will use exposure information and SHEDS to quantify the effect of microenvironment concentrations and characteristics, as well as human activity, to estimate individual exposures to fine PM. In stage 4, we will examine the spatial temporal relationships between the health end-points (all nature-cause mortality, specific cardiopulmonary mortality and morbidities) and the exposures to PM2.5 and its species in a hierarchical generalized Poisson model and case-crossover analyses, accounting for socio-economic factors, meteorological variables and other potential confounders.

Field Verification of Undercut Criteria and Alternatives for Subgrade Stabilization in the Piedmont Area
Mohammed A. Gabr, Roy H. Borden
NC Department of Transportation
$134,182
09/01/13 - 12/31/14
The proposed work will seek to investigate the applicability of the undercut criteria in the Piedmont Physiographic region and validate approaches to improving soil bearing properties investigated in the laboratory. The proposed plan includes the field implementation of four instrumented test pads for performance monitoring. In addition to a control pad, one pad will implement undercutting and replacement with select fill, a second will include undercutting in conjunction with ABC and the use of geosynthetics, and a third will include chemical stabilization. The field data will be used to verify performance of alternative or supplemental approaches to undercut to limit volume change and improve soil properties and workability.

CAREER: From the Kitchen to the Clouds: Research and Teaching on the Emission and Evolution of Aerosols from Household Energy Use by the Global Poor
Andrew Grieshop
National Science Foundation (NSF)
$400,000
05/01/14 - 04/30/19
The following goals define the scope of the program: 1) Explore how combustion conditions and atmospheric influences dictate the ‘aging’ of aerosol emissions from biofuel burning, and thus their effects on air quality and climate; 2) Bridge lab and field measurements and develop approaches to simulate real-world emission and aging processes that control the net impacts of various stove and fuel types; 3) Cooperatively develop and deploy a simple approach to assess stoves in households during new technology roll-out; 4) Engage students from high school to graduate levels and international partners in hands-on learning and research activities to develop skills and interest.

Development of a Second-Generation System for In-Use Cookstove Emission Testing
Andrew Grieshop
NCSU Faculty Research & Professional Development Fund
$7,000
07/01/13 - 06/30/14
This project aims to develop and characterize a second-generation stove emission measurement system (STEMS-2G) for use in field campaigns to study the adoption and performance of cookstove designs. The design builds on experience and lessons from a one-year deployment of the first generation STEMS in order to build a more robust and portable system with an on-board data acquisition and control system and smaller and more sensitive sensors. Development, construction and laboratory testing of system will take place during project period.

Experimental Interventions to Facilitate Clean Cookstove Adoption, Promote Clean Indoor Air, and Mitigate Climate Change
Andrew Grieshop
Yale University
$114,941
03/01/14 - 02/28/17
This project has four broad objectives, linked to feasible improvements in clean stove design and dissemination and their impacts on health and climate: 1) assess the acceptability and availability of different stove technologies and fuels, 2) experiment by varying stove price and social interactions to determine the impact of these variables on stove adoption rates, 3) measure in situ the impacts of stove adoption on indoor and outdoor air pollution, and climate-forcing, and 4) model the impacts of widespread stove adoption on regional and global climate. The field measurement components of the project take place in two regions in India.

Arbitrarily Wide Angle Wave Equations: New Constructs for Subsurface Imaging, Unbounded Domain Analysis and Multiscale Modeling of Solids
Murthy N. Guddati
National Science Foundation (NSF)
$243,968
09/15/10 - 08/31/14
One-way wave equations (OWWE) are mathematical constructs that propagate waves in a specified direction while suppressing them in the opposite direction (e.g. in two dimensions, they have a 180-degree range of propagation). Arbitrarily wide-angle wave equations (AWWE), developed over the years by the PI, are computationally tractable approximations of OWWE that are applicable for many complex settings ranging from wave propagation in elastic and anisotropic continuous media, to phonon propagation in discrete lattice systems. This project is aimed at mathematical analysis of stability of AWWE, followed by its utilization to design (a) absorbing boundary conditions, (b) wave-based subsurface imaging algorithms, and (c) strategies to couple atomistic and continuum models of crystalline solids.

Argentinian Nuclear Regulatory Authority Master Research and Technical Information Exchange Agreement
Abhinav Gupta, Vernon C. Matzen, Matthew K. Ronning
Argentinian Nuclear Regulatory Authority
Unfunded
12/02/08 - 12/01/13
SEESR-GC: Simulation of the Seismic Performance of Nonstructural Systems
Abhinav Gupta
Consortium of Universities for Research in Earthquake Engineering (CUREE)
$190,282
09/15/07 - 08/31/13
Overall objective is to study the seismic performance of non-structural ceiling systems in buildings such as fire suppression piping, suspended ceiling fixtures, HVAC ducts, and partitions. NCSU’s work is focused on computer modeling, optimization, and fragility evaluations for designing piping configuration needed to conduct experiments. Subtasks of this study focus on verification of theoretical formulations for seismic analysis of coupled building-piping systems as well as development of new formulations for improved verification with respect to the experimental results obtained by other participating organizations.

Seismic Qualification of GIS Equipment
Abhinav Gupta
ABB, Inc
$25,000
08/15/13 - 12/31/14
This study is aimed at seismic qualification of GIS equipment. Typically, a GIS unit is placed on a floor which is essentially at the ground level. Furthermore, a particular type of GIS unit is conventionally qualified by a shake table test in which the ground motion is fairly large compared to typical design values. However, the filtered ground motion can be much larger than the experimental values when the unit is located at an elevated floor above the ground. Consequently, the floor accelerations are expected to be significantly influenced by the dynamic characteristics of the building housing the unit. This interaction and the subsequent qualification is being studied in this research.

Development of a Constitutive Model for Simulation of Stress-Strain Responses of HA230 under Thermo-Mechanical Cyclic Loading
Tasnim Hassan
Honeywell International, Inc.
$494,800
01/01/10 - 08/15/13
Honeywell Aerospace is seeking the development of time independent and time dependent plasticity models for analyzing the constitutive response of metallic alloys which are employed in gas turbine engines. The alloys range from low strength materials such as HA-230 and Hast-X to intermediate strength alloys such as Ti-6-4 and Ti-6-2-4-2 to high strength alloys such as U720LI, DP718. This study will develop constitutive model for simulating thermo-mechanical responses of HA-230. The temperatures range will vary from room temperature to as high as 1800F. At elevated temperatures, time dependence of deformation is expected to play a significant part. The phenomena that have to be included in an all encompassing constitutive model are (i) the hysteresis and Bauschinger effect, and strain hardening and softening and (ii) stress relaxation and time dependent creep at peak stresses. Development of advanced constitutive models helps in improving accuracy and fidelity in prediction of stress and strain.
redistribution in engine components during service. The redistributed stresses and strains are parameters that are used to assess the useful life of a component. Models for predicting component lives are developed from specimen coupon tests, the results of which embody stress redistribution according to at least one of the phenomena mentioned above.

Monitoring Microstructural Evolution Of Alloy 617 With Nonlinear Acoustics For Remaining Useful Life Prediction: Multiaxial Creep-fatigue And Creep-ratcheting
Tasnim Hassan
Pennsylvania State University
$200,653
08/04/10 - 12/31/13
The proposed research is aimed at characterizing the microstructure mechanisms activated in Alloy 617 by mechanical loading and dwell times at elevated temperature. The acoustic harmonic generation method will be researched for microstructural characterization. It is a nonlinear acoustics method with excellent potential for nondestructive evaluation, and even online continuous monitoring once high temperature sensors become available. It is unique because it has the ability to quantitatively characterize microstructural features well before macroscale defects (e.g., cracks) form. The nonlinear acoustics beta parameter will be correlated to microstructural evolution using a systematic approach to handle the complexity of multiaxial creep-fatigue and creep-ratcheting deformation. The diverse project team, which includes a minority institution, enables the results of the microstructural evolution characterization to be employed for remaining useful life prediction. The unified constitutive model currently being developed for design purposes will be adapted for life prediction by correlating the beta parameter evolution obtained from nondestructive evaluation (or eventually online monitoring) to the model’s internal state variables. Such a microstructure based constitutive model will enable improving the ASME-NH code for Alloy 617.

