Civil, Construction, and Environmental Engineering Research Projects 2007-08

The Department of Civil, Construction, and Environmental Engineering encourages active collaboration and cross-disciplinary activities and has a strong commitment to innovative research. The department supports close partnerships with industry and government in an effort to conduct research at the cutting edge of science and technology. Research sponsored and funded by organizations such as the National Science Foundation, the US Environmental Protection Agency, and the North Carolina Department of Transportation is focused primarily on serving public needs and enhancing the ability of industry and government to respond to those needs.

Departmental research and educational activities are strengthened through its centers and laboratories. The Constructed Facilities Laboratory (CFL) is located on the University's Centennial Campus. The research and development programs of the CFL support the mission of the Centennial Campus of creating industry, government, and university partnerships. The CFL is a sophisticated structure with specially designed reaction floors and walls to support three-dimensional loading. A $2.9 million Academic Research Infrastructure grant, co-funded by the National Science Foundation and NC State University, provided extensive state-of-the-art research equipment for constructed infrastructure research. Also on the Centennial Campus is the Institute for Transportation Research and Education (ITRE), which is conducting research, education, and technical assistance projects related to surface transportation issues. ITRE, which is administered at the university level, carries out numerous activities in collaboration with our faculty and graduate students. It is also the administrative home of the Center for Transportation and the Environment, which also involves our faculty and students. The Center for Nuclear Power Plant Structures, Equipment and Piping performs research on innovative solutions to problems in nuclear power plants and transfers this technology to the industry.

The projects described in this brochure are examples of some of the exciting research taking place in the Department. They are also illustrative of our efforts to create solutions through innovation and multidisciplinary research contributions covering a broad spectrum of basic and applied research. The faculty in Civil, Construction, and Environmental Engineering, their students, and colleagues continue to identify new research opportunities in an effort to find solutions to the problems currently faced by the profession and to predict issues that will challenge the profession in the future.

PROGRAMS OF GRADUATE STUDY

The Department of Civil, Construction, and Environmental Engineering offers graduate programs with a major in Civil Engineering leading to the degrees of:

- Master of Civil Engineering (MCE) – available both on-campus and by distance education
- Master of Science (MS)
- Doctor of Philosophy (PhD)

Each degree program is available with the following areas of specialization:

- Computer-Aided Engineering
- Construction Engineering and Management
- Geotechnical/Geoenvironmental Engineering
- Structures and Mechanics
- Transportation Systems and Materials
- Water Resources, Coastal, and Environmental Engineering

In addition, inderdisciplinary programs such as Engineering/Administration encourage a breadth of background from several specialties. Graduate students are encouraged to take supporting courses in a second area of specialization in civil engineering or the strong supporting programs in other departments of the University, including mathematics, statistics, computer science, operations research, business, economics, public administration, city and regional planning, marine, earth and atmospheric sciences, and others.

The research conducted by graduate students under the direction of the faculty both educates the student in the research process and advances the knowledge available for application in industry. The ability gained by the students in research advances their careers in industry where new methods of design and construction must frequently be discovered, evaluated, and applied. The university research results are published by the students and faculty and conveyed to national societies and industry associations where model codes, specifications, and regulations are promulgated. The faculty are active as members and leaders of such organizations and, as a result, are able to bring this state-of-the-art knowledge to the classroom.

To aid the practicing professional who later discovers the need for advanced study but is not located near a university with appropriate master's programs, the Master of Civil Engineering degree is available by distance education. The requirements for the on-campus and the distance student are the same, and thus the degree awarded is the same. Over 40 of the on-campus courses are now offered in the distance mode.

For more information go to: **www.ce.ncsu.edu**

COMPUTER-AIDED ENGINEERING

Improved Water Resources Sustainability Through Multi-time Scale Forecasting and Adaptive Mulit-purpose Reservoir Management

S. Arumugam and S. Ranjithan
National Science Foundation
$299,963
03/05 to 02/11

This project has three major objectives. The first is to develop an integrated approach to promote sustainable water systems through combined application of both weather information-based near-term streamflow forecasts and climate-based short-term streamflow forecasts. The second objective is to apply and demonstrate the approach for two water supply systems, one experiencing rapid increase in water demand in NC, and another serving multiples uses in Virginia. The third objective is to develop an instructional tool for assessing various water management measures and streamflow forecasts in promoting sustainable water management and to incorporate the tool in undergraduate/graduate curricula at several Universities.

A Discrete Numerical Investigation into Soil-Structure Interaction with Extraterrestrial Applications

T.M. Evans
NASA/NC Space Grant Program
$15,000
04/09 to 03/10

While there has been scientific study of the soil and rock materials of the surface of the Moon and Mars, little is known about their engineering properties due to the difficulty and cost associated with collecting and transporting to Earth enough material to perform meaningful tests. Without this information, it is impossible to develop optimized designs for wheels, tires, foundation systems, landing gear, resource recovery infrastructure, or exploration tools. To circumvent the difficulties associated with collecting and testing extra-terrestrial soil, this work will develop discrete numerical models for simulating soil-structure interaction that will be used to provide a reasonable prediction of the bulk material properties of extraterrestrial granular matter.

Integration of Sensor Technologies into the Civil Engineering Curriculum

T.M. Evans and M.A. Gabr
National Science Foundation
$150,000
01/09 to 01/11

The use of sensors and instrumentation for monitoring civil engineering infrastructure has been of paramount importance since ancient times. The specific goals of the proposed project are to: a) Identify the sensors most relevant to earth structures and foundations and categorize the extent of instrumentation necessary to provide quality data for monitoring, diagnostics, and prognostic Analyses; b) Identify structures and building foundations on campus that are most suitable for instrumentation and install a comprehensive network of automated sensors; c) Develop undergraduate hands-on educational modules, emphasizing sensor operation; experimental data collection, processing and visualization; and statistical analysis.

Effect of Gradation on Predicted Performance of Aggregate Base Course

T.M. Evans and A.A. Tayebali
North Carolina Department of Transportation
$82,490
01/08 to 06/09

The primary objectives of this research are to evaluate the effect of aggregate gradation on the mechanical properties of the ABC materials; and to develop numerical model(s) based on the discrete element method (DEM) to predict mechanical properties with changes in gradation. The DEM models will also provide insight into the underlying micromechanics that may contribute to variations in material performance as a function of ABC gradation. It is anticipated that this research study will result in performance-related criteria that can be incorporated into the NCDOT Standard Specifications that are used for acceptance of ABC material for pavement structure.

Load Combination Method and Analytical Methodology for IRWST and Other Dynamic Loads in Piping Analysis
A. Gupta

Korea Power Electric Company, KOPES, South Korea
$16,000
2008

This project is aimed at providing technical knowledge on state-of-the-practice for combining various dynamic loads such as those due to Earthquake, Loss of Coolant Accident (LOCA), and Safety Relief Valves (SRV) in a nuclear power plant piping system analysis. This work has different aspects that relate to: (a) Providing background information on the currently specified load combination procedures in USNRC recommended and ASME recommended guidelines, (b) Theoretical basis for various recommendations, and (c) Train KOPEC engineers on incorporating appropriate load combination methods in an actual piping analysis and assist them with interpreting the results.

Development of a Seismic Fragility Methodology for Nuclear Power Plant Structures

Marty McCann Jr. (Stanford University), **Abhinav Gupta** *(NCSU), and Jack Baker (Stanford University)*
Kajima Corporation of Japan through CUREE/Kajima Partnership
$57,687
2009-2011

The purpose of this study is to develop and implement a generalized seismic fragility methodology for structural components and systems. The study will develop an approach that provides a closer integration of the characterization of earthquake ground motions and the performance of critical facilities. This research is aimed at developing an approach that takes advantage of Kajima structural analysis capabilities and integrates an improved characterization of earthquake ground motions with a detailed reliability analysis of structure performance. The work is being conducted jointly by a multi-institutional team of researchers from NC State University, Stanford University, and Kajima Corporation of Japan.

NEESR-GC: Simulation of the Seismic Performance of Nonstructural Systems

A. Gupta and M. Margakis (University of Nevada, Reno); other participating institutions: SUNY-Buffalo, UC-San Diego, Cornell, GA-Tech, NC A&T, and UNC-Chapel Hill (Project Managed by CUREE)
$212,000 (NCSU); $194,000 (NSF); $18,000 (NCSU Graduate School via AGEP program-NSF)
2007-2012

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.

Engineering to Enhance the Resilience of the Built and Natural Environments

R. Leuttich (UNC-CH), M. Overton, G.F. List, R. Seracino, M. Gabr, R. Ranjithan, D. Brill, J. Baugh
Department of Homeland Security, Center of Excellence
$2,593,890
08/08 to 07/14

The objective is to investigate innovative and proactive approaches to plan, design and construct CCI components to provide services needed to increase disaster preparedness and resilience of the integrated CCI system, as well as to protect the natural environment. To achieve this goal, five highly interrelated research projects are being proposed. Each project has a project leader and anticipated partners; however, the projects are proposed as complementary pieces contributing products to be used to meet the overarching objective to enhance the resilience of the built and natural environment, a single objective. As such, project leaders will work together to coordinate efforts, align case studies, transfer outcomes, develop scenarios, etc. toward a highly integrated product.

Application of Municipal Solid Waste Decision Support Tool to Wake County, North Carolina

M.A. Barlaz and S.R. Ranjithan
U.S. Environmental Protection Agency
$60,000
12/04 to 08/09

The objective of this project is to develop alternatives for the management of municipal solid waste for Wake County, NC. Alternatives will be developed to examine tradeoffs among cost, environmental burdens, resource consumption and landfill diversion using a solid waste management life-cycle inventory model developed by the investigators.

Assessment of Environmental Emissions associated with the Beneficial Reuse of Industrial, Commercial and Agricultural Wastes

M. A. Barlaz and S. Ranjithan
Delaware Solid Waste Authority
$142,976
06/06 to 08/08

The objective of this research is to estimate the environmental benefits of the recycling and reuse of commercial, industrial and agricultural wastes generated in the State of Delaware.

Calibration of Rutting Models for HMA Structural and Mix Design

R. Kim and M.N. Guddati
NCHRP 9-30A, Subcontract from Applied Research Associates, Inc.
$70,000
11/05 to 10/08

The objective of this research effort is to recommend revisions to the HMA rut depth prediction model in the mechanistic-empirical pavement design guide and software developed in NCHRP Project 1-37A for consideration by the NCHRP Project 1-40 panel and the AASHTO Joint Task Force on Pavements. The recommended revisions will be based on the calibration and validation of distress models with measured materials properties and performance data from existing field and other full-scale pavement sections that incorporate modified as well as unmodified asphalt binders.

Top-Down Fatigue Cracking of Hot-Mix Asphalt Layers

Y.R. Kim and M.N. Guddati
NCHRP 1-42A, Subcontract from University of Florida
$120,000
06/06 to 05/09

In this research, the viscoelastic continuum damage model implemented in the finite element program (VECD-FEP++) will be used to investigate the top-down fatigue cracking mechanism in hot-mix asphalt pavements. The VECD model and the dynamic modulus from the IDT test will serve as the primary experimental tools. The resulting VECD-FEP++ will be used to simulate the behavior of asphalt pavements with varying loading, environmental, and pavement factors. The results from the simulation will be investigated to develop mechanistic procedures to evaluate the top-down cracking propensity of asphalt pavement as a function of various factors and to predict the top-down cracking performance of asphalt pavement.

High-end Computing in Environmental Engineering with Application to Subsurface Characterization

G. Mahinthakumar
National Science Foundation (Career)
$400,000
07/03 to 06/09

Accurate characterization of the subsurface is important in development of reliable and efficient groundwater management practices. Accurate and reliable estimation of hydraulic conductivity distribution, contaminant distribution, and/or contaminant source release history is necessary for problems such as estimating groundwater yields, design of efficient

cleanup strategies, and identifying responsible parties in a contamination incident. This requires solution of an inverse problem because direct measurement of detailed subsurface properties is not feasible. Inverse problems are difficult to solve and are computationally demanding. This multidisciplinary NSF Career project will investigate novel computational strategies for efficient solution of large-scale inverse problems in subsurface characterization.

ITR: A Prototype to Support Near Real-Time Environmental Characterization

G. Mahinthakumar, R. Ranjithan, and Nick Karonis (Northern Illinois University)
National Science Foundation
$497,418
09/03 to 08/07

The overall goal of this project is to investigate formal computational approaches that can readily harness grid computing for the efficient solution of environmental characterization problems. To this end, we will develop a grid-enabled software framework. Two alternative paradigms, one based on the grid-enabled version of MPI (Message Passing Interface), and the other based on Java will be explored. The framework will be applied to groundwater and surface water problems, both of which are of prime societal importance.