MRI: Development of a Miniature, High Temperature, Multiaxial Testing Equipment for Advanced Materials and Engineering Research
Tasnim Hassan, Korukonda L. Murty, Gracious Ngaile, Yong Zhu
National Science Foundation (NSF)
$438,951
08/15/13 - 07/31/16
A novel testing system will be designed and developed for mechanical testing of miniature tubular coupons (1 mm outer diameter and 0.05 mm wall thickness) under any combination of axial, torsional, and internal pressure loading, and desired gaseous environment in the room to 1000°C temperature. This system can be set under an optical microscope (OM) and scanning electron microscope (SEM) for in-situ microstructural studies. With the emerging research in materials genome, performing miniature coupon testing under realistic loading and environmental conditions is in urgent need. Manufacturing processes induce localized material heterogeneity whose influence on failure mechanism can only be studied through testing miniature coupons. Extreme service loading and environmental conditions alter local material properties, which can only be studied through miniature coupons in determining remaining life of critical components. The system will impact design and development of new materials, high
performance components, and micro-forming processes. It will eliminate the long (10-20 years) trial & error methods of designing new materials. The system development will be performed by a multidisciplinary team of four faculty members and 2 PhD students. Undergraduate students and K-12 teachers and students will get hands-on experience with the system.

Multiaxial Creep-fatigue and Creep-ratcheting Failures of Grade 91 Steel for Addressing Design Issues of Next Generation Reactor Pressure Vessel NEUP
Tasnim Hassan
Battelle Energy Alliance, LLC
$769,435
10/01/09 - 09/30/14
The proposed research will develop systematic sets of uniaxial and multiaxial data at high temperature (850-950oC), including creep-fatigue and creep-ratcheting, for Alloy 617, a primary candidate material for the intermediate heat exchanger (IHX) in next generation nuclear plants (NGNP). This set of experimental results will provide data for updating the ASME-NH Code Case for Alloy 617. A unified constitutive model (UCM) will be developed and validated based on these experimental results. Validation of the UCM for both the uniaxial and multiaxial fatigue failures will ensure robustness for design-by-analysis methodology according to subsection NH. The earlier ASME Code Case draft of Alloy 617 was developed based on tensile and creep data, and limited creep-fatigue data. Hence, developing additional high temperature failure data and a UCM is given very high priority by the NGNP project. A DOE, ORNL, INL and ASME collaborative effort initiated ten tasks for addressing ASME Code issues for Gen IV reactors. The tasks on addressing creep-fatigue, ratcheting, and the inelastic design-by-analysis method using a UCM are ranked very high priority. Similar to creep, at high temperature, it is important to design components against ratcheting failure. Hence, this proposed research plans sets of uniaxial and multiaxial experiments that involve creep-fatigue-ratcheting interactions. The experimental responses of Alloy 617 will be scrutinized in order to quantify the influence of creep on fatigue and ratcheting failures. The loading histories prescribed in the multiaxial experiments mimic the loading histories at critical structural locations. Thus, the UCM developed and validated from multiaxial responses will simulate structural responses more accurately. Design-by-analysis methodology based on such a UCM will reduce conservatism in the design. However, developing such a UCM will require incorporation of various modeling features, such as: strain-range dependence, erasure of memory or subsequent cyclic softening, multiaxial ratcheting parameter, and loading nonproportionality. These model features are not available in the finite element software, ANSYS and ABAQUS, which severely limits modeling capabilities and the ability to design the IHX. Integrating multiple modeling features in a UCM model is a difficult task, however accomplishing such a UCM will allow safe, economical, and sustainable design of NGNPs. Hence, this proposed project will develop a robust UCM based on the nonlinear kinematic hardening model of Chaboche. Such a model will have a large number of interdependent parameters, which are difficult to determine manually. Hence, a genetic algorithm based parameter optimization scheme will be developed to facilitate the use of the UCM by designers and regulators. Finally, the UCM to be developed will be implemented into ANSYS and ABAQUS for high temperature nuclear design applications. Three graduate students and one junior researcher will experience NGNP design development through this research, which will prepare them to lead the profession into the future.
An innovative technique for improving seismic performance of steel beam-column connection with the advantages of the reduced beam section (RBS) connection, but with improved energy dissipation. Through a pilot study the concept is validated numerically at NC State University. This proposed research will conduct a systematic set of beam-column connection experiments for evaluating the novel seismic performance enhancement concept. The novel concept involves heat treating sections of beam flanges by exposing these sections to very high temperatures for certain amount of time before slow air cooling. Such heat treatment reduces the strength of steel in the heat treated areas of the flange. Consequently, under seismic loading plastic hinge develops at the heat treated beam section (HBS). Among the three moment resisting connections prequalified for special and intermediate moment frames by the 2005 AISC 358 standards, the reduced beam section (RBS) is the most popular because of its seismic performance and cost effectiveness. In the RBS connections, “weakening” of the beam flanges induces plastic hinge away from the welds. In case of the HBS connections, plastic hinge develops at the heat treated beam section where steel strength is reduced by the heat treatment. As the beam flange dimensions, and the elastic and plastic moduli of steel are not altered in the HBS connection, the lateral and torsional buckling resistance of the HBS connection is higher than the RBS connection. Consequently, the HBS connections will dissipate a larger amount of energy with a minimum loss of strength or stiffness than the RBS connections. The proposed research will experimentally validate this novel seismic performance enhancement concept, and develop the design methodology for implementing the concept. The proposed research will conduct seven seismic experiments on the HBS beam-column connections to evaluate their seismic performance. The novel seismic performance enhancement technique will be validated on the welded unreinforced flange-bolted web (WUF-B) connection and hence an additional experiment on WUF-B connection (without heat treatment) will be conducted for reference. Strains, displacements and rotations at various locations will be recorded for investigating both the local and global failure mechanisms of the HBS connections. In the first step, a set of monotonic and cyclic material experiments on heat treated coupons will be conducted. The material coupons will be heat treated by exposing to various peak temperatures in the range of 800-1150oC and two hold times at peak temperatures. This set of material data will be analyzed to quantify the influence of heat treatment on material responses and used to determine the constitutive model parameters of the Chaboche model in ANSYS. A series of finite element analyses of the HBS connection using the Chaboche nonlinear kinematic hardening model will be performed to determine the optimum heat treatment parameters: i) maximum temperature and hold time, and ii) length of the heat treated flange section and, and iii) offset of the heat treated section from the column flange. The seismic performance of the HBS connection with i) both the top and bottom flanges are heat treated (new construction), and ii) only the bottom flange is heat treated (existing building) will be evaluated experimentally. Finally, based on the experimental and finite element analysis data a design methodology for the novel HBS connection will be developed.
Bio-Binders From Hydrothermal Conversion of Biomass for Paving Applications
Cassandra A Hintz, Wenqiao Yuan
NCSU Research and Innovation Seed Funding Program
$20,000
01/01/13 - 12/31/13
Currently, over 90% of pavements worldwide are constructed with an asphaltic surface, which results in use of 30 million tons of asphalt annually in the US alone. Asphalt is a byproduct of refining petroleum, a non-renewable resource and thus, supplies are diminishing. There is a need for development of alternative binders from bio-renewable resources. This project will investigate the use of bio-binders produced via hydrothermal conversion of biomass as an alternative to asphalt. Both micro algae and corn cob will be evaluated as biomass feedstock for production of bio-binders. Experimental characterization of bio-binders will be conducted to assess their potential use as paving binders.

In-Situ Determination of Emulsion Application Rate for Tack Coats and Surface Treatments
Cassandra A Hintz
NC Department of Transportation
$197,146
08/16/13 - 08/15/15
Emulsions are used as bonding agents in tack coats and surface treatments. The rate of emulsion application is critical in determining the performance of both tack coats and chip seals and thus is an important design factor. It has been demonstrated that field emulsion applications rates are highly variable, which is not captured using current measures for quality control. The objective of the proposed research is to develop a test method to enable in-situ determination of emulsion application rates at specific locations along a roadway. The proposed research will result in improved quality control of emulsion application rates, which lead to prolonged pavement service life, decreased life cycle costs, and enhanced safety.

Investigation of the Effect of Temperature on Asphalt Binder Fatigue
Cassandra A Hintz
University of Wisconsin - Madison
$24,992
01/01/13 - 01/31/14
The purpose of the proposed work is to develop specifications for selection of the Linear Amplitude Sweep (LAS) testing temperature for ranking the relative damage tolerance of asphalt binders. Accomplishing this task requires two components: first, a comprehensive analysis of the effect of temperature on binder damage resistance must be conducted. This analysis will serve as input to the second component: development of a specification for selection of the testing temperature for ranking the relative damage tolerance of asphalt binders.

Physico-Chemical Reinforcement of Fillers in Asphalt Mastics
Asphalt concrete is composite materials consisting of aggregates of varying size, asphalt binder, and air voids. Coarse aggregates in asphalt mixtures are effectively coated by a blend of asphalt binder and filler (i.e., dust), termed asphalt mastic. The mastic constitutes the weakest phase of asphalt concrete and therefore performance of asphalt pavements is highly correlated to the properties of the mastic. Thus, pavement performance can be improved if the mastic is engineered to resist damage. Such engineering requires a fundamental understanding the mechanisms of interactions between asphalt binder and mineral filler. The objective of the proposed research herein is to develop a fundamental understanding of the physico-chemical interaction between fillers and asphalt.

Characterization of Different RAP Sources
Narendra P. Khosla
NC Department of Transportation
$272,213
08/16/13 - 08/15/15
The objective is to characterize recycled binder from different RAP sources across the state of North Carolina. Nine major RAP sources are identified, three from each geographical region in NC and samples will be collected from different locations within each source. Recycled binder will be extracted from each sample and characterized using Dynamic Shear Rheometer (DSR) test. Blends containing varying percentage of recycled binder will also be tested to determine maximum allowable recycled binder content corresponding to a specific recycled binder.

Determining Recycled Asphalt Binder Limits Contributed by Waste Materials
Narendra P. Khosla
NC Department of Transportation
$113,434
08/16/11 - 03/31/14
In this project, NCDOT’s current specification for designing recycled HMA mixes will be compared to other agencies’ specifications and/or research practices. The specific objectives of this research project will be to investigate various sources of recycled binder including Recycled Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS) to determine limits for the amount of allowable recycled material based on Performance Grade (PG) binder testing. Using the allowable amount of recyclable materials, the effects on HMA mixes will be determined through material performance. As a result, a draft specification will be developed utilizing the limits for recycled materials based on recycled binder percentages in the mix.

Impact of Binders from Waste Materials on Performance of Surface Mixtures
Narendra P. Khosla
NC Department of Transportation
In this project, NCDOT's current specification for allowable percentage of recycled materials in higher traffic mixes will be evaluated using mixture performance testing. The specific objectives of this research project will be to investigate various sources of recycled binder including Recycled Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS) to determine limits for the amount of allowable recycled material based on Performance Grade (PG) binder testing. Using the allowable amount of recyclable materials, the effects on HMA mixes will be determined through material performance. As a result, a draft specification will be developed utilizing the limits for recycled materials based on recycled binder percentages in the mix.
program to develop guidelines regarding the maximum amount of traffic that the modified chip seals can support using improved construction procedures.

Field Calibration and Implementation of the Performance-Based Chip Seal Mix Design Method
Youngsoo R. Kim
NC Department of Transportation
$290,792
08/16/12 - 08/15/14
As the general performance of roadways in the United States has deteriorated over time, an increased interest in preventive maintenance and rehabilitation has come to the fore. Without appropriate preventive maintenance over the course of a pavement’s life cycle, the cost needed to restore the pavement more than quadruples. Chip seals are among the most efficient and cost-effective methods utilized by state highway agencies to preserve and rejuvenate existing pavements. For example, in North Carolina, although approximately 8% of roadway pavement expenditures is spent on surface treatment construction, that percentage constitutes about 50% of the miles paved. Thus, it has become imperative for agencies to optimize the use of these treatments in terms of prolonged service life, decreased life cycle costs, increased operational efficiency, and enhanced safety.

Hot Mix Asphalt Performance-Related Specification (HMA-PRS) Based on Viscoelastoplastic Continuum Damage (VEPCD) Models
Youngsoo R. Kim, Murthy N. Guddati
US Dept. of Transportation (DOT)
$1,326,102
02/06/08 - 07/31/14
This task will establish a system to simulate the healing potential of the asphalt mixes being tested and evaluated under this project so that the framework can be applied to any mix through the performance-related specifications (PRS). Work that is currently underway in this project includes conducting a suite of laboratory tests on asphalt mixtures from various locations around the world. The tests range from simple practical techniques to more accurate and detailed tests. This suite of tests is being conducted to provide inputs into pavement performance prediction models that will form the basis of the PRS for asphalt mixture production. The current project testing plan does not include an evaluation of the healing aspects of these mixture specimens, and the models being applied within this project currently use a simplified, empirically adjusted model to address healing performance. Since the onset of this project, however, other research has led to advances in terms of the ability to analyze the healing aspects of asphalt mixes.

Long-Term Aging of Asphalt Mixtures for Performance Testing and Prediction
Youngsoo R. Kim, Cassandra A Hintz
National Academy of Sciences
$800,000
05/21/13 - 05/21/16
The objective of the proposed research is to develop a calibrated and validated procedure to simulate long-term aging of asphalt mixtures for performance testing and prediction. The final product of the proposed research will be a laboratory aging procedure and associated models that prescribe a set of laboratory aging conditions to represent the long-term aged state of asphalt mixture in a pavement as a function of climate, depth, and air voids. The proposed research will be conducted by a research consortium led by NCSU, including Western Research Institute, Arizona State University, and Nichols Consulting Engineers.

MEPDG Inputs for Warm Mix Asphalts
Youngsoo R. Kim, Benjamin Underwood
NC Department of Transportation
$293,667
08/16/11 - 08/15/14
The objectives of the proposed research project are: (1) to determine the dynamic moduli, fatigue characteristics, and rutting characteristics of WMA mixtures that are currently used in North Carolina as a function of moisture conditioning and aging levels; (2) to compare the material properties of WMA mixtures with their HMA counterparts; and (3) to develop recommendations for MEPDG input parameters for the various WMA mixtures. These objectives will be accomplished by performing dynamic modulus tests for stiffness characterization, direct tension cyclic tests for fatigue performance characterization, and triaxial repeated load permanent deformation (TRLPD) tests for rutting characterization. These tests will be performed on various WMA and HMA mixtures subjected to varying moisture conditioning and aging levels in order to address these two major sources for the different behaviors between the HMA and WMA mixtures.