DDDAS-TMRP (Collaborative Research): An Adaptive Cyberinfrastructure for Threat Management in Urban Water Distribution Systems

G. Mahinthakumar, E.D. Brill, R. Ranjithan (Co-PI's, NCSU), J. Uber (Univ. of Cincinnati); Gregor Von Laszewski (Univ. of Chicago); and K. Harrison, (Univ. of South Carolina)
National Science Foundation (Dynamic Data Driven Application Systems Program)
$779,986 (NCSU share $264,624)
01/06 to 12/09

The goal of this multidisciplinary research is to develop a cyberinfrastructure system for water distribution system threat management that will both adapt to and control changing needs in data, models, computer resources and management choices facilitated by a dynamic workflow design. Using virtual simulation and a field study, this cyberinfrastructure will be tested on illustrative scenarios for adaptive management of contamination events in water distribution systems.

Development of a Design Tool for Planning Aqueous Amendment Injection Systems

R.C. Borden, G. Mahinthakumar, T.J. Simpkin (CH2M HILL) and C. Zawtocki (Solutions-IES)
DOE, Environmental Security Technology Certification Program
$503,000
03/06 to 12/10

The overall objective of this project is to develop a set of tools to assist design engineers in developing effective, reasonably efficient systems for distributing aqueous amendments for in situ treatment of groundwater contaminants. At this time, the primary applications for the tools will be for design of in situ chemical oxidation systems using permanganate and in situ anaerobic bioremediation systems using soluble substrates and emulsified oil. However, as technology evolves, this general approach should be applicable to distribution of other aqueous amendments.

PERI: Performance Engineering Research Institute: Application Engagement

G. Mahinthakumar
UT Battelle LLC
$279,776
04/07 to 06/11 (renewed annually)

This project is part of a larger scale effort funded by DOE through the SciDAC (Scientific Discovery through Advanced Computing) program. The overall goal of the project is to develop and maintain an enabling technology center in the area of high-end computer performance called performance engineering research institute (PERI). NCSU component of this project will focus on performance analysis, performance modeling, and performance optimization of SciDAC groundwater application codes.

Modeling the Impact and Blast Performance of Fiber Reinforced Concrete

V.C. Matzen and Abhinav Gupta
Idaho National Laboratory
$25,000 per year (annual renewal)
2006 to 2009

This study is aimed at providing an experiment-based application for the blast/impact software investigation to be carried out at INL. Active research collaboration between INL and the Center for Nuclear Power Plant Structures, Equipment and Piping at NCSU is proposed. The collaboration will provide NCSU personnel an access to the advanced finite element software available at INL to model the structural performance of FRC. Simple experiments on FRC structural members will be conducted at NCSU for reconciliation of analytical and experimental results. The purpose would be to help in the development of new FRC material to withstand impact and blast loads.

Procedures for Multi Hazard Risk Assessment in Civil Infrastructure Systems

R. Ranjithan, D. Brill, J. Baugh, Mo Gabr, M. Overton, and R. Seracino
$19,813
05/08 to 12/10

The pilot project will develop an outline of a multihazard risk assessment methodology associated with floods and levees. It will also identify model requirements and data needs. This work will serve as a prototype for future work to develop a more comprehensive methodology for considering a broader range of natural hazards and civil infrastructure

CONSTRUCTION ENGINEERING AND MANAGEMENT

Investigation of Highway Asset Inventory and Data Collection Methods

R. Kim, J. Hummer, M. Gabr, and D. Johnston
NC Department of Transportation
$200,670
04/01 to 12/08

The North Carolina Department of Transportation (NCDOT) is co-hosting a National Workshop on Highway Asset Inventory and Data Collection in September 2008. Four infrastructure elements have been identified as the focal areas for the workshop: 1) pavements, 2) bridges, 3) geotechnical features and drainage, and 4) roadside appurtenances. To evaluate the accuracy of various asset data collection technologies, vendors for these technologies will be invited and will test selected test sections. Research is needed to develop an experimental design for the vendor testing, to perform ground truth testing of the test sections, and to analyze the data from vendors to compare against the ground truth measurements.

Bridge Management System Criteria

D. Johnston
North Carolina Department of Transportation
$7,700
07/08 to 08/08

Technical assistance project to develop criteria for development, revision, and update of NCDOT Bridge Management System.

Function Code Modifications of RESNEEDS Bridge Maintenance Software

D. Johnston
North Carolina Department of Transportation
$7,700
11/08 to 01/09

Technical assistance project to revise RESNEEDS Bridge Maintenance Management software to accept new work function codes and associated unit costs and work quantities and to analyze for optimum use of funds.

Life Cycle Inventory and Impact Analysis Framework for Nonroad Construction Vehicles and Equipment Based

H.C. Frey and W.J. Rasdorf
National Science Foundation
$375,000
08/03 to 08/08

The objectives of this work are to: (1) Characterize the second-by-second in-use emissions and energy use of nonroad construction vehicles and equipment, including emissions of nitric oxide, carbon monoxide, hydrocarbons, carbon dioxide, and particulate matter, including real time sensing and monitoring where needed to fill data gaps; (2) Develop a life cycle inventory of conventional nonroad construction vehicles and equipment; and (3) Identify and recommend methods for reducing energy use, emissions, and impact.

Establishing Monitoring Programs for Travel Time Reliability (SHRP L-02)

G. List, B. Williams, and N. Rouphail
Transportation Research Board
$1,800,000
03/09 to 03/12

The Institute for Transportation Research and Education (ITRE), in conjunction with Kittelson & Associates, Inc. (KAI), Berkeley Transportation Systems (BTS), the National Institute of Statistical Sciences (NISS), the University of Utah, and Rensselaer Polytechnic Institute (RPI) are partnering in Establishing Monitoring Programs for Travel Time Reliability. As part of the SHRP 2 program, this project focuses on travel time reliability, helping operating agencies develop systems hardware, software, and tactical strategies that enable them to better monitor travel time reliability and convey their findings to their customers and other data users.

Development of Traffic Data Input Resources for the Mechanistic-Empirical Pavement Design Process

Y.R. Kim, G. List, J. Stone, and W. Rasdorf
North Carolina Department of Transportation
$339,030
07/07 to 06/09

The Mechanistic-Empirical Pavement Design Guide for New and Rehabilitated Pavement Structures uses nationally based data traffic inputs and recommends that state DOTs develop their own site-specific and regional values. NCDOT recently completed an implementation plan for adopting the MEPDG, and two of the critical implementation recommendations addressed new data collection requirements for site-specific truck classification counts, truck axle load spectra, regional average seasonal adjustment factors, and forecasting methods for axle loads, as well as truck class volumes. This research project addresses these NCDOT traffic data and forecasting needs for implementing the MEPDG.

Torsional Strengthening of Concrete Structures Using Near Surface Mounted Fiber Reinforced Polymers Australian Research Council

R. Al-Mahaidi (Monash University) and S. Rizkalla
$1,540,818
07/07 to 07/10

The proposed study focuses on the torsional strengthening of concrete flexural members in bridges and buildings using Fiber Reinforced Polymers (FRP). Since the mid 1980s, a significant number of studies on flexural and shear strengthening of beams and axial strengthening of columns have been performed. The area of torsional strengthening has received little attention and thus no reliable data exists to enable the incorporation of the topic in design guidelines. The proposed study will fill the gap that currently exists in the FRP strengthening of RC structures. It will also provide the engineering community with analytical tools for the design of FRPs in torsional strengthening applications.

Developing a Telematics Platform for Bridge Monitoring and Health Prognositcs

S. Rizkalla
National Science Foundation (Supplement to RB²C Center)
$100,000
07/07 to 06/09

The approach proposed in this TIE project integrates the extensive research on physics of bridge damages and instrumentation of bridge monitoring system, conducted at the RB²C Center, with the feature-based smart prognostic agent, namely the Watchdog Agent® developed by the IMS Center, to accurately quantify and predict bridge deterioration. The major merit of this work will be the initiation of a combined physics-statistics-based prognostics approach, which expands and integrates the theories and tools developed in RB2C and IMS. The developed methodology will bring about innovation to predict bridge deterioration and provide a general framework for prognostic bridge health management for next-generation intelligent transportation maintenance systems.

Strengthening In-Fill Brick Walls with Composite

S. Rizkalla
E. Fyfe Company
$89,000
07/07 to 06/09

This research is designed to examine the effectiveness of various strengthening techniques for In-fill brick walls using glass fiber reinforced polymer material. The experimental progress consists of fourteen full-scale In-fill brick wall unites subjected to uniform pressure to simulate the pressure and extreme wind loading conditions. Various constraints and anchorage systems were included.

I/UCRC Center, "Repair of Buildings and Bridges with Composites (RB²C)" – Three Year Extension

S. Rizkalla
National Science Foundation
$90,000
08/07 to 08/10

The NSF Industry/University Cooperative Research Center entitled "Repair of Buildings and Bridges with Composites" (RB²C), is located at the Constructed Facilities Laboratory, North Carolina State University (NCSU). The Center is working in collaboration with the Center located at the University of Miami, Florida. The Center at NCSU focuses on the needs of the construction industry in development of new and innovative structural components as well as strengthening/repair methods for existing structures using advanced composite materials.

GEOTECHNICAL/GEOENVIRONMENTAL ENGINEERING

Development of a Design Tool for Planning Aqueous Amendment Injection Systems

Environmental Security Technology Certification Program
R. C. Borden (NCSU), G. Mahinthakumar (NCSU) T. J. Simpkin (CH2M HILL) and C. Zawtocki (Solutions-IES)
$503,000
03/06 to 12/10

The overall objective of this project is to develop a set of tools to assist design engineers in developing effective, reasonably efficient systems for distributing aqueous amendments for in situ treatment of groundwater contaminants. At this time, the primary applications for the tools will be for design of in situ chemical oxidation systems using permanganate and in situ anaerobic bioremediation systems using soluble substrates and emulsified oil. However, as technology evolves, this general approach should be applicable to distribution of other aqueous amendments.

Enhanced Anaerobic Bioremediation using Soy Flour, Soy Protein Concentrate, and Lecithin

United Soybean Board (through Smith, Bucklin & Associates, LLC)
R. C. Borden
$60,000
09/08 to 08/09

We have been studying the use of emulsified soybean oil for soil and groundwater remediation for several years. This research has dramatically improved our understanding of how soybean oil is distributed in the subsurface and how it stimulates pollutant biodegradation. In this project, we will evaluate the use of soy flour, soy protein concentrate, and lecithin as alternative materials for production of an emulsified soybean oil product for anaerobic bioremediation.

Anaerobic Biotreatment of Acid Mine Drainage at Ore Knob Mine

R.C. Borden
NC Department of Environment and Natural Resources
$153,194
08/05 to 07/08

Ore Knob Branch and Peak Creek are impaired due to discharge of acid mine drainage (AMD) from an abandoned copper/zinc mine. AMD production from the large tailings impoundment will be controlled by injecting emulsified soybean oil into the sediments to stimulate growth of naturally occurring bacteria. These bacteria will then use the soybean oil as a food source, consuming any dissolved oxygen and stopping further AMD production. Once oxygen is depleted, the sulfate reducing bacteria will reduce sulfuric acid to sulfide and precipitating heavy metals.

Impacts of Sampling and Handling Procedures on DNA- and RNA-based Microbial Characterization and Quantification of Groundwater and Saturated Soil

F.L. de los Reyes III and R.C. Borden
Strategic Environmental Research and Development Program
$487,955
03/07 to 06/09

The overall objective of this project is to determine the relationships of sample processing procedures to the effectiveness and efficiency of three molecular techniques used in qualitative and quantitative analysis of microbial populations in groundwater and associated saturated soil samples.

Engineering to Enhance the Resilience of the Built and Natural Environments

R. Leuttich (UNC-CH), M. Overton, G.F. List, R. Seracino, M. Gabr, R. Ranjithan, D. Brill, J. Baugh
Department of Homeland Security, Center of Excellence
$2,593,890
08/08 to 07/14

The objective is to investigate innovative and proactive approaches to plan, design and construct CCI components to provide services needed to increase disaster preparedness and resilience of the integrated CCI system, as well as to protect the natural environment. To achieve this goal, five highly interrelated research projects are being proposed. Each project has a project leader and anticipated partners; however, the projects are proposed as complementary pieces contributing products to be used to meet the overarching objective to enhance the resilience of the built and natural environment, a single objective. As such, project leaders will work together to coordinate efforts, align case studies, transfer outcomes, develop scenarios, etc. toward a highly integrated product.