Multiscale Modeling of Asphalt Concrete for Fatigue Cracking Evaluation
Youngsoo R. Kim, Murthy N. Guddati
Texas A&M Research Foundation
$860,000
12/26/06 - 06/30/14
Work at WRI-TTI-NCSU under previous funding directed by FHWA has developed continuum damage and micromechanics models of fatigue damage in asphalt mixtures/pavements. In the proposed study, these models will be refined and a wide range of materials and conditions will be tested. The primary objective of the proposed research is to understand the fatigue cracking phenomena in asphalt concrete at multiple scales from which material specifications and design methods would be developed.

Performance of Cracking Mitigation Strategies on Cracked Flexible Pavements
Youngsoo R. Kim, Mohammed A. Gabr
NC Department of Transportation
$288,767
08/16/11 - 08/15/14
Problems with reflective cracking in asphalt concrete (AC) overlays on cracked flexible pavements have been observed for many years in North Carolina. Left untreated, such cracks can severely degrade the service life of asphalt pavements. Intrusion of water into the subgrade and/or base material quickens the deterioration process, leading to early and costly failure of the whole pavement structure. Therefore, it is in the economic interest of the state of North Carolina to investigate methods that reduce or, at the very least, retard reflective cracking in AC overlays.

Performance-Related Specification for Pavement Construction
Youngsoo R. Kim
$221,550
09/19/13 - 09/18/18
The objective of proposed research is to further develop and demonstrate the products from the current FHWA project funded to NC State University (DTFH61-08-H-00005) such that Performance-Related Specifications become a viable option for use during pavement construction. This objective will be accomplished by conducting the 30 tasks described in the technical proposal. The direct for the proposal is Applied Research Associates and NCSU will be a subcontractor.

Performance-Related Specifications for Asphaltic Binders Used in Preservation Surface Treatments
Youngsoo R. Kim, Benjamin Underwood
National Academy of Sciences
$500,000
08/01/11 - 11/29/14
Pavement preservation treatments (PSTs) are an effective means of improving surface quality and extending the service life of pavements. One of the primary constituents of PSTs is the asphaltic binder. The most commonly used forms of asphaltic binder in PSTs are hot asphalt and emulsion. Although it is well known that the properties of the asphaltic binders are critical to the performance of the PSTs, current specifications for asphaltic binders in PSTs are empirical in nature and do not use binder properties that are related directly to the performance of PSTs. The primary objectives of this research are: (1) to evaluate existing binder tests and, if necessary, identify new tests that relate to performance, and (2) to develop Performance-Related Specifications for PSTs that provide a direct relationship between the key quality characteristics of asphaltic binders and performance.

Performance-Related Specifications for Pavement Preservation Treatments
Youngsoo R. Kim, Cassandra A Hintz
Michigan State University
$6,996
02/03/14 - 02/03/16
North Carolina State University (NCSU) will assist Michigan State University (MSU) in developing guidelines to facilitate development of PRS for asphalt pavement preservation
treatments. As part of this effort NCSU will assist MSU in the planning phase of the research project, which will consist aiding MSU in reviewing literature to identify most widely used preservation treatments for asphalt pavements and corresponding design and quality assurance practices, identifying processes and an outline for guidelines for pavement preservation treatment PRS development, and identifying corresponding data needs and developing demonstration examples. The aforementioned research will be used as input for development of a research plan by MSU with aid of NCSU.

Surface Layer Bond Stresses and Strength
Youngsoo R. Kim, Akhtarhusein A. Tayebali, Murthy N. Guddati
NC Department of Transportation
$311,649
08/16/12 - 08/15/14
In North Carolina, the investigations of several highway projects have indicated that the debonding of the top surface layer in an asphalt pavement is a contributing factor in the premature cracking of pavements. Examples of these pavements include I-795 in Wayne County and US-64 in Martin County. In addition, an occurrence of excessive debonding was observed some years ago in Division 13 of the NCDOT. Pavements in Buncombe County, where emulsions were used as a tack coat, experienced more incidents of debonding than pavement sections in Rutherford County where PG 64-22 asphalt cement was used as the tack coat. In these pavements, the debonding distress often was accompanied by cracking. Although it is not clear whether the cracking or the debonding occurred first, the debonding nonetheless contributed to the distress and failure of the pavement.

1,4-Dioxane in North Carolina Drinking Water Sources: Occurrence and Treatment Options
Detlef R. Knappe
NCSU-WRRI Urban Water Consortium
$120,531
05/15/14 - 05/14/16
Recent data from a nationwide study evaluating drinking water quality indicate that the highest concentrations of the industrial solvent 1,4-dioxane occur in North Carolina. Objectives of this research are: 1. Through a literature review, identify possible sources of 1,4-dioxane and effective treatment options for 1,4-dioxane removal, 2. Through stream sampling campaigns, identify 1,4-dioxane sources and determine factors that control 1,4-dioxane concentrations in surface waters, 3. At the bench-scale, assess the effectiveness of existing treatment processes at North Carolina utilities for 1,4-dioxane removal and identify treatment conditions for effective 1,4-dioxane removal, and 4. Identify new treatment options for 1,4-dioxane removal. The results of the proposed research will provide needed information for water quality professionals to manage 1,4-dioxane discharges.

Bromide Occurrence In North Carolina Drinking Water Sources And Effect On Disinfection Byproduct Formation
Detlef R. Knappe
The objectives of the research are to (1) assess the spatial and temporal variability of bromide concentrations in NC drinking water sources, (2) identify bromide sources in NC watersheds, and (3) relate bromide concentrations at drinking water intakes to DBP concentrations in drinking water. Goals of this research are to (1) develop a baseline bromide occurrence database for NC prior to any hydraulic fracturing activity, (2) identify bromide sources in NC watersheds, and (3) develop a database relating bromide occurrence to DBP concentrations in NC drinking water. The database will be useful for policy makers to identify acceptable bromide levels in surface waters that serve as a source for drinking water and/or develop bromide standards for watersheds.

Development and Evaluation of Colloidal Materials to Adjust Aquifer pH and Enhance Contaminant Biodegradation
Detlef R. Knappe
Solutions-IES, Inc. formerly Solutions Industrial & Environmental Services
$122,110
01/01/13 - 03/01/15
Laboratory column and microcosm experiments will be conducted to evaluate the advantages and disadvantages of solid and liquid suspensions for adjusting aquifer pH and enhancing contaminant biodegradation.

Effectiveness of Sub-Micrometer Sized Powdered Activated Carbon for the Combined Removal of Disinfection By-Product Precursors and Trace Organic Pollutants
Detlef R. Knappe
Water Research Foundation
$150,000
10/01/09 - 09/01/13
The principal objective of the proposed research is to assess the effectiveness of sub-micrometer sized powdered activated carbon (PAC) for the combined removal of disinfection by-product (DBP) precursors and trace organic pollutants. Specific objectives include (1) evaluate the effects of PAC particle size on DBP precursor and micropollutant removal (as-received PACs versus sub-micrometer PACs derived from the as-received PACs), (2) identify physical and chemical PAC characteristics that are important for effective DBP precursor and micropollutant removal, and (3) evaluate the effectiveness of different process trains for DBP precursor, micropollutant, and PAC removal (conventional treatment, microsand-enhanced flocculation, ceramic microfiltration (MF) membranes preceded by coagulant addition). The proposed research will offer conventional surface water treatment plants with a potentially cost-effective treatment tool for meeting DBP standards that will require minimal capital investment. An expected side-benefit of sub-micrometer PAC treatment will be the effective removal of many trace organic contaminants such as taste and odor compounds, pesticides, and emerging organic contaminants.
The United States Environmental Protection Agency (EPA) is in the process of developing new regulations for carcinogenic volatile organic compounds (cVOCs) by granular activated carbon adsorption. The new regulation may include a group of thirteen currently regulated cVOCs plus up to eight cVOCs that are on EPA's Contaminant Candidate List. The objective of this project is to survey existing cVOC treatment facilities to collect information on current treatment practices and to estimate impacts of alternative regulatory constructs on capital and operational costs.