Investigation of Highway Asset Inventory and Data Collection Methods

NC Department of Transportation
R. Kim, J. Hummer, M. Gabr, D. Johnston
$200,670
04/01 to 12/08

The North Carolina Department of Transportation (NCDOT) is co-hosting a National Workshop on Highway Asset Inventory and Data Collection in September 2008. Four infrastructure elements have been identified as the focal areas for the workshop: 1) pavements, 2) bridges, 3) geotechnical features and drainage, and 4) roadside appurtenances. To evaluate the accuracy of various asset data collection technologies, vendors for these technologies will be invited and will test selected test sections. Research is needed to develop an experimental design for the vendor testing, to perform ground truth testing of the test sections, and to analyze the data from vendors to compare against the ground truth measurements.

Field Verification of Undercut Criteria and Alternatives for Subgrade Stabilization

M.A. Gabr and R.H. Borden
NCDOT
$64,000
04/09 to 04/10

The proposed plan encompasses field instrumentation of three test pads; one with the implementation of undercutting and replacement with quality fill, a second includes undercutting in conjunction with the use of geosynthetics, and a third includes chemical stabilization. Each test location will include a control section in addition to the test pad with the specified stabilization measure. The field data will be used to perform a comparative cost analysis to illustrate the relative cost of each measure such that an informed decision on cost-effective subgrade stabilization can be made.

Development of Undercut Criteria and Alternatives for Subgrade Stabilization

M. Gabr and R.H. Borden
NC Department of Transportation
$266,000
08/07 to 06/09

The main objective of the proposed project is to develop undercut criteria for different site conditions and provide tools for identifying depth of undercut, as well as alternative or supplemental approaches to improving soil bearing properties and workability. The approach to be developed will be supplemented with the use of expedient in situ probing technique, such as shear vane or Dynamic Cone Penetromenter (DCP), which are currently used by NCDOT but not necessarily to define undercut criteria. The research work will encompass laboratory and field work as well as modeling and analysis of data

STRUCTURAL ENGINEERING AND MECHANICS

Calibration of Rutting Models for HMA Structural and Mix Design

Y.R. Kim and M.N. Guddati
NCHRP 9-30A, Subcontract from Applied Research Associates, Inc.
$70,000
11/05 to 10/08

The objective of this research effort is to recommend revisions to the HMA rut depth prediction model in the mechanistic-empirical pavement design guide and software developed in NCHRP Project 1-37A for consideration by the NCHRP Project 1-40 panel and the AASHTO Joint Task Force on Pavements. The recommended revisions will be based on the calibration and validation of distress models with measured materials properties and performance data from existing field and other full-scale pavement sections that incorporate modified as well as unmodified asphalt binders.

Parameter Determination for Chaboche Model in ANSYS Finite Element Software Package for Two Materials

Tasnim Hassan
Honeywell International, Inc.
$24, 871
11/07 to 08/09

Honeywell Aerospace of the Honeywell International is attempting to develop design methodology for turbine or compressor disk that is successively taken to higher and higher strains in a spin test (through higher and higher rotational speeds) until the disk bursts. The ratcheting mechanism is involved in this progressive failure. However, the ratcheting mechanisms of the involved materials, PM Astroloy and forged Ti-6-4, are not known. In addition, the parameters of the Chaboche model which will be used in the finite element analysis for design development are not known. Through this project a set of experimental responses (experiments to be conducted by Honeywell Aerospace) and Chaboche model parameters for structural analysis will be developed.

A Multiscale Study of Ratcheting Failure Mechanisms in Austenitic and Ferritic Steel Welded Joints

Tasnim Hassan and K.L. Murty
National Science Foundation
$319,000 ($7,500 supplementary REU grant for 2006-08)
08/04 to 01/09

The goal of the project is to study multiscale failure mechanisms of austenitic and ferritic steel welded joints subjected to low-cycle fatigue loading. The progressive accumulation of strain with cycle known as ratcheting is believed to result in unexpected failures of defect-free joints. This project will perform low-cycle fatigue tests of welded joints and transmission and scanning electronic microscopy studies of dislocation substructures of the heat affected zone and base metals at various stages of fatigue life. Efforts will be made to develop a model for simulating ratcheting responses of welded joints using both macroscale and multiscale based constitutive models.

SST: Polymer Waveguide Sensors for Performance-Based Assessment and Health Monitoring of Civil Infrastructure Systems

Tasnim Hassan, M.J. Kowalsky and K. Peters
National Science Foundation
$430,000 + $22,000 supplementary REU grant in 2004-2008
08/04 to 07/08

The goal of the project is to develop polymer sensors for health monitoring of civil infrastructure systems. Of specific interest is to develop a sensor that can measure strains in excess of 6% under high strain rates. Although the sensors to be developed can be utilized under a variety of load conditions and structural materials, this research program will focus on application of the sensors to concrete and steel structures subjected to earthquakes loads. The research will develop a data acquisition system that can be utilized in health monitoring and techniques for bonding the polymer sensors to concrete structures.

Hot Mix Asphalt Performance-Related Specifications Based on Viscoelastoplastic Continuum Damage Models

Y.R. Kim and M.N. Guddati
DTFH61-08-H-00005, Federal Highway Administration
$2,142,401
02/08 to 02/12

Models developed at NCSU over the years provide a unique opportunity to develop a mechanistic Performance-Related Specification (PRS) for hot mix asphalt (HMA) mixtures. This project will focus on development of different analytical and experimental tools that can be used for the development of the HMA-PRS. The HMA-PRS will be hierarchical in nature; that is, a higher level specification uses more complete and accurate test and analysis methods, which requires more sophisticated testing.

Multiscale Modeling of Asphalt Concrete for Fatigue Cracking Evaluation

Y.R. Kim and M.N. Guddati
Texas A&M Research Foundation/FHWA
$466,000
12/06 to 11/11

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.

Development of a Seismic Fragility Methodology for Nuclear Power Plant Structures

Marty McCann Jr. (Stanford University), **Abhinav Gupta** *(NCSU), and Jack Baker (Stanford University)*
Kajima Corporation of Japan through CUREE/Kajima Partnership
$57,687
2009-2011

The purpose of this study is to develop and implement a generalized seismic fragility methodology for structural components and systems. The study will develop an approach that provides a closer integration of the characterization of earthquake ground motions and the performance of critical facilities. This research is aimed at developing an approach that takes advantage of Kajima structural analysis capabilities and integrates an improved characterization of earthquake ground motions with a detailed reliability analysis of structure performance. The work is being conducted jointly by a multi-institutional team of researchers from NC State University, Stanford University, and Kajima Corporation of Japan.

NEESR-GC: Simulation of the Seismic Performance of Nonstructural Systems

A. Gupta and M. Margakis (University of Nevada, Reno); other participating institutions: SUNY-Buffalo, UC-San Diego, Cornell, GA-Tech, NC A&T, and UNC-Chapel Hill (Project Managed by: CUREE)
$212,000 (NCSU); $194,000 (NSF); $18,000 (NCSU Graduate School via AGEP program-NSF)
2007 to 2012

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.

Load Combination Method and Analytical Methodology for IRWST and Other Dynamic Loads in Piping Analysis

A. Gupta
Korea Power Electric Company, KOPEC, South Korea
$16,000
2008

This project is aimed at providing technical knowledge on state-of-the-practice for combining various dynamic loads such as those due to Earthquake, Loss of Coolant Accident (LOCA), and Safety Relief Valves (SRV) in a nuclear power plant piping system analysis. This work has different aspects that relate to: (a) Providing background information on the currently specified load combination procedures in USNRC recommended and ASME recommended guidelines, (b) Theoretical basis for various recommendations, and (c) Train KOPEC engineers on incorporating appropriate load combination methods in an actual piping analysis and assist them with interpreting the results.

Effect of Load History on the Seismic Performance of RC Members' Alaska DOT

M. J. Kowalsky and J.M. Nau
$225,000 + $50,000 for Test Specimens
08/08 to 07/11

There are two related problems in this research via large scale experimental testing and fiber-based and solid-element based analysis. Most well detailed modern reinforced concrete sections fail by buckling of reinforcement. 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. There is a need to propose strain limit states that account for low temperature effects and regional seismic load histories, and develop an approach for AKDOT engineers to easily relate proposed strain limits to target displacements for design.

Seismic Performance of Spirally Welded Pipe Piles

M. Kowalsky and Tasnim Hassan
Skyline Steel Corporation
$307,000
04/07 to 07/09

Spirally welded pipe piles are manufactured in a manner that may result in various categories of welded joints any of which at or near the plastic hinge zone of a pile may determine its seismic performance. The location of the plastic hinge zone in the ground will depend on the stiffness of the soil, ground temperature, and pile diameter. This project will conduct experiments to determine the load-displacement responses under the AISC 341 load protocol, Appendix S, as well as to determine failure mechanisms for these three welds located at the plastic hinge of the pile.

Ductility of Welded Steel Column to Cap-Beam Connections

M. Kowalsky, Tasnim Hassan, and J.M. Nau
Alaska Department of Transportation
$210,000
08/07 to 07/09

This research will assess the ductility of a commonly used steel pipe-column to steel cap-beam connection used in Alaska for bridge and dock structures. The final goal is to develop recommendations for ductility capacity of the existing connection detail and for an alternative detail capable of sustaining the design ductility level while allowing for inspection. Recommendations will be provided for both current force-based design as provided in the 2004 AASHTO LRFD specifications (force reduction factors, ductility limits, displacement amplification factors) as well as for displacement-based design (target displacements and equivalent damping) as is being developed for future AASHTO bridge specifications.

Modeling the Impact and Blast Performance of Fiber Reinforced Concrete

V.C. Matzen and Abhinav Gupta
Idaho National Laboratory
$25,000 per year (annual renewal)
2006 to 2009

This study is aimed at providing an experiment-based application for the blast/impact software investigation to be carried out at INL. An active research collaboration between INL and the Center for Nuclear Power Plant Structures, Equipment and Piping at NCSU is proposed. The collaboration will provide NCSU personnel an access to the advanced finite element software available at INL to model the structural performance of FRC. Simple experiments on FRC structural members will be conducted at NCSU for reconciliation of analytical and experimental results. The purpose would be to help in the development of new FRC material to withstand impact and blast loads.

Procedures for Multi Hazard Risk Assessment in Civil Infrastructure Systems

R. Ranjithan, D. Brill, J. Baugh, Mo Gabr, M. Overton, and R. Seracino
$19,813
05/08 to 12/10

The pilot project will develop an outline of a multihazard risk assessment methodology associated with floods and levees. It will also identify model requirements and data needs. This work will serve as a prototype for future work to develop a more comprehensive methodology for considering a broader range of natural hazards and civil infrastructure.

Engineering to Enhance the Resilience of the Built and Natural Environments

R. Leuttich (UNC-CH), M. Overton, G.F. List, R. Seracino, M. Gabr, R. Ranjithan, D. Brill, and J. Baugh
Department of Homeland Security, Center of Excellence
$2,593,890
08/08 to 07/14

The objective is to investigate innovative and proactive approaches to plan, design and construct CCI components to provide services needed to increase disaster preparedness and resilience of the integrated CCI system, as well as to protect the natural environment. To achieve this goal, five highly interrelated research projects are being proposed. Each project has a project leader and anticipated partners; however, the projects are proposed as complementary pieces contributing products to be used to meet the overarching objective to enhance the resilience of the built and natural environment, a single objective. As such, project leaders will work together to coordinate efforts, align case studies, transfer outcomes, develop scenarios, etc. toward a highly integrated product.

I/UCRC Center, "Repair of Buildings and Bridges with Composites (RB^{2}C)" – Three Year Extension

S. Rizkalla
National Science Foundation
$90,000
08/07 to 08/10

The NSF Industry/University Cooperative Research Center entitled "Repair of Buildings and Bridges with Composites" (RB^{2}C), is located at the Constructed Facilities Laboratory, North Carolina State University (NCSU). The Center is working in collaboration with the Center located at the University of Miami, Florida. The Center at NCSU focuses on the needs of the construction industry in development of new and innovative structural components as well as strengthening/repair methods for existing structures using advanced composite materials.

Torsional Strengthening of Concrete Structures Using Near Surface Mounted Fiber Reinforced Polymers Australian Research Council

R. Al-Mahaidi (Monash University) and S. Rizkalla
$1,540,818
07/07 to 07/10

The proposed study focuses on the torsional strengthening of concrete flexural members in bridges and buildings using Fiber Reinforced Polymers (FRP). Since the mid 1980s, a significant number of studies on flexural and shear strengthening of beams and axial strengthening of columns have been performed. The area of torsional strengthening has received little attention and thus no reliable data exists to enable the incorporation of the topic in design guidelines. The proposed study will fill the gap that currently exists in the FRP strengthening of RC structures. It will also provide the engineering community with analytical tools for the design of FRPs in torsional strengthening applications.

Evaluation of Bond Characteristics of MMFX Steel

S. Rizkalla
NSF – I/UCRC - RB^{2}C - MMFX Technologies Corporation
$183,333
07/05 to 12/09

The high-strength steel commercially known as Micro-composite Multi-structural formable (MMFX) steel could lead to potential savings through the use of lower reinforcement ratios due to it's higher strength. The proposed research will investigate the bond behavior of MMFX steel to concrete. The first phase of the proposed research program will include the parameters believed to significantly affect the bond strength: concrete compressive strength, bar size, concrete clear cover, and confinement level. Three universities are participating in this study, namely, University of Texas at Austin, The University of Kansas, and North Carolina State University. Each university will test twenty-two full-scale splice beams for the first phase of the program.

Development of Rational Design Methodology for Precast, Prestressed Concrete Spandrel Beams

S. Rizkalla and P. Zia
NSF - I/UCRC - RB^{2}C – Precast/Prestressed Concrete Institute
$170,000
07/06 to 06/09

The goal of the proposed research is to develop appropriate design procedures and to simplify the detailing requirements for precast, L-shaped spandrel beams. The research includes an extensive experimental program designed to test prototype precast L shaped spandrel beams and an analytical phase based on non-linear finite element techniques.

Developing a Telematics Platform for Bridge Monitoring and Health Prognositcs

S. Rizkalla
National Science Foundation (Supplement to RB^{2}C Center)
$100,000
07/07 to 06/09

The approach proposed in this TIE project integrates the extensive research on physics of bridge damages and instrumentation of bridge monitoring system, conducted at the RB2C Center, with the feature-based smart prognostic agent, namely the Watchdog Agent® developed by the IMS Center, to accurately quantify and predict bridge deterioration. The major merit of this work will be the initiation of a combined physics-statistics-based prognostics approach, which expands and integrates the theories and tools developed in RB2C and IMS. The developed methodology will bring about innovation to predict bridge deterioration and provide a general framework for prognostic bridge health management for next-generation intelligent transportation maintenance systems.

Basalt Fiber Reinforced Cementitious Matrix Composites for Infrastructure Repair

S. Rizkalla
National Science Foundation (Supplement to RB^{2}C Center)
$50,000
07/07 to 06/09

The project focuses on the strengthening and upgrade of existing reinforced concrete (RC) structures using a new class of composites made of basalt fibers embedded in a cement-based matrix (BFRC). Basalt fibers are manufactured in a single-stage process by melting naturally occurring basalt rock. The BFRC confining system represents a promising solution to overcome limitations of current fiber-reinforced-

polymer (FRP) systems that make use of carbon or glass fibers impregnated with an epoxy resin. The research will first study the mechanical and durability performance of commercial grade basalt fibers and then of the system obtained by combining them with the cementitious matrix.

Strengthening In-Fill Brick Walls with Composite

S. Rizkalla
E. Fyfe Company
$89,000
07/07 to 06/09

This research is designed to examine the effectiveness of various strengthening techniques for In-fill brick walls using glass fiber reinforced polymer material. The experimental progress consists of fourteen full-scale In-fill brick wall unites subjected to uniform pressure to simulate the pressure and extreme wind loading conditions. Various constraints and anchorage systems were included.

Behavior of Concrete Sandwich Panels Reinforced with CFRP Grid

S. Rizkalla
AltusGroup
$47,000
08/06 to 07/08

The objective of the study is to determine the behavior of prestressed concrete sandwich panels under the effect of gravity and simulated wind loading conditions. The panels are reinforced transversely by a new innovative carbon fiber reinforced polymer to achieve composite action under the combined gravity and wind load. The research consists of an experimental program which included testing of six full-scale sandwich panels varying from 20 to 40 feet. All panels will be tested under fatigue and monotonic loading conditions to failure.

TRANSPORTATION SYSTEMS AND MATERIALS

Development and Evaluation of Methodological Framework for Real-World Vehicle Energy Use and Emissions Estimation at Multiple Temporal and Vehicular Scales

H.C. Frey and N.M. Rouphail
National Science Foundation
$299,985
05/08 to 05/11

Vehicle Fuel Use and Emissions (FU&E) have substantial national energy and environmental implications, but are confounded by intra/inter-vehicle variability and, therefore, require scientific inquiry to develop an improved basis for their characterization and management. The main objectives of this research are to: (1) quantify intra-vehicle variability in FU&E due to inter-driver variability, cold start, ambient conditions, and road grades; (2) develop FU&E models based on multiple levels of vehicle aggregation and multiple temporal scales; and (3) evaluate the interface of these models with transportation models and for use with real-time vehicle detection.

In-Vehicle Energy and Emissions Information System (IVEEIS)

H.C. Frey and N.M. Rouphail
National Science Foundation
$299,997
01/03 to 12/08

The key objectives of this research project are to (1) develop a micro-scale predictor of energy use and emissions that is deployable at the individual vehicle level in real-time; (2) identify, compare, and evaluate alternate energy use and emissions sampling/reporting schemes that are appropriate at the vehicle and network levels; (3) develop and test a prototype In-Vehicle Energy and Emissions Information System (IVEEIS); and (4) formulate and assess the utility of IVEEIS in developing transportation design and control measures aimed at energy and emission management policies.

Procedure for Curve Warning Signing, Delineation, and Advisory Speeds for Horizontal Curves

J.E. Hummer

North Carolina Department of Transportation
$195,839
08/08 to 08/10

The project will develop a consistent study process that NCDOT personnel should follow when deciding upon the right mix of devices to control horizontal curves. After synthesizing the guidance from the literature and cataloging the practices of the NCDOT, we will develop a set of potential new study methods. The research team intends to examine GIS, database management systems, inventories, and widely-available aerial photos. A new study method for deciding on curve devices can have applications in several places in the NCDOT and can be applied in a proactive manner to all curves

Superstreet Benefits and Capacities

J.E. Hummer
North Carolina Department of Transportation
$223,113
08/08 to 05/10

Superstreets are relatively new designs for arterial streets that involve rerouting certain minor street movements. They have the potential to provide lower delay, lower collision rates, and other benefits in places where conventional improvement alternatives are infeasible. This project will investigate the safety and capacity effects of the 15 or so superstreets that have been installed in North Carolina in recent years. The project will also develop a procedure to allow engineers to estimate the level of service provided by a superstreet in the design stages. If project results are positive, superstreets may become standard features of the urban landscape.

Pavement Marking Performance Analysis

J.E. Hummer and W. Rasdorf
NC Department of Transportation
$174,876
7/07 to 06/09

With an investment of $1 million after five years of data collection, the NCDOT requested that NCSU develop a pavement markings research plan in order to analyze relationships between pavement marking retroreflectivity values and variables such as marking color, marking age, pavement

surface, and AADT. Understanding retroreflectivity performance over time is important to establishing a pavement marking strategy that maximizes the material's service life and minimizes the replacement of pavement markings that still have sufficient retroreflectivity. Furthermore, this understanding will enable the NCDOT to implement management strategies that achieve the Federal standards for minimum pavement marking retroreflectivity.

Non-Conventional Alternative Intersection Treatments Guide

J.E. Hummer
Vanasse Hangen Brustlin, Inc.
08/06 to 08/08

Heavy traffic flows at intersections present challenges to engineers regarding excessive delays and worsening safety performance. Major side effects also include pollution, wasted fuel, increased stress levels, and economic losses. Several innovative intersection designs that divert left turn movements and reduce signal phases have been studied by researchers and implemented by users, including continuous flow intersections, median u-turns, and superstreets. This study sponsored by the FHWA is to develop an informational guide for those designs that includes a design selection procedure, coverage on operational issues, geometric design considerations, pedestrian accommodations, safety estimations, cost assessments, and marketing materials.

Procedure for Curve Warning Signing, Delineation, and Advisory Speeds for Horizontal Curves

J. Hummer, W. Rasdorf, and C.V. Zegeer
North Carolina Department of Transportation
$195,839
08/08 to 08/10

This project will meet the NCDOT's need for a consistent process in the application of traffic control devices on horizontal curves. It will develop a consistent study process that NCDOT field personnel should follow when deciding upon the right mix of devices. After synthesizing the guidance from the literature and cataloging the practices of the NCDOT, we will develop a set of potential new study methods. The research team intends to utilize GIS, database management systems, inventories, and widely-available aerial photos in this project. A new study method for deciding on curve devices can have applications in several places in the NCDOT. Eventually, a new study method for curve warnings can be applied in a proactive manner to all curves on all roads.

Validation of APA Design Critera for Field Surface Mixtures

N.P. Khosla
NC Department of Transportation/FHWA
$131,379
08/04 to 12/09

Premature rutting of asphalt pavements is a serious concern experienced in recent years due to the increased traffic and wheel loads. Therefore, it is important to estimate the rutting potential of a mixture before construction. Several test methods are in practice to assess the rutting potential of a mixture. Of the different laboratory rut testers, the Asphalt Pavement Analyzer (APA) is the most widely used loaded wheel tester. Using the correlations between the results of APA and shear tests, this research project aims to validate and modify the rut depth criteria developed in the earlier project, by incorporating the test results of field surface mixtures.

Effect of the Use of Higher Percentages of RAP in NCDOT Hot Mix Asphalt

N.P. Khosla
NCDOT/FHWA
$235,554
07/07 to 06/09

The recycling of asphalt pavements has become a very routine procedure throughout the country. The use of higher percentages of RAP in construction would provide initial cost savings. However, a life cycle cost analysis is needed in order to determine whether use of higher percentages of RAP provides an economical advantage for the life cycle. In order to predict life cycle costs, the fatigue life and rut resistance of mixtures containing various amounts of RAP will be calculated from laboratory testing using the Simple Shear Tester (SST). Based on these results, the life cycle economic analysis can be completed and the optimum percentage of RAP can be determined.

Determining HMA Mix Design Methodologies for Predicting Fatigue Rutting Using Tensile Strength Testing

N.P. Khosla
NC Department of Transportation/FHWA
$229,041
07/07 to 06/09

During its lifetime, an asphalt concrete layer is subjected to many distress mechanisms: rutting, fatigue cracking, temperature cracking and moisture induced damage. Moisture damage of asphalt mixes, better known as stripping, is one of the major distresses affecting pavement performance. Since there is no strength criterion prescribed in the design of Superpave mixtures, an optimized value of tensile strength can be used as a good criterion in design of Superpave mixtures. This project aims at developing a mix design methodology using tensile strength testing of various asphalt mixtures as well as the correlations among the tensile strength and performance parameters of mixtures (fatigue and rutting).

An Investigation of the Effect of N_{design} Values on Performance of Superpave Mixtures

N.P. Khosla
NCDOT/FHWA
$357,141
08/09 to 08/12

The ultimate goal of a mix design is to have a mix that performs adequately in the field. The volumetric properties of a mix are very sensitive to the N_{design} values. Therefore, a detailed study is needed to find which compaction level in the mix design process produces an appropriate compaction effort for field conditions. In this regard, a reduction in N_{design} values is needed in the NCDOT mix design criteria. However, this decision will be made on scientific basis and a thorough evaluation of fatigue and rutting evaluation of our materials and mixtures.

Development of a Field Testing System for Asphalt Surface Treatments

Y. Kim
NCDOT
$282,072
08/08 to 08/10

This research will attempt to develop a field asphalt surface treatment (AST) test method based on the findings from AST research projects undertaken at North Carolina State University (NCSU). The benefits of reliable, performance-based in situ test methods for ASTs are enormous and include: (a) evaluation of the likely performance of newly constructed ASTs; (b) identification of practices that lead to poor performance and correction of deficiencies before serious AST performance problems occur; (c) verification of the performance-based design of ASTs, selection of materials, and determination of the best AST construction practices; and (d) improved operational efficiency and performance of the North Carolina AST program.