Evaluation of Henry's Law Constant and Freundlich Adsorption Constant for VOCs
Detlef R. Knappe
Water Research Foundation
$100,000
10/01/12 - 10/01/15
One goal of the USEPA’s new Drinking Water Strategy is to address contaminants as a group rather than one at a time. Carcinogenic volatile organic compounds (cVOCs) are expected to be the first group to be regulated. The objectives of the research are to (1) determine the effects of temperature and background water quality on Henry’s Law constants describing cVOC partitioning between air and water, and (2) determine the effects of temperature, background water quality, and GAC type on Freundlich adsorption constants describing cVOC adsorption by GAC at regulatory relevant concentrations (low parts per billion levels).

New water Treatment Technology Utilizing Non-Thermal Plasma Technology.
Steven Christopher Shannon, Detlef R. Knappe
Chancellor's Innovation Fund (CIF)
$72,213
07/01/13 - 09/30/14
A compact water treatment source capable of displacing existing technologies due to its lower cost of operation and potential zero-chemical operation for applications ranging from water treatment to sterilization to fertigation of agricultural water supplies is proposed.

Removal of Perfluorinated Compounds by Powdered Activated Carbon Blends, Superfine Powdered Activated Carbon, and Magnetic Anion Exchange Resins
Detlef R. Knappe
Water Research Foundation
$150,000
01/01/11 - 12/01/14
The principal objective of the proposed research is to assess the effectiveness of innovative powdered activated carbon (PAC) adsorption and magnetic anion exchange processes for the
removal of perfluorinated compounds (PFCs) from drinking water sources. Specific objectives include (1) determining whether blending of microporous and mesoporous PACs is advantageous for the removal of PFCs that cover a broad range of molecular weights, (2) evaluating the effectiveness of superfine PAC (S-PAC) for PFC removal, and (3) evaluating the effectiveness of a magnetic anion exchange resin for PFC removal. An important goal of the third objective is to identify effective resin regeneration strategies.

Survey of Existing VOC Treatment Installations and Evaluation of cVOC Removal Efficiencies by Various Technologies
Detlef R. Knappe
ARCADIS U.S., Inc.
$60,000
10/01/12 - 09/30/14
The United States Environmental Protection Agency (EPA) is in the process of developing new regulations for carcinogenic volatile organic compounds (cVOCs) in drinking water. The new regulation may include a group of eight currently regulated cVOCs plus up to eight cVOCs that are on EPA's Contaminant Candidate List. The objective of this project is to survey existing cVOC treatment facilities to collect information on current treatment practices and to estimate impacts of alternative regulatory constructs on capital and operational costs.

Effect of Load History on Performance Limit States of Bridge Columns
Mervyn J. Kowalsky, James M. Nau
AUTC (Alaska University Transportation Center)
$250,000
11/25/08 - 08/31/14
There are two related problems addressed in this research: (1) Currently, structural engineers utilize concrete and steel strain limit states that have minimal experimental or theoretical basis. While the strain limits that are typically utilized attempt to account for cyclic loading, there is no current basis for their selection. Furthermore, the strain limits typically proposed do not consider the effects of temperature. Lastly, while strain limits that occur early in the non-linear range are well established (i.e. serviceability limit state), the strain limits which define maximum structural capacity are less well defined. Most well detailed modern reinforced concrete sections fail by buckling of reinforcement, a limit state which is still ill-understood. (2) In design, engineers relate strains to displacement via monotonic section analysis, however, earthquakes impose cyclic loading on structural systems. As a result, strain limits that are currently utilized can be correlated to different displacement limits depending on the load history the structure is subjected to. As a result, there is a pressing need to (1) Propose strain limit states that account for low temperature effects and regional seismic load histories, and (2) Develop an approach to allow AKDOT engineers to easily relate proposed strain limits to target displacements for design.

Reinforced Concrete Filled Pipe Piles in Soil
Mervyn J. Kowalsky, James M. Nau, Mohammed A. Gabr
This project builds upon the work previously conducted on behavior of Reinforced Concrete Filled Pipe Piles through the performance of the following tasks: (1) Large scale testing of reinforced concrete filled pipe piles in soil; and (2) FEA and fiber-based SSI analysis. The specific goals of this proposed research project are to examine the impact that soil stiffness has on: (1) Pipe pile strain limit states; (2) Plastic hinge length and integration of curvature for deformations; (3) Proposed analysis methods, and (4) Damping

Grade 80 Reinforcement for Seismic Uses
Mervyn J. Kowalsky, Rudolf Seracino
California Department of Transportation
$99,720
06/16/14 - 08/31/15
Caltrans has expressed a desire to utilize ASTM A706 Grade 80 reinforcing steel for design of capacity protected members, as well as for members expected to form plastic hinges in bridges. As a consequence, the complete stress-strain curve of the material must be characterized such that it may be used in moment-curvature analysis and section design. There is little information available in the literature on material tests of A706 Grade 80 steel, thus necessitating a comprehensive evaluation across many bar diameters, mills, and heats to get a statistically defendable stress-strain curve of the material. The goal of this research project is to determine the stress-strain curve for A706 Grade 80 steel. In order to achieve this goal, the work is divided into three tasks: (1) Review of existing data; (2) Physical testing of materials; and (3) Recommendations on stress-strain curve.

Quantifying the Impact of Change from Project Authorization to Start-Up
Min Liu
University of Texas - Austin
$49,100
09/01/10 - 11/30/13
Change is a serious and expensive problem for the Construction Industry, as demonstrated by the number of previous CII studies and the number of papers published on this subject. We believe it is important and timely to conduct more research to quantify change's comprehensive impact at project's different phases from authorization to start-up, and on factors other than labor productivity. CII's existing benchmark database would give us a large number of projects and a broader view of projects by which to test, verify, discover, etc. other aspects of project change and its impact on project success. Incorporating those statistical findings would allow us to develop both those findings into an industry-friendly and usable report.

Using Simulation to Explore the Investment in Planning by Project Teams
Min Liu
Lean Construction Institute (LCI)
Integrated Project Delivery (IPD), Target Value Design (TVD) and Last Planner (LPS) call for new levels of cooperation on projects. Relational contracts, Integrated Forms of Agreement, used on these projects typically establish a shared risk/reward system; a pre-established agreement on the sharing of pains and gains. These contracts mobilize cooperation by rewarding performance of the delivery team as a whole rather than by each party improving productivity of each trade. In this approach, the underlying theory of project success has shifted from optimizing the performance of each party to optimizing the project as a whole.

Evaluation of Reinforcing Bars Coated with Magnesium Phosphate Ceramic, CICI Core Project 7
Gregory Lucier, Rudolf Seracino, Mohammad Pour-Ghaz
Center for Integration of Composites into Infrastructure (CICI) - NCSU Research Site
$75,000
01/01/13 - 12/31/14
Memberships

An Adaptive Leak Detection And Risk Analysis Framework For Urban Water Distribution Systems
Gnanamanikam Mahinthakumar, Sanmugavadivel Ranjithan, Earl D. Brill
National Science Foundation (NSF)
$291,122
08/15/11 - 07/31/15
The primary goal of this project is to understand how routine measurements of pressure, flow and water quality data could be used to characterize leaks and contaminant intrusion in urban water distribution systems and illustrate how this information could be used to aid in the risk assessment of these systems.