Hot Mix Asphalt Performance-Related Specifications Based on Viscoelastoplastic Continuum Damage Models

Y.R. Kim and M.N. Guddati
DTFH61-08-H-00005, Federal Highway Administration
$2,142,401
02/08 to 02/12

Models developed at NCSU over the years provide a unique opportunity to develop a mechanistic Performance-Related Specification (PRS) for hot mix asphalt (HMA) mixtures. This project will focus on development of different analytical and experimental tools that can be used for the development of the HMA-PRS. The HMA-PRS will be hierarchical in nature; that is, a higher level specification uses more complete and accurate test and analysis methods, which requires more sophisticated testing.

Multiscale Modeling of Asphalt Concrete for Fatigue Cracking Evaluation

Y.R. Kim and M.N. Guddati
Texas A&M Research Foundation / FHWA
$466,000
12/06 to 11/11

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.

Comprehensive Performance Evaluation of Polymer Modified Hot Mix Asphalt Mixtures

Y.R. Kim and R.H. Borden
Korea Kumho Petrochemical Co., Ltd.
$24,924
10/06 to 10/08

With the goal of accurate pavement performance evaluation, the PI and his co-workers at NCSU have been developing advanced models for hot-mix asphalt (HMA) mixtures under complex loading conditons. Over the past decade, they have been successful in developing material models that can accurately capture various critical phenomena such as: microcrack induced damage this is critical for fatigue modeling; strain rate-temperature interdependence; and viscoplastic flow that is critical for rutting evaluation The resulting model is termed the viscoelastoplastic continuum damage (VEPCD) model.

Investigation of Highway Asset Inventory and Data Collection Methods

Y. Kim and J.E. Hummer
North Carolina Department of Transportation
$200,670
04/08 to 12/08

The technologies available to collect data on highway assets have advanced rapidly in recent years. The NCDOT and FHWA hosted a national expo in September 2008 to showcase the technologies. The project team helped organize the event, lining up speakers and exhibitors. A major part of the effort was in evaluating the accuracy of the data collected by vans driving test sections of highway. This part of the project team evaluated data pertaining to the roadway surface and the roadside. The experiment showed that vans generally provide good quality data, although the quality varies depending upon the particular variable.

Top-Down Fatigue Cracking of Hot-Mix Asphalt Layers

Y.R. Kim & M.N. Guddati
NCHRP 1-42A, Subcontract from University of Florida
$120,000
06/06 to 05/09

In this research, the viscoelastic continuum damage model implemented in the finite element program (VECD-FEP++) will be used to investigate the top-down fatigue cracking mechanism in hot-mix asphalt pavements. The VECD model and the dynamic modulus from the IDT test will serve as the primary experimental tools. The resulting VECD-FEP++ will be used to simulate the behavior of asphalt pavements with varying loading, environmental, and pavement factors. The results from the simulation will be investigated to develop mechanistic procedures to evaluate the top-down cracking propensity of asphalt pavement as a function of various factors and to predict the top-down cracking performance of asphalt pavement.

Calibration of Rutting Models for HMA Structural and Mix Design

Y.R. Kim and M.N. Guddati
NCHRP 9-30A, Subcontract from Applied Research Associates, Inc.
$70,000
11/05 to 10/08

The objective of this research effort is to recommend revisions to the HMA rut depth prediction model in the mechanistic-empirical pavement design guide and software developed in NCHRP Project 1-37A for consideration by the NCHRP Project 1-40 panel and the AASHTO Joint Task Force on Pavements. The recommended revisions will be based on the calibration and validation of distress models with measured materials properties and performance data from existing field and other full-scale pavement sections that incorporate modified as well as unmodified asphalt binders.

Engineering to Enhance the Resilience of the Built and Natural Environments

R. Leuttich (UNC-CH), M. Overton, G.F. List, R. Seracino, M. Gabr, R. Ranjithan, D. Brill, J. Baugh
Department of Homeland Security, Center of Excellence
$2,593,890
08/08 to 07/14

The objective is to investigate innovative and proactive approaches to plan, design and construct CCI components to provide services needed to increase disaster preparedness and resilience of the integrated CCI system, as well as to protect the natural environment. To achieve this goal, five highly interrelated research projects are being proposed. Each project has a project leader and anticipated partners; however, the projects are proposed as complementary pieces contributing products to be used to meet the overarching objective to enhance the resilience of the built and natural environment, a single objective. As such, project leaders will work together to coordinate efforts, align case studies, transfer outcomes, develop scenarios, etc. toward a highly integrated product.

Guidelines on the Use of Auxiliary Through Lanes at Signalized Intersections

N.M. Rouphail and J.E. Hummer
National Cooperative Highway Research Program 3-98 (through a subcontract to Kittelson and Associates, Inc.)
$175,175
03/09 to 02/11

Auxiliary through lanes—added just prior to an intersection and dropped just after—are a promising way to increase capacity where needed without huge financial or environmental impacts. There are several challenges that must be overcome before such treatments are widespread, however. To meet those challenges, the project team will develop models to predict utilization of auxiliary through lanes by drivers, examine the effects of the lanes on signal timing, develop delay equations, and examine the safety implications of the lanes. The final product will be guidelines for designers considering such installations in the US and elsewhere.

Wireless Electronic Toll and Traffic Management

G.F. List
Region II University Transportation Research Center
$110,000
10/05 - present

This project, originally started at Rensselaer in conjunction with W. Wallace, is focused on advancing the state-of-the-art in technology that allows transportation system managers to observe the performance of their systems. Several wireless, solar-powered E-ZPassSM tag readers have been installed in Rensselaer County east of Albany. The units are being tested for their ability to detect passing traffic and operate under widely varying weather conditions.

Incident Management for Safe, Secure and Productive Transportation Systems

G.F. List
Region II University Transportation Research Center
$40,000
10/05 - present

This project, originally started at Rensselaer in conjunction with W. Wallace, is focused on assessment of incident management systems that are designed for and can be deployed by medium-sized regions comparable to the Albany area. The study works closely with the New York State Thruway Authority and the New York State Police to develop case studies in incident management. This includes review of operating plans and procedures and the how these agencies integrate their operations across multiple regional dispatch and traffic management centers.

North Carolina Statewide Logistics Plan

G.F. List, R. Foyle (ITRE), J.E. Hummer, J. Stone, and B. Williams
NC Office of State Budget and Management
$707,450 at ITRE ($198,012 to NC State)
01/08 to 12/08

This project, sponsored by the North Carolina State Office of Budget and Management, developed a statewide freight logistics plan for North Carolina. Co-contributors were J. Cameron and H. Canipe (Transtech) and Erik Stomberg (Hatch Mott MacDonald). Most importantly, the plan suggests legislative and regulatory actions to enable North Carolina to be more pro-active in facilitating commercial enterprises, goods movement and economic prosperity. It recommends creation of a freight logistics authority reporting to the governor that has bonding ability and an empowerment to make freight-related infrastructure investment decisions. It also recommends bold investments in the freight aspects of the interstate system, intermodal facilities, ports, and air freight through public-private partnerships.

North Carolina Truck Traffic Profiles

G.F. List, J.R. Stone, and B. Mei
NC Department of Transportation
$128,287
07/06 to 12/08

Better trip profiles are needed to understand the extent to which heavy trucks are using the state's various categories of highways, from rural secondary roads to urban interstates. Pavement and bridge engineers need a better sense of truck weights and axle spacings. Investment decision makers and planners need a better picture of truck volumes, trip distances, and weight distributions by highway class and route category. To help meet these needs, this project aims to create better truck trip flow profiles.

LTPP Computed Parameter: Dynamic Modulus

Y.R. Kim
FHWA
09/07 to 06/09
$156,888

The primary objective of this project is to develop estimates of the dynamic modulus (|E*|) of hot mix asphalt (HMA) layers on LTPP test sections following the models used in the Mechanistic-Empirical Pavement Design Guide (M-E PDG), for storage in the LTPP Pavement Performance Database.

Development of a New Chip Seal Mix Design Method

Y.R. Kim
NCDOT
$258,835
07/07 to 06/09

The objective of the proposed research project is to develop a new chip seal mix design method that can be applied to

lightweight aggregate and polymer-modified emulsion as well as to normal aggregate and emulsion, and can be utilized efficiently by field personnel. This design procedure will utilize test methods that are currently under development at North Carolina State University (NCSU) with the objective of measuring important design parameters. The developed design procedure will be verified and calibrated through field experiments.

Performance Based Analysis of Polymer-Modified Emulsions in Asphalt Surface Treatments

Y.R. Kim
NCDOT
$248,097
07/06 to 06/09

This project focuses on the performance evaluation of polymer-modified emulsions in asphalt surface treatments. Limited research and data exist on quantifying the overall performance of polymer-modified surface treatments and associated cost-effectiveness. This project will test the improvement in surface treatment performance resulting from modifying the emulsion with polymers and its cost-effectiveness, in addition to providing baseline performance information about standard surface treatments which will be most valuable in planning maintenance activities. Recommendations will be made on the selection of a proper surface treatment option based on existing pavement distress, traffic volume, and road functionality.

Local Calibration of the MEPDG for Flexible Pavement Design

Y.R. Kim
NC Department of Transportation
$316,756
07/06 to 08/15

The objective of this study is to calibrate the NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide with local data by developing a material database using typical layer materials (HMA and unbound materials) for flexible pavements in North Carolina. The scope of research includes both fatigue cracking and rutting. The primary products of the proposed research are the flexible pavement layer materials performance database and the MEPDG HMA performance model coefficients for typical North Carolina HMA mixtures. An additional product will be an implementation plan with instructions for modifying the MEPDG to incorporate the local coefficients. This plan will shorten the delay between the research and the implementation of the pavement design.

Development of Traffic Data Input Resources for the Mechanistic-Empirical Pavement Design Process

Y.R. Kim, G. List, J. Stone, and W. Rasdorf
North Carolina Department of Transportation
$339,030
07/07 to 06/09

The Mechanistic-Empirical Pavement Design Guide for New and Rehabilitated Pavement Structures uses nationally based data traffic inputs and recommends that state DOTs develop their own site-specific and regional values. NCDOT recently completed an implementation plan for adopting the MEPDG, and two of the critical implementation recommendations addressed new data collection requirements for site-specific truck classification counts, truck axle load spectra, regional average seasonal adjustment factors, and forecasting methods for axle loads, as well as truck class volumes. This research project addresses these NCDOT traffic data and forecasting needs for implementing the MEPDG.

Statewide Logistics Plan for North Carolina

G.F. List and J.E. Hummer
NC Office of State Budget and Management
$198,012
01/08 to 12/08

The objective of the project is to develop a statewide logistics plan that will address North Carolina's long term economic, mobility, and infrastructure needs. The plan will include, but not be limited to, the following components: 1) identification of priority commerce needs, 2) enumeration of transportation infrastructure actions, including multimodal solutions, that will support key industries vital to the State's long term economic growth, 3) endorsement of the plan based on input from State agencies and the private sector regarding those needs and actions, and 4) a timetable to meet any identified needs.

Blind Pedestrian Access to Complex Intersections, Phase II

N. Rouphail
National Institutes of Health
Direct Sponsor: Western Michigan University
$487,000
06/07 to 05/12

Pedestrians who are blind make crossing decisions based on information about predictable patterns of vehicular movement. This information is conveyed by traffic sounds and accessible pedestrian signals. At roundabouts, these strategies do not apply because traffic flows freely and often unpredictably. Pedestrians negotiate roundabouts at crosswalks located about one to three car lengths back from the circulating roadway. Splitter islands (medians) either raised like traditional traffic islands or simply painted on the pavement provide a pedestrian refuge midway through street crossings. This research develops and evaluates methods to improve locating, aligning and crossing of blind pedestrians at roundabouts.

Guidelines for the Use of Auxiliary Through Lanes at Signalized Intersections

Nagui M. Rouphail
Kittleson and Associates
National Academy of Sciences, NCHRP 3-98
$190,575 (total funding $400,000)
03/09 to 02/11

Auxiliary through lanes (ATLs) are applied at signalized intersections to increase intersection and corridor capacity. For the purpose of this project, ATLs are defined as limited length lanes additional to through lanes upstream and downstream of an intersection (per the Request for Proposals for this project), as illustrated in the FHWA's Signalized Intersections: Informational Guide. This project will produce operational and safety analysis methods and design guidelines to assist transportation professionals in the evaluation and design of ATLs.

Ubiquitous Transportation Network Modeling and Simulation

Seoul National University
N. Rouphail
$50,000
10/08 to 08/09

The objectives of this research are to synthesize the state of the art in implementing u-T communication protocols between vehicles (V2V) for traffic operations applications, and to define functional requirements for implementing the u-T communications in a micro simulation environment. The project will also develop and implement the methodology to model network impact of the u-T communications system on the performance of uninterrupted facilities, primarily freeways or expressways. Key performance parameters will investigate the effect on operational measures (compared to a baseline condition) the impact of V2V technology market penetration, network congestion and network connectivity, using a case study application.

National Cooperative Highway Research Program 3-98

Kittelson and Associates, Inc. (subcontract)
N.M. Rouphail and J.E. Hummer
$175,175
03/09 to 02/11

Auxiliary through lanes—added just prior to an intersection and dropped just after—are a promising way to increase capacity where needed without huge financial or environmental impacts. There are several challenges that must be overcome before such treatments are widespread, however. To meet those challenges, the project team will develop models to predict utilization of auxiliary through lanes by drivers, examine the effects of the lanes on signal timing, develop delay equations, and examine the safety implications of the lanes. The final product will be guidelines for designers considering such installations in the US and elsewhere.

Regional Development, Population Trend and Technology Change Impacts on Future Air Pollution Emissions

U.S. Environmental Protection Agency STAR grant via University of North Carolina at Chapel Hill, and Center for Transportation and the Environment
N.M. Rouphail
$238,690
11/04 to 11/08

The research tests the hypothesis that smart-growth development patterns can significantly influence the quantity and location of direct and indirect emissions from mobile sources. The patterns of interest include the type of development and its location. We will develop a general method for exploring the leverage that smart-growth development patterns have on the spatial pattern and quantity of emissions from mobile sources. We will explore scenarios and chart the envelope of the effectiveness of smart growth as a means for reducing emissions. We will determine whether substantial emissions reductions are feasible with forecasts of the market penetration of smart growth.

Understanding the Contributions of Operations, Technology, and Design to Meeting Highway Capacity Needs

N. Rouphail and B. Williams
Strategic Highway Research Program-C05 Project
Transportation Research Board, National Research Council
Modeling component – NCSU/ITRE
Direct Sponsor: Kittleson and Associates
$335,346 (total contract $1M)
01/08 to 01/10

This research quantifies the capacity benefits of operations, design, and technology improvements at the network level. This will provide transportation planners with information and tools to analyze operational improvements and develop guidelines for sustained service rates. The methods will include integration of traffic and performance data from multiple sources and applications of new assessment methods to identify packages of strategies that can substitute for capacity additions. These will combine technological, operational and design approaches that will be validated with independent data. Guidance at the network level for planners and operational managers on how these approaches could be cost-effective will emerge.

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Visions Disabilities

Ron Hughes (ITRE) and Nagui Rouphail
UNC-CH, NCHRP 3-78
$730,000
01/00 to 12/09

The objective of this research is to produce recommendations for geometric designs, traffic control devices, and other treatments that enable pedestrians who are visually impaired to cross roundabouts and channelized turn lanes (CTL's) independently and safely. These recommendations should be suitable for inclusion in transportation-industry practice and policies, including the AASHTO Policy on Geometric Design of Highways and Streets and the FHWA Manual on Uniform Traffic Control Devices. Consideration should be given to the impact of the recommendations on all users of roundabout intersections, including occupants of passenger car and trucks, pedestrians (including pedestrians with vision impairments), and bicycles.

Effect of Gradation on Predicted Performance of Aggregate Base Course

T.M. Evans and A.A. Tayebali
North Carolina Department of Transportation
$82,490
01/08 to 06/09

The primary objectives of this research are to evaluate the effect of aggregate gradation on the mechanical properties of the ABC materials; and to develop numerical model(s) based on the discrete element method (DEM) to predict mechanical properties with changes in gradation. The DEM models will also provide insight into the underlying micromechanics that may contribute to variations in material performance as a function of ABC gradation. It is anticipated that this research study will result in performance-related criteria that can be incorporated into the NCDOT Standard Specifications that are used for acceptance of ABC material for pavement structure.

Assessing Operational, Pricing and Intelligent Transportation System Strategies for the I-40 Corridor using DYNSMART-p

NC Department of Transportation
B. Williams and N.M. Rouphail
$96,061 (year 1 only)
08/08 to 08/10

The Raleigh Durham area in NC experienced tremendous growth in both population (50%) and travel (56%) in the period 1995-05. The I-40 corridor, which encompasses I-40, I-85, I-440, I-540, NC147, and US-70 is already under great strain. This project proposes to deliver a calibrated DYNASMART-P model of the Triangle region that will provide performance assessment capability and can be adapted for use throughout the state. It is envisioned as the first step in a five-year program to bring DYNASMART-P capability to statewide modeling of NC's strategic highway corridors, evacuation modeling of the state's entire coastal region, and detailed program support modeling for each of the state's metropolitan areas and regions.

EPA Truck Anti-Idling Demonstration Project

A. Tazewell (NC Solar Center), H.C. Frey, and J.R. Stone
US Environmental Protection Agency
$90,000
02/06 to 08/08

The objective is to assess potential environmental benefits of heavy-duty diesel freight truck idle reduction technologies installed on trucks in NC. A key goal is to quantify actual grams per gallons emissions with a portable gas analyzer and compare this data with data extrapolated from an on-board data logger and fuel use with and without idle reduction technologies.

WATER RESOURCES AND ENVIRONMENTAL ENGINEERING

Improved Water Resources Sustainability Through Multi-time Scale Forecasting and Adaptive Mulit-purpose Reservoir Management

S. Arumugam and S. Ranjithan
National Science Foundation
$299,963
03/05 to 02/11

This project has three major objectives. The first is to develop an integrated approach to promote sustainable water systems through combined application of both weather information-based near-term streamflow forecasts and climate-based short-term streamflow forecasts. The second objective is to apply and demonstrate the approach for two water supply systems, one experiencing rapid increase in water demand in NC, and another serving multiples uses in Virginia. The third objective is to develop an instructional tool for assessing various water management measures and streamflow forecasts in promoting sustainable water management and to incorporate the tool in undergraduate/graduate curricula at several Universities.

Landfill Gas Management: A Roadmap for EREF Directed Research

M.A. Barlaz and D.R. Reinhart
Environmental Research and Education Foundation
$58,870 (to NCSU)
10/07 to 06/09

The study will develop a roadmap for EREF-directed research to quantify all aspects of landfill gas generation, collection, attenuation, and emissions. Attainment of this objective will require a multi-year, multi-investigator and multi-agency effort. To insure that implementation of this program meets the industry's goals, a plan is essential. In this study we will present a research plan to (1) improve gas generation modeling, (2) optimize gas collection system design, (3) quantify fugitive gas emissions, (4) facilitate landfill odor management, and (5) improve the data available to calculate the carbon footprint of landfills at both the site-specific and national levels.

Predictive Tools for Sustainable Solid Waste Management Using Bioreactor Landfills

M.A. Barlaz and C. H. Benson (Univ. Wisconsin)
National Science Foundation
$306,979 (to NCSU)
02/06 to 01/10

The objective of this proposal is to develop quantitative, field-validated, engineering methods to improve the design and operation of bioreactor landfills. Three thrust areas have been identified where research can directly contribute to improvements in bioreactor technology by reducing cost and increasing predictability: (1) landfill hydrology, (2) solids decomposition, and (3) settlement prediction. A predictive model will be developed that relates moisture, solids decomposition, and waste settlement that will improve the predictability of airspace utilization, the industry's ultimate metric. In all areas, fundamental laboratory-scale studies are tightly coupled to models and field-scale work at bioreactor landfills operated by industrial partners.

Application of Municipal Solid Waste Decision Support Tool to Wake County, North Carolina

M.A. Barlaz and S.R. Ranjithan
U.S. Environmental Protection Agency
$60,000
12/04 to 08/09

The objective of this project is to develop alternatives for the management of municipal solid waste for Wake County, NC. Alternatives will be developed to examine tradeoffs among cost, environmental burdens, resource consumption and landfill diversion using a solid waste management life-cycle inventory model developed by the investigators.

Assessment Landfill Gas Pathway – Laboratory Simulation of Partitioning of Chemical and Biological Contaminants under Anaerobic Decomposition in a Landfill

M.A. Barlaz, D.R.U. Knappe, D.R.U. and F.L. de los Reyes
U.S. Environmental Protection Agency
$700,000
09/04 to 12/09

The overall objectives of this research are to (1) develop and validate a model to predict the behavior of chemical

contaminants in refuse and (2) measure the survival and transport of biological agents in landfills. Experimental work will be conducted with surrogates for selected chemical warfare agents to quantify physical, chemical and biological processes affecting their behavior in landfills. Concurrently, a model describing contaminant fate and transport in landfills will be developed. Molecular probes will be developed for suitable surrogates of biological warfare agents and the probes will be used to measured survival and transport in batch and reactor systems.

Decision Support Tool and Guidance Document for Management of Debris from Incidents of National Significance

M.A. Barlaz, D.R.U. Knappe, and F. de los Reyes
Eastern Research Group
$60,742
9/08 to 12/09

The objective of this research is to develop and confirm a model that describes the behavior of trace organic compounds in a simulated landfill.

North Carolina Landfill Capacity Study

Morton A. Barlaz
North Carolina Solid Waste Association of North America
$15,000
8/08 to 6/09

The objective of this research is to develop a methodology to project the remaining landfill capapcity in North Carolina and to apply the methodology to each of the state's 40 permitted municipal solid waste landfills.

Microbial Community Profiling of Anaerobic Refuse Decomposition: Response to Acidic Conditions, Shock Loads and Moisture Addition

Morton A. Barlaz (Francis de los Reyes will functionally serve as a co-PI in terms of advising the student working on this project)
Waste Management Inc.
$600,907
04/04 to 3/09 (will be extended to 2010 with an additional $100,000)

This research will address the following questions related to landfill bioreactor operation: (1) How do landfills progress from the acid phase of decomposition to a stable methanogenic phase of decomposition and are acid-tolerant or acidophilic methanogens involved? (2) Is the methanogen community that is active during decomposition stable, and if not, is the variability important? (3) What is the effect of shock loads of rapidly degradable substrate on the methanogen community? (4) What is the effect of leachate recycle on a continuous or pulsed basis on the methanogen community?

Hydrogen Production at the Waimanalo Gulch Landfill: A Proposal to Explain Landfill Behavior

Morton A. Barlaz and Francis de los Reyes
Waste Management of Hawaii
$299,980 (includes a $58,968 sub contract to Dr. Roger Babcock at the University of Hawaii)
03/07 to 09/08

The objectives of the research are to (1) develop an understanding of the conditions that are responsible for H_2 production at the Waimanalo Gulch Landfill, (2) characterize microbial populations in samples of refuse excavated from areas that are producing H_2 as well as samples from laboratory-scale reactors to reproduce the H_2 production observed in the field and (3) use the information on microbial populations and reactor performance to propose strategies for the control of H_2 production and excessive temperatures at the landfill. The microbial ecology of the refuse will be characterized by using molecular techniques (TRFLP and 16S rRNA gene sequences).

Study of Landfill Gas as a Pathway for Chemical and Biological Contaminants

US Environmental Protection Agency
M.A. Barlaz, D.R.U. Knappe, and F.L. de los Reyes, F. L.
$700,000
08/04 to 12/09

The objective of this research is to develop information on the behavior of chemical and biological agents in landfills.

Assessment of Environmental Emissions Associated with the Beneficial Reuse of Industrial, Commercial and Agricultural Wastes

M. A. Barlaz and S. Ranjithan
Delaware Solid Waste Authority
$142,976
06/06 to 08/08

The objective of this research is to estimate the environmental benefits of the recycling and reuse of commercial, industrial and agricultural wastes generated in the State of Delaware.

Anaerobic Biotreatment of Acid Mine Drainage at Ore Knob Mine

R.C. Borden
NC Department of Environment and Natural Resources
$153,194
08/05 to 07/08

Ore Knob Branch and Peak Creek are impaired due to discharge of acid mine drainage (AMD) from an abandoned copper/zinc mine. AMD production from the large tailings impoundment will be controlled by injecting emulsified soybean oil into the sediments to stimulate growth of naturally occurring bacteria. These bacteria will then use the soybean oil as a food source, consuming any dissolved oxygen and stopping further AMD production. Once oxygen is depleted, the sulfate reducing bacteria will reduce sulfuric acid to sulfide and precipitating heavy metals.