BRIGE: Improving Resiliency of Coastal Systems using Bio-Mediated Soil Improvement & Promoting Women in Engineering
Brina Mortensen Montoya
National Science Foundation (NSF)
$175,000
01/01/14 - 12/31/15
The proposed project addresses two needs: improving the resiliency of coastal systems and increasing the female engineering population. This project will assess the potential for microbial induced calcite precipitation (MICP) to be used as a soil improvement method to protect coastal sand dunes from storm-induced instability by addressing the following objectives: 1) evaluating the increase in shear strength and reduction of erosion potential, and 2) addressing the potential effects that the MICP may have on the coastal ecology. The diversity-related goals of this project include increasing the interest of engineering among young female students and increasing the recruitment and retention female university students into graduate programs and
academic careers. The proposed outreach program has been designed to expose female students to different career paths in engineering and provide female engineering role models the students can connect to throughout their educational career.

Shoreline Monitoring at Oregon Inlet Terminal Groin
Margery F. Overton
NC Department of Transportation
$117,851
08/16/12 - 08/15/13
The purpose of this ongoing project (1989 to present) is to monitor and evaluate the shoreline response north and south of the Oregon Inlet due to the construction of the terminal groin built to protect Bonner Bridge at the north end of Pea Island. Phase one of the study was to establish the 'historical erosion rates' for the study area since the change in dredging operations in the inlet in 1984 and before the March 1989 storm. Phase two of the study (1989 through 2012), was to implement the monitoring program as per the permit requirement to determining position of the shoreline from aerial photography at a two month interval and to evaluate the response of the shoreline in the context of the historical erosion rates. The monitoring agreement specified the triggers and actions if the observed erosion exceeded the historic values over spatial and temporal scales of concern. This monitoring effort continues in support of the permit for the Oregon Inlet Terminal Groin. With the negotiation of the permit for the construction of the new Bonner Bridge, monitoring requirements for an expanded project area and for additional metrics have been defined. This scope has been added to the ongoing terminal groin monitoring project in anticipation of future design and planning need for the NC12 transportation corridor.

Shoreline Monitoring at Oregon Inlet Terminal Groin
Margery F. Overton
NC Department of Transportation
$111,850
08/16/13 - 08/15/14
The purpose of this ongoing project (1989 to present) is to monitor and evaluate the response of a six mile stretch of shoreline just south of the terminal groin constructed to protect the bridge at the north end of Pea Island. The purpose of phase one was to establish the 'historical erosion rates' for the study area since the change in dredging operations in the inlet in 1984 and before the March 1989 storm. The continuing phases of the project consist of determining position of the shoreline from air photography every two months and evaluating the response of the shoreline in the context of the historical erosion rates. This project has been expanded approximately 7 miles to the south and has added additional metrics to enhance decision making for the NC12 corridor.

Southeast Climate Science Center
The Department of the Interior (DOI) is establishing a network of geographically dispersed DOI Regional Climate Science Centers (Regional Centers). Regional Centers will be based at host organizations that have suitable facilities, partnerships, and science capabilities, and will involve multiple active collaborators. Regional Centers will house up to twelve (12) USGS and DOI employees and will work in close partnership with the host institution with the goal to understand high priority science needs and to develop science information and tools that can help land, water, fish and wildlife, and cultural heritage resource managers develop strategies for responding to climate change. Objectives are to 1) Provide land, water, fish and wildlife, ocean, coastal, and cultural heritage resource managers with the tools and information to develop and execute strategies for successfully adapting to and mitigating the impacts of climate change. 2) Provide modeling and forecasting information and tools, integrate physical climate models with ecological models, assess climate change vulnerabilities, forecast changes, and develop standardized approaches. 3) Provide funding for researchers through cooperative agreements that involve climate change science as a major component.

Innovative Component Design and Retrofit of Critical Civil Infrastructure
Margery F. Overton, Mohammed A. Gabr, George F. List, Rudolf Seracino, John W. Baugh, Sanmugavadivel Ranjithan, Earl D. Brill
UNC - General Administration
$2,806,408
07/01/13 - 06/30/14
This project is developing computational approaches to assess the effects of storms on civil infrastructure in a geographic region of interest. In this extension to the current project, we will be working with end users and delivering a software product called the Subdomain Modeling Tool (SMT), a graphical user interface that provides a front end for some of the enhancements we have already made to the ADCIRC program for storm surge simulation.

DHS Homeland Security HS-STEM Career Development Grants (CDG)
Sanmugavadivel Ranjithan, Earl D. Brill, Mohammed A. Gabr, Margery F. Overton, Rudolf Seracino, John W. Baugh, George F. List, Alixandra Demers
US Dept. of Homeland Security (DHS)
$390,000
09/30/09 - 09/30/13
The purpose of this proposal is to establish a graduate research fellowship program to train students to be future leaders in the area of engineering of resilient civil infrastructure systems for coastal regions considering natural hazards. This program will be conducted in coordination with the ongoing DHS Center of Excellence on Natural Disasters, Coastal Infrastructure and Emergency Management.

Retaining Wall Inventory and Assessment System
The objective of this research is to design and develop a database archival and retrieval system for electronic documentation, management, qualitative analysis, and display of retaining walls, especially critical walls such as those adjacent to bridges. Such structures include MSE, soil-nail, tie-back, gravity, cantilever, and pile panel walls. The database to be created will include wall location, geometry, internal configuration, local geology, and external signs of stress such as tilt and cracking. The development of rating criteria models that are specific to wall types will also be explored in consultation with NCDOT. The spatial data will be organized in such a way as to be able to link to NCDOT systems.

Driver Behavior in Complex Navigation and Hazard Negotiation Under Distraction
David B. Kaber, Joseph E. Hummer, William J. Rasdorf, Guk Ho Gil
NC Department of Transportation
$133,517
07/01/12 - 09/30/13
Previous research has not investigated how drivers use roadway signage for destination identification when simultaneously performing navigation and/or hazard avoidance. Furthermore, it is not known how drivers prioritize or manage such tasks when subject to information processing capacity demands due to in-vehicle distractions, such as navigation aid use. Although several studies have been conducted on the affect of logo sign formats on driver behavior, the effectiveness of specific formats for supporting driver cognition when distracted or posed with safety-critical driving situations is not known. The first objective of the present study is to describe how drivers prioritize performance and safety goals in the presence or absence of in-vehicle distractions. As drivers make decisions from moment-to-moment, which are related to achieving a destination or maintaining safe vehicle control, we also seek to describe the pattern of driver visual attention to information sources in the environment that are related to concurrent driving goals, including logo and warning signs. The second and final objective is to determine the effect of logo sign configurations, including conventional six-panel and nine-panel, on the capability of drivers to comprehend sign information under normal conditions and in the presence of competing safety concerns and distraction. The study will make use of a high-fidelity driving simulator and realistic simulation scenarios. Drivers will be exposed to highway driving for extended periods in which they are required to use a navigation device for destination exit identification, negotiate a construction zone and roadway hazards, and use logo signs for selecting an exit. Drivers will also complete trials in which use of the navigation device (or in-vehicle distraction) is not required. Driver safety margin measures (time headway) will be collected to make inferences on goal management. Performance measures will be collected to assess the stability of speed and position control under distraction and when using signage. Visual behavior measures will be collected to assess levels of driver distraction due to navigation device use as well as the extent of focus on various roadway sign formats. Results are expected to provide insight into how drivers alter performance and safety goal structures when posed with in-vehicle distraction tasks, as well as how goal management and distraction translate to the use of roadway signs. Recommendations will be made to the NC DOT regarding optimal logo sign
configuration for various driving circumstances. Such recommendations may impact actual NC DOT sign installations and, consequently, motorist use of signs on North Carolina Highways.