Development of a Design Tool for Planning Aqueous Amendment Injection Systems

R.C. Borden, G. Mahinthakumar, T.J. Simpkin (CH2M HILL) and C. Zawtocki (Solutions-IES)
DOE, Environmental Security Technology Certification Program
$503,000
03/06 to 12/10

The overall objective of this project is to develop a set of tools to assist design engineers in developing effective, reasonably efficient systems for distributing aqueous amendments for in situ treatment of groundwater contaminants. At

this time, the primary applications for the tools will be for design of in situ chemical oxidation systems using permanganate and in situ anaerobic bioremediation systems using soluble substrates and emulsified oil. However, as technology evolves, this general approach should be applicable to distribution of other aqueous amendments.

Identifying and Quantifying Functionally Active Denitrifying Populations in Complex Environments Using Catabolic Gene Expression Analysis

National Science Foundation
F. L. de los Reyes III
$299,990
06/09 to 05/12

The research described in this proposal will develop and optimize a novel molecular technique to determine phylogenetic identity of functionally active nitrate-, nitrite-, nitric oxide-, and nitrous oxide-reducers in activated sludge and soil. The specific objectives are to: (1) optimize the Sequential mRNA FISH Flow Cytometry (SmRFF) method (developed previously in our lab) and investigate its potential for other microbial processes; (2) determine the effect of floc structure, DO and carbon and nitrogen levels on the active denitrifying community; (3) identify ammonia oxidizing bacteria (AOB) that denitrify; and (4) examine the denitrifying ecology of a bioreactor that uses denitrifying AOB for treating high ammonia, low COD wastewater.

PERI: Performance Engineering Research Institute: Application Engagement

G. Mahinthakumar
UT Battelle LLC
$279,776
04/07 to 06/11 (renewed annually)

This project is part of a larger scale effort funded by DOE through the SciDAC (Scientific Discovery through Advanced Computing) program. The overall goal of the project is to develop and maintain an enabling technology center in the area of high-end computer performance called performance engineering research institute (PERI). NCSU component of this project will focus on performance analysis, performance modeling, and performance optimization of SciDAC groundwater application codes.

Factors Affecting the Formation of Fats, Oils, and Grease (FOG) Deposits in Sewer Systems

NC Water Resources Research Institute
F. L. de los Reyes III and Joel J. Ducoste
$50,000
03/09 to 02/10

This research will quantify FOG deposit formation rates in sewer collection systems using a pipe loop system that can be challenged with different wastewater characteristics, flow rates, and constituents. This project will (1) quantify impact of kitchen wastestream and food service establishment (FSE) effluent quality on FOG deposit formation rate utilizing a pilot scale pipe-loop system; (2) assess impact of FOG from food disposal units on FOG deposits formation rate; and (3) assess impact of pipe surface material on FOG deposit formation rate. This information will provide wastewater municipalities with strategies to maintain a sustainable sewer collection system in cities that are experiencing significant growth and alleviate potential environmental and public health harm from FOG related SSOs.

Evaluation of Computational Fluid Dynamics (CFD) for Modeling UV-Initiated Advanced Oxidation Processes

AWWARF
Joel Ducoste and Detlef Knappe
$150,000
01/06 to 12/09

The goal of this research is to evaluate Computational Fluid Dynamics (CFD) for modeling UV-initiated AOPs that will ultimately help professionals in research, regulatory, consulting, and treatment facilities better analyze, design, and operate UV/AOP systems. Several steps will be taken including development of a dynamic UV/H2O2 advanced oxidation CFD model that can be combined with complex kinetic pathways for characterizing the degradation of various water supply contaminants, evaluation of non-ideal reactor hydraulics on the degradation of contaminants using the UV/H2O2 AOP, and evaluation of design parameters, including the effects of lamp type, lamp age, lamp failure on the overall efficiency of the AOP system.

Alternative Water & Waste Management Processes for Local Governments Study

C. M. Williams, S. Liehr, K. Zering, F. L. de los Reyes III
$25,000
12/08 to 06/09

The ultimate goal of this study is to identify cost-effective wastewater treatment and disposal technologies available to small municipalities in NC with populations ranging in size from 500 to 5,000. The immediate objective is to conduct an assessment of the various swine technologies previously studied at NCSU, as well as various new and emerging treatment and disposal technologies and decentralized strategies, with a goal of identifying and ranking those systems with the highest potential of success for treating domestic wastewater from small rural communities. Since different communities have different treatment goals and different permit requirements, efforts will be made to identify systems that meet these different objectives.

Impacts of Sampling and Handling Procedures on DNA- and RNA-based Microbial Characterization and Quantification of Groundwater and Saturated Soil

F.L. de los Reyes III and R.C. Borden
Strategic Environmental Research and Development Program
$487,955
03/07 to 06/09

The overall objective of this project is to determine the relationships of sample processing procedures to the effectiveness and efficiency of three molecular techniques used in qualitative and quantitative analysis of microbial populations in groundwater and associated saturated soil samples.

Effects of Biological Drain Products on Grease Interceptors: Microbiological and Chemical Characterization

Consumer Specialty Products Association
F. L. de los Reyes III
$128,162
08/07 to 01/09

The overall objective of the project is to determine the chemical and microbiological effects of biological drain products on grease interceptor (GI) characteristics and performance. The specific objectives are: (1) to identify the effects of bioaugmentation on the microbial community structure and function in grease interceptors; (2) to determine if there is a negative effect to downstream effluent from use of biological additives (i.e., determine if biaougmentation results in passing grease downstream); and (3) to start to address regulatory ordinances concerning biological drain products.

NSF IREE: International Research and Education in Engineering

National Science Foundation
F. L. de los Reyes III
$19,650
08/06 to 07/09 (Supplement to NSF MIP funding with Dr. Joel Ducoste and Dr. Michael Hyman)

This project establishes a collaborative arrangement with the University of the Philippines, Manila Water Company, and Gawad Kalinga, a non-profit organization involved in improving the environment and lives of poor families in the Philippines. The international research involves: (1) analysis of nitrogen-removal performance of 31 full-scale wastewater treatment plants in Metro Manila, Philippines; (2) sampling and molecular analysis of the microbial flocs in the mixed liquor of these treatment bioreactors; (3) analysis of domestic and community wastewater treatment systems in rural and urban Gawad Kalinga (GK) villages designed and built for former squatter and poor families; and (4) participation of undergraduate researcher in a GK community build with beneficiary families.

Ecophysiology of Nitrifying and Denitrifying Communities and their Interactions in Microbial Flocs

National Science Foundation, Microbial Observatories-Microbial Interactions and Processes
F. L. de los Reyes III, Joel Ducoste, and Michael Hyman
$430,000
07/04 to 06/09

This project will apply a multidisciplinary approach to characterize the factors that control community structure and function in nitrogen-transforming microbial flocs. The specific objectives of the project are to: (1) Determine the effect of microscopic floc structure on rates and diversity of microbial activities involved in nitrogen removal; (2) Determine the impact of bioreactor macro conditions on floc size, shape, and function; (3) Characterize the carbon- and nitrogen-based metabolic interactions among ammonia-oxidizing, nitrite-oxidizing, and denitrifying bacteria within a floc; and (4) Develop a macroscale model of nitrogen and carbon removal in activated sludge that incorporates microscale processes in flocs.

A Unified Approach to Understanding, Education, and Design of Disinfection Processes using Computational Fluid Dynamics (NSF Career)

J.J. Ducoste
National Science Foundation
$375,000
09/01 to 08/08

This research uses CFD to (1) develop and evaluate alternative disinfection models to predict effluent microbial inactivation through continuous flow systems, and (2) assess the impact of disinfectant injection methods and multiple disinfectant injection points on microbial inactivation and DBP formation. The educational plan involves development of a CFD disinfectant training module. This module will be designed around a graphical user interface (GUI) that will be the primary mode of communication between the user and the CFD model. The module will be composed of three sections: (1) PowerPoint/video-based disinfection process-lecture series, (2) solved disinfection problems and simulated tracer tests, and (3) team-based disinfection design problems.

Ecophysiology of Nitrifying and Denitrifying Microbial Communities and their Interactions in Microbial Flocs

J.J. Ducoste (Co-PI), PI: Francis de los Reyes: CCEE, Co-PI: M. Hyman: Microbiology
National Science Foundation
$430,000
07/04 to 07/09

The specific objectives of the project are: (1) To determine the effect of floc structure (floc size and shape) on microbial activity rates, activity diversity, species diversity, relative numbers, and spatial arrangement of microorganisms involved in nitrogen removal; (2) To determine the impact of bioreactor macro conditions (DO, substrate type and loading) on floc size, shape, and function; (3) To characterize the carbon and nitrogen interactions of ammonia-oxidizing, nitrite oxidizing, and denitrifying bacteria within a floc; and (4) To develop a macroscale model of nitrogen and carbon removal in activated sludge that incorporates microscale processes in flocs.

Evaluation of Computational Fluid Dynamics (CFD) for Modeling UV-Initiated Advanced Oxidation Processes

J.J. Ducoste and D. Knappe
American Water Works Association Research Foundation
$150,000
01/06 to 12/08

This research will evaluate Computational Fluid Dynamics (CFD) for modeling UV-initiated AOPs that will ultimately help professionals in research, regulatory, consulting, and treatment facilities better analyze, design, and operate UV/AOP systems. Several steps will be taken that include the development of a dynamic UV/H2O2 advanced oxidation CFD model that can be combined with complex kinetic pathways for characterizing the degradation of various water supply contaminants, the evaluation of non-ideal reactor hydraulics on the degradation of contaminants using the UV/H2O2 AOP, and the evaluation of design parameters, including the effects of lamp type, lamp age, and lamp failure on the overall efficiency of the AOP system.

In-Vehicle Energy and Emissions Information System (IVEEIS)

H.C. Frey and N.M. Rouphail
National Science Foundation
$299,997
01/03 to 12/08

The key objectives of this research project are to (1) develop a micro-scale predictor of energy use and emissions that is deployable at the individual vehicle level in real-time; (2) identify, compare, and evaluate alternate energy use and emissions sampling/reporting schemes that are appropriate at the vehicle and network levels; (3) develop and test a prototype In-Vehicle Energy and Emissions Information System (IVEEIS); and (4) formulate and assess the utility of IVEEIS in developing transportation design and control measures aimed at energy and emission management policies.

Life Cycle Inventory and Impact Analysis Framework for Nonroad Construction Vehicles and Equipment Based

H.C. Frey and W.J. Rasdorf
National Science Foundation
$375,000
08/03 to 08/08

The objectives of this work are to: (1) Characterize the second-by-second in-use emissions and energy use of nonroad construction vehicles and equipment, including emissions of nitric oxide, carbon monoxide, hydrocarbons, carbon dioxide, and particulate matter, including real time sensing and monitoring where needed to fill data gaps; (2) Develop a life cycle inventory of conventional nonroad construction vehicles and equipment; and (3) Identify and recommend methods for reducing energy use, emissions, and impact.

Regional Development, Population Trend and Technology Change Impacts on Future Air Pollution Emissions

N.M. Rouphail and H.C. Frey
U.S. Environmental Protection Agency STAR grant via University of North Carolina at Chapel Hill, and Center for Transportation and the Environment
$238,690
11/04 to 11/08

The research tests the hypothesis that smart-growth development patterns can significantly influence the quantity and location of direct and indirect emissions from mobile sources. The patterns of interest include the type of development and its location. We will develop a general method for exploring the leverage that smart-growth development patterns have on the spatial pattern and quantity of emissions from mobile sources. We will explore scenarios and chart the envelope of the effectiveness of smart growth as a means for reducing emissions. We will determine whether substantial emissions reductions are feasible with forecasts of the market penetration of smart growth.

EPA Truck Anti-Idling Demonstration Project

A. Tazewell (NC Solar Center), H.C. Frey, and J.R. Stone
US Environmental Protection Agency
$90,000
02/06 to 08/08

The objective is to assess potential environmental benefits of heavy-duty diesel freight truck idle reduction technologies installed on trucks in NC. A key goal is to quantify actual grams per gallons emissions with a portable gas analyzer and compare this data with data extrapolated from an on-board data logger and fuel use with and without idle reduction technologies.

Exposure Assessment Advising to U.S. Environmental Protection Agency

H. C. Frey
A Spatial-Temporal Modeling Approach for Evaluating the Impact of Environmental Stressors, in Conjunction with Human Activity, on Human Health
M. Fuentes (Statistics), H. C. Frey, S. Ghosh (Statistics)
National Institutes of Health
$333,280 (Year 1 - $66,923 for Frey portion), renewable for up to three years
01/08 to 12/10

The focus of this research is on development of new statistical methods for investigating the spatial and temporal associations between airborne fine particulate matter (PM) less than 2.5 microns in diameter ($PM_{2.5}$). Human exposure to $PM_{2.5}$ will be quantified using an exposure simulation model for selected regional case studies taking into account ambient concentration, indoor concentrations in microenvironments, and human activity patterns. The use of exposure rather than ambient concentration is hypothesized to better explain differences in the rate of mortality and morbidity associated with $PM_{2.5}$.