Behavior and Design of Directly-Loaded L-Shaped Beam Ledges, CICI Core Project No. 5
Sami H. Rizkalla, Gregory Lucier
Center for Integration of Composites into Infrastructure (CICI) - NCSU Research Site
$127,692
07/01/13 - 06/30/15
Membership

Development of Rational Design Methodologies for Dapped Ends of Prestressed, CICI Core Project 6
Sami H. Rizkalla, Gregory Lucier
Center for Integration of Composites into Infrastructure (CICI) - NCSU Research Site
$90,000
07/01/12 - 12/31/14
Memberships: Precasted double tees with thin stems are a widely used and highly successful floor member in parking structures and other buildings. Frequently, the end supports are dapped such that the bottom of the double tee is level with the bottom of the inverted tee or ledge beam on which it is supported. The dapped connection detail is especially important at cross overs between spans in parking structures because the overall structural depth and floor-to-floor height need not be increased where the double tee is supported by and inverted tee beam. While the title of the research project implies the primary objective is the “development of rational design methodologies,” the RFP also discusses the need for industry standard details for dapped double tees. Both objectives are appropriate. Rational design methodologies are needed to proportion reinforcement in the dapped end, and standard industry details are needed to assure effectiveness and constructability. Thus, the objective of this research is twofold: 10 develop rational methodologies for proportioning key reinforcements in dapped end double tees, and 2) develop standard details that been rigorously reviewed by industry experts and have proven to be effective by extensive analyses and tests.

Center for Integration of Composites into Infrastructure Membership (CICI), Full Member with special service privileges
Sami H. Rizkalla
Nippon Steel & Sumikin Materials Co., Ltd. Composites Co. formerly Nippon Steel Materials Co., Ltd.
$200,000
07/01/12 - 06/30/14
Membership

CICI Administrative Account
Sami H. Rizkalla, Gregory Lucier
Efficient infrastructure systems such as highways, bridges, buildings, pipelines, flood control systems and utilities are all necessary for a healthy economy and comfortable standard of living. Concrete and steel are the backbones of physical infrastructure. It is envisioned that the proposed Center will focus on new research concerning: 1) development of constituent material combinations for optimum end products, 2) cost-effective ways to manufacture products, 3) “green” production, including the use of bio-fiber and resins and industrial byproducts, 4) further development and application of standard test procedures, guide-specifications, design methods and rapid, modular construction techniques in addition to continuing research started by RB2C concerning the development of innovative and sustainable structural materials and systems for infrastructure applications, renewal of existing infrastructure, load testing and assessment of constructed facilities, and structural health monitoring and prognostics. The center activities will enhance the international competitiveness of the American industry in the area of composites including modular construction and rapid deployment techniques using natural and bio-materials; thus reducing carbon emissions into the atmosphere. For example, the advanced composite systems to be developed by the center for emergency conditions such as natural disasters could be implemented in other parts of the world. The Nation as a whole would benefit as composite use would, in general, lead to structures of higher safety, shorter construction times and longer life spans at a reduced overall cost, and the creation of new job opportunities and industrial sectors. Member companies and end users will also benefit from the interaction with others in their field as they become familiar with technologies used outside their own domains of practice. All companies in the composites and construction communities will benefit from the highly trained undergraduate and graduate students. In addition to the publishing of journal articles and conference presentations to promote the scientific research and knowledge dissemination, a tenet of the proposed center will be to educate practicing engineers and end users who are not familiar with composites, but could make great use of their unique properties in conjunction with traditional materials, by learning techniques on design, manufacturing, construction and repair.
Unconventional interchange design solutions provide options that agencies explore to overcome pitfalls associated with conventional solutions for congested diamond interchanges. Unconventional designs involve rerouting one or more movements—often left turns—to reduce the number of conflict points remaining in the middle of the interchange which allows reduction in signal phases less lost time, fewer opportunities for crashers, and other potential operational, safety, and environmental benefits. The most prominent unconventional service interchange design with no loops and no (substantive) weaving at the moment is the double crossover diamond (DCD) interchange, also known as the diverging diamond interchange.

Pedestrian and Bicycle Accommodations on Superstreets
Nagui M. Rouphail, Christopher Michael Cunningham, Sarah O'Brien, Joseph E. Hummer, Robert S. Foyle
NC Department of Transportation
$200,000
08/16/11 - 08/15/13
A research project just completed for NCDOT by the proposers showed that the superstreets that NCDOT has installed recently across the state have served motorists wonderfully. They were shown to produce lower travel times for motorists under a variety of traffic volume conditions. They were also shown to produce great collision savings “almost 50 percent” at rural unsignalized installations compared to the conventional intersections they replaced. Because they will reduce the need for expensive widening, bypass, and interchange projects, superstreets will save the NCDOT huge amounts of money in the future. However, public reaction to superstreet proposals is lukewarm at best. Two groups that seem firmly opposed to superstreet proposals are pedestrians and bicyclists. In theory, pedestrians and bicyclists should both benefit from superstreet projects compared to conventional intersections. Crossing pedestrians should benefit because they cannot be hit unless a vehicle runs a red signal, for example. However, pedestrians typically object to a two-stage crossing of the main street, a zig-zag crossing path,
the perception that main street traffic is traveling faster than normal, and a perception that the median is wider than normal. Bicyclists, who should benefit from the perfect signal progression on the main street, typically object to the greater travel distances required to make a minor street left turn or crossing maneuver. It would be a shame if the objections of pedestrians and bicyclists to superstreets “some well-grounded and some spurious” slowed installation of a device that is otherwise delivering great benefits to the motoring public. The purpose of the proposed project is to find ways to overcome the objections raised by pedestrians and bicyclists to superstreets. The project will have two specific objectives. First, the researchers will recommend changes in superstreet design and operation practices to overcome the objections. It is likely that some small, subtle, and inexpensive tweaks to current practices could help overcome most objections. Second, the researchers will develop materials that NCDOT can use to reach out to pedestrians and bicyclists during the planning and design stages for a superstreet project and show them that the project will be beneficial for them too. These materials could include presentations, videos, animations, brochures, web pages, and other forms. The researchers will use several methods to achieve objectives. The researchers will make video and other observations of existing superstreets with some pedestrian and bicycle activity, in North Carolina or elsewhere. The researchers will employ simulation to calculate the benefits from various treatment possibilities. Most importantly, the researchers will gather the opinions of pedestrians and bicyclists early and often throughout the project. This will likely include surveys and focus groups, perhaps with a panel of pedestrians and bicyclists that is consulted at many points throughout the project. The project will result in ways to address the objections of pedestrians and bicyclists to superstreets, either through better designs and operations or through better public outreach. In the end, this research effort along with previous work conducted by the team will allow all users of North Carolina roadways to enjoy additional superstreet installations that are safer, cause less delay, and save money compared to conventional roadways.

Delay and User Cost Estimation for Work Zones on Urban Arterials
Bastian Schroeder, Nagui M. Rouphail, Billy M. Williams
NC Department of Transportation
$199,768
08/16/12 - 08/15/14
Work zone and construction impacts on arterial streets constitute a considerable source of congestion in North Carolina metropolitan areas. Work zones that cause a “significant” disruption to the traveling public are required to undergo a performance evaluation to assure that impacts can be minimized to the extent possible. This includes decisions on the type of work zone scenario to be considered, as well as an assessment of the feasible times of day during which construction activities are permitted. However, NCDOT does not currently have an evaluation tool that could be used to perform such analyses on urban arterials. With the presently available tools, the analyst is limited to either performing peak period analyses using analytical tools not originally designed to evaluate work zones, or contracting a cost-intensive and high-effort simulation analysis of the proposed activities.

Work Zone Traffic Analysis & Impact Assessment
Additional duties to be performed are the estimation of travel time and volume impacts on additional alternate routes from the DTA Lite Model, inclusion of the Triangle Expressway toll road in the network analysis and the evaluation of estimated benefits from the future extension of the toll road to connect to Interstate I-40.

Assessment of Deteriorated Cored Slabs Bridge No: 150035 and 150039
Rudolf Seracino, Gregory Lucier, Mohammad Pour-Ghaz
NC Department of Transportation
$123,695
08/16/13 - 08/15/14
The main objectives of this research is to (i) critically evaluate existing non-destructive techniques used to quantify the extent of corrosion in existing in-service members, and that can be readily adopted by NCDOT maintenance engineers and contracted bridge inspectors, (ii) undertake detailed field investigations of the two bridges scheduled for superstructure replacement creating a comprehensive photographic record of the degrees and extent of deterioration, (iii) implement the non-destructive techniques on eight deteriorated prestressed concrete cored slab units identified and taken directly from the in-service bridges in order to evaluate their effectiveness and develop protocols for future use, and (iv) test the eight units to destruction in three-point bending to experimentally quantify and observe their failure mode and residual capacity.

CFRP Strands in Prestressed Cored Slab Units
Rudolf Seracino, Gregory Lucier, Sami H. Rizkalla
NC Department of Transportation
$91,649
08/16/13 - 08/15/14
Prestressed concrete cored slab units are common, efficient sections for short to medium span bridge construction. Such units are found on thousands on NC bridge spans and are still used extensively for new bridge construction and bridge deck replacements. The limiting factor in the lifespan of such cored slab is usually corrosion of the internal steel reinforcement (the lower-layer prestressing strands in particular). Road salts and coastal environments can reduce the design lifespan of such bridge elements by 50% or more. The research aims to investigate the potential use of non-corroding Carbon Fiber Reinforced Polymer (CFRP) prestressing strands in place of steel strands and the use of Glass Fiber Reinforced Polymer stirrups in place of steel stirrups. The use of these new materials has the potential to greatly enhance the durability and corrosion resistance of cored slab deck members. The research will include literature and design guide study, full-sale laboratory testing of cored slab girders, material testing, computer modeling, and rational analysis. Design recommendations and guidelines will be developed for the NCDOT.
Nondestructive Concrete Characterization System
Rudolf Seracino, Gregory Lucier
NLA Diagnostics, LLC
$134,171
11/18/13 - 11/18/15
During covert operations, the U.S. Army may be required to breach a concrete wall or structure using a controlled explosion. In order to choose the most effective charge size and placement, it is necessary to perform a rapid field assessment of the material properties (such as strength of concrete) and structural properties (such as thickness of the concrete, location of the reinforcement, and metallic substrate) of the target structure. The research aims to develop a more advanced, accurate, non-destructive, and covert method of assessing concrete material and structural properties.

Effectiveness of TSR Test in Evaluating Moisture Sensitivity of WMA Mixes
Akhtarhusein A. Tayebali, Mohammad Pour-Ghaz
NC Department of Transportation
$290,950
08/16/13 - 08/15/15
The NCDOT requires that asphalt mixtures used in pavement construction meet the NCDOT moisture sensitivity specifications prior to approval of the job mix formula (JMF). Foaming-based warm mix asphalt (WMA) mixes, based on water injection WMA technologies, such as Astec’s Double Barrel® foamed technology, and WMA technologies that use Zeolite additives such as Advera, tend to fail the current required tensile strength ratio (TSR) tests. However, pavements constructed with these same WMA mixes in the United States and in North Carolina have performed well to date. Either the current TSR test protocol needs to be modified or a new test is needed for WMA mixes.

Impact of WMA Technology on the Use of RAP Mixtures in NC
Akhtarhusein A. Tayebali
NC Department of Transportation
$259,138
08/16/12 - 08/15/14
The primary objective of this research project is to study the effect of using RAP in WMA. Various HMA and WMA mixtures, with and without RAP material, will be characterized with respect to fatigue life, resistance to permanent deformation, susceptibility to thermal cracking, and moisture susceptibility. Fatigue life and rut resistance of the mixtures will be evaluated by conducting dynamic modulus and flow number tests. The moisture-induced damage of the mixtures will be determined using the Tensile Strength Ration (TSR) as per AASHTO T-283 test procedure.

Development of Near Real Time Performance Measurements for Closed-Loop Signal Systems (CLS) Using Historical Traffic Data from Existing Loop Detectors
The NCDOT Central Office System Timing (COST) Section is charged with developing, evaluating, and maintaining closed-loop signal system timing plans across the state. Currently, signal plan evaluation is a manpower intensive task that involves field observation and travel time runs. This approach to plan evaluation is costly and inefficient. The project team will devise a data collection plan to support the rigorous development of closed-loop system performance models. The accuracy and precision of these models will be assessed relative to field observed performance measurements. Recommendations will be developed for the implementation of the best performing models. A comparative evaluation of system travel time estimates from the proposed models with respect to INRIX arterial surveillance data will be provided. Along these lines, it is anticipated that the performance models developed will also support ongoing NCDOT efforts to deploy a comprehensive statewide mobility and reliability monitoring system and to provide timely, accurate, and useful traveler information.

IMAP-Assessment of Benefits/Costs, Route Selection, and Prioritization
Billy M. Williams, Nagui M. Rouphail, Ali Hajbabaie
NC Department of Transportation
$202,216
08/16/13 - 08/15/15
Between 2004 and 2013 NCDOT’s IMAP program coverage grew from approximately 320 centerline miles to approximately 690 centerline miles. Demand for further expansion of the IMAP program continues unabated. The project team proposes to conduct a thorough review of the state of the practice and well as directly applicable research. The resulting synthesis of best practices and application-ready research will in turn provide the basis for new methodologies implemented in an accompanying computational engine. This computational tool will enable NCDOT to conduct accurate assessments of IMAP program costs and benefits, including evaluation of public and private delivery of service options, and to conduct selection and prioritization of routes for IMAP system expansion.

SmartLink-Baseline for Measurement of Benefits
Billy M. Williams, Nagui M. Rouphail, George F. List
NC Department of Transportation
$193,657
08/16/12 - 08/15/14
The proposed project will be designed and conducted to provide the key components necessary to establish the Smartlink benefits measurement system. First, an appropriate set of supporting and direct measures of systems benefits must be selected and defined. Second, detailed data requirements for calculating the selected performance measures must be identified and specified. Third, a pre-ATMS system deployment (before condition) data set must be assembled based on the specified data requirements. This before condition data set will serve at the baseline benchmark of the transportation system performance. Finally, the project will define and
establish a methodology for continual updating of the required system data and benefits measurements and periodic reporting of the resulting (and continually updated) cost-benefit analyses.

CAREER: Multi-Scale Interactions of Waves, Currents and Morphology With Application to Rip Currents
Jie Yu
National Science Foundation (NSF)
$567,232
07/15/09 - 06/30/15
Coastal evolution has become even more a concern under the scenarios of rising global sea levels, changing climate and accelerating human activities. World-wide, coastal erosion is becoming a still more serious problem than it already is. Being in direct contact with the land, the hydrodynamics in the surf zone has significant influences on nearshore sediment transport, hence shoreline erosion, and on the transport and mixing that affect the water quality in coastal oceans and floodplains. Understanding of the complex dynamics of the nearshore hydro-morphodynamic system is clearly of fundamental relevance to the development of reliable predictive tools upon which science-based decisions on planning, management and mitigation rely to build a sustainable and resilient coastal environment. The proposed research aims to improve this understanding by investigating in depth the mutli-scale interactions among three key processes in the nearshore, i.e. waves, currents and sediment transport, with application to rip currents. This research is intrinsically suitable, thus will be used as an instrument, to develop a strong integrated program of research and education in Coastal Dynamics and Environmental Fluid Mechanics, a long-term goal of the PI’s overall career development plan at NC State University.