Spatial Temporal Analysis of Health Effects Associated with Sources and Speciation of Fine Particulate Matter

M. Fuentes (Statistics), H. C. Frey, Y. Zhang (MEAS), M. Bell (Yale U.), and F. Dominici (Johns Hopkins)
U.S. Environmental Protection Agency STAR Grants Program
$893,439 ($179,997 Frey portion)
05/08 to 05/11

This project will investigate adverse health outcomes associated with population exposure to fine particulate matter (PM) less than 2.5 microns in diameter ($PM_{2.5}$), and speciation of the fine PM to characterization geographic differences, sources, and population heterogeneity in putatively $PM_{2.5}$ mediated health effects. We will answer the following questions: What is the recommended framework to integrate atmospheric models with monitoring data and other sources of information (i.e. source apportionment) to obtain a better spatial and temporal characterization of fine PM components and sources? How to use source apportionment and exposure assessment approaches in national epidemiological studies, while characterizing different sources of uncertainty in the models and the data?

Development and Evaluation of Methodological Framework for Real-World Vehicle Energy Use and Emissions Estimation at Multiple Temporal and Vehicular Scales

H.C. Frey and N.M. Rouphail
National Science Foundation
$299,985
05/08 to 05/11

Vehicle Fuel Use and Emissions (FU&E) have substantial national energy and environmental implications, but are confounded by intra/inter-vehicle variability and, therefore, require scientific inquiry to develop an improved basis for

their characterization and management. The main objectives of this research are to: (1) quantify intra-vehicle variability in FU&E due to inter-driver variability, cold start, ambient conditions, and road grades; (2) develop FU&E models based on multiple levels of vehicle aggregation and multiple temporal scales; and (3) evaluate the interface of these models with transportation models and for use with real-time vehicle detection.

Development of Undercut Criteria and Alternatives for Subgrade Stabilization

M. Gabr and R.H. Borden
NC Department of Transportation
$266,000
08/07 to 06/09

The main objective of the proposed project is to develop undercut criteria for different site conditions and provide tools for identifying depth of undercut, as well as alternative or supplemental approaches to improving soil bearing properties and workability. The approach to be developed will be supplemented with the use of expedient in situ probing technique, such as shear vane or Dynamic Cone Penetromenter (DCP), which are currently used by NCDOT but not necessarily to define undercut criteria. The research work will encompass laboratory and field work as well as modeling and analysis of data.

Treatment Options for the Removal of Emerging Pollutants of Concern

Urban Water Consortium
D.R.U. Knappe
$52,919
01/09 to 01/10

Objectives of the proposed research are to (1) identify, through a review of the literature, potential human health and ecotoxicological effects associated with the presence of biochemically active compounds (BACs) in water and (2) assess, at the bench scale, the BAC removal effectiveness of drinking water treatment processes that are currently employed by North Carolina Urban Water Consortium (UWC) members. The goals of the proposed research include (1) setting BAC concentration targets for finished drinking water and (2) identifying opportunities for enhancing BAC removal with drinking water treatment processes currently employed at UWC

Removal of 2-Methylisoborneol and Geosmin with High-Silica Zeolites and Zeolite-Enhanced Ozonation

American Water Works Association Research Foundation
D.R.U. Knappe
$150,000
02/06 to 12/09

The principal objective of this research is to assess the effectiveness of two innovative treatment methods for the control of earthy/musty odors associated with the presence of 2-methylisoborneol (MIB) and geosmin in drinking water. Treatment method 1 is an adsorption/reaction process based on the use of high-silica zeolites, a class ofatalytic adsorbents that has not been studied extensively for water treatment applications. Treatment method 2 is an adsorption/oxidation process based on the combined use of high-silica zeolites and ozone (zeolite-enhanced ozonation).

Protecting Receiving Waters: Removal of Biochemically Active Compounds from Wastewater by Ozonation and Activated Carbon Adsorption Processes

NC Water Resources Research Institute
D.R.U. Knappe
$50,000
03/09 to 02/10

The objectives of this research are to (1) measure oxidation kinetics of six model BACs during ozonation of NC wastewater matrices and, with the aid of a mathematical model, predict ozone doses required to achieve BAC oxidation levels of 90 and 99% for wide range of BACs, and (2) identify suitable powdered activated carbon (PAC) types and effective PAC addition points in wastewater treatment plants and determine PAC doses that yield BAC removals of 90 and 99%.

Impact of UV Location and Sequence on By-Product Formation

D.R.U. Knappe
NC Water Resources Research Institute Subcontract – primary sponsor is AWWARF
$21,899
01/08 to 12/08

The purpose of this research is to measure the formation of assimilable organic carbon (AOC) when water is irradiated with UV light at doses that are typically used in disinfection or advanced oxidation processes. AOC concentrations will be measured by a new flow-cytometric method that utilizes a natural consortium of bacteria harvested from a local lake water.

Development of an Analytical Method for Taste and Odor Compounds and Application to NC Drinking Water Sources and Finished Waters

D.R.U. Knappe
NC Water Resources Research Institute
$50,000
03/08 to 08/09

A highly sensitive analytical method will be developed that will permit the identification and quantification of many common T&O compounds in NC drinking water sources and finished waters. To date, little is known about which compounds cause T&O problems in NC drinking waters, and water treatment professionals typically have to adjust treatment processes on a trial and error basis to improve the T&O quality of the water. Knowledge about which compounds are responsible for T&O problems would allow utilities to tailor their treatment approaches to the compound(s) involved in a particular T&O episode such that the desired finished water quality is obtained in an effective and economical manner.

Protecting Receiving Waters: Removal of Biochemically Active Compounds from Wastewater by Sequential Photochemical and Biological Oxidation Processes

D.R.U. Knappe
NC Water Resources Research Institute
$50,000
03/07 to 08/08

The principal objective of the proposed research is to quantify the effectiveness of combining UV/H_2O_2 and biological oxidation processes for the mineralization of six biochemically active compounds (BACs) (the antimicrobial compounds sulfamethazine, sulfadiazine, trimethoprim, the endocrine disrupting chemical bisphenol-A and 17-αethinyl estradiol, and the analgesic diclofenac) that commonly occur in conventionally treated wastewater.

High-end Computing in Environmental Engineering with Application to Subsurface Characterization

G. Mahinthakumar
National Science Foundation (Career)
$400,000
07/03 to 06/09

Accurate characterization of the subsurface is an important element in the development of reliable and efficient groundwater management practices. Accurate and reliable estimation of hydraulic conductivity distribution, contaminant distribution, and/or contaminant source release history is necessary for problems such as estimating groundwater yields, design of efficient cleanup strategies, and identifying responsible parties in a contamination incident. This requires solution of an inverse problem because direct measurement of detailed subsurface properties is not feasible. Inverse problems are difficult to solve and are computationally demanding. This multidisciplinary NSF Career project will investigate novel computational strategies for the efficient solution of large-scale inverse problems in subsurface characterization.

ITR: A Prototype to Support Near Real-Time Environmental Characterization

G. Mahinthakumar, R. Ranjithan, and Nick Karonis (Northern Illinois University)
National Science Foundation
$497,418
09/03 to 08/07

The overall goal of this project is to investigate formal computational approaches that can readily harness grid computing for the efficient solution of environmental characterization problems. To this end, we will develop a grid-enabled software framework. Two alternative paradigms, one based on the grid-enabled version of MPI (Message Passing Interface), and the other based on Java will be explored. The framework will be applied to groundwater and surface water problems, both of which are of prime societal importance.

DDDAS-TMRP (Collaborative Research): An Adaptive Cyberinfrastructure for Threat Management in Urban Water Distribution Systems

G. Mahinthakumar, E.D. Brill, R. Ranjithan (Co-PI's, NCSU), J. Uber (Univ. of Cincinnati); Gregor Von Laszewski (Univ. of Chicago); and K. Harrison, (Univ. of South Carolina)
National Science Foundation (Dynamic Data Driven Application Systems Program)
$779,986 (NCSU share $264,624)
01/06 to 12/09

The goal of this multidisciplinary research is to develop a cyberinfrastructure system for water distribution system threat management that will both adapt to and control changing needs in data, models, computer resources and management choices facilitated by a dynamic workflow design. Using virtual simulation and a field study, this cyberinfrastructure will be tested on illustrative scenarios for adaptive management of contamination events in water distribution systems.

Shoreline Monitoring at Oregon Inlet

M.F. Overton and J. S. Fisher
NC Department of Transportation
$89,895
07/07 to 08/09

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.

Engineering to Enhance the Resilience of the Built and Natural Environments

R. Leuttich (UNC-CH), M. Overton, G.F. List, R. Seracino, M. Gabr, R. Ranjithan, D. Brill, and J. Baugh
Department of Homeland Security, Center of Excellence
$2,593,890
08/08 to 07/14

The objective is to investigate innovative and proactive approaches to plan, design and construct CCI components to provide services needed to increase disaster preparedness and resilience of the integrated CCI system, as well as to protect the natural environment. To achieve this goal, five highly interrelated research projects are being proposed. Each project has a project leader and anticipated partners; however, the projects are proposed as complementary pieces contributing products to be used to meet the overarching objective to enhance the resilience of the built and natural environment, a single objective. As such, project leaders will work together to coordinate efforts, align case studies, transfer outcomes, develop scenarios, etc. toward a highly integrated product.

Integration of Sensor Technologies Into the Civil Engineering Curriculum

T.M. Evans and M.A. Gabr
National Science Foundation
$150,000
01/09 to 01/11

The use of sensors and instrumentation for monitoring civil engineering infrastructure has been of paramount importance since ancient times. The specific goals of the proposed project are to: a) Identify the sensors most relevant to earth structures and foundations and categorize the extent of instrumentation necessary to provide quality data for monitoring, diagnostics, and prognostic Analyses; b) Identify structures and building foundations on campus that are most suitable for instrumentation and install a comprehensive network of automated sensors; c) Develop undergraduate hands-on educational modules, emphasizing sensor operation; experimental data collection, processing and visualization; and statistical analysis.

Field Verification of Undercut Criteria and Alternatives for Subgrade Stabilization

M.A. Gabr and R.H. Borden
NCDOT
$64,000
04/09 to 04/10

The proposed plan encompasses field instrumentation of three test pads; one with the implementation of undercutting and replacement with quality fill, a second includes undercutting in conjunction with the use of geosynthetics, and a third includes chemical stabilization. Each test location will include a control section in addition to the test pad with the specified stabilization measure. The field data will be used to perform a comparative cost analysis to illustrate the relative cost of each measure such that an informed decision on cost-effective subgrade stabilization can be made.

Procedures for Multi Hazard Risk Assessment in Civil Infrastructure Systems

R. Ranjithan, D. Brill, J. Baugh, Mo Gabr, M. Overton, and R. Seracino
$19,813
05/08 to 12/10

The pilot project will develop an outline of a multihazard risk assessment methodology associated with floods and levees. It will also identify model requirements and data needs. This work will serve as a prototype for future work to develop a more comprehensive methodology for considering a broader range of natural hazards and civil infrastructure

Understanding Rip Currents: The Multi-scale Interaction of Waves, Currents and Morphology

Jie Yu
National Science Foundation
$90,000
09/08 to 08/09

Surf zone currents, driven by breaking waves, strongly influence coastal erosion, hence coastal overtopping and flooding, and water quality. Understanding these currents is important to the development and protection of coastal environment, economy and ecosystem. This research will involve a comprehensive investigation of linear instability mechanisms leading to rip currents on beaches initially lacking of alongshore variability, setting the stage for further studies on nonlinear dynamics of circulations and multi-scale dynamics of the interactions of wave, current and sediment morphology. Improved understanding of the complex dynamics of nearshore hydro-morphodynamics system is needed for development of reliable predictive tools essential to science-based planning, decision-making and mitigation strategies.

A Generation Mechanism for Rip Currents

Jie Yu
North Carolina Sea Grant
$9,828
01//08 to 12//08

This project will investigate an instability leading to rip current formation. The initial instability is due to the two-way wave-current interaction. However, the sediment dynamics, once coming into play, may well accelerate the process. Thus, the work is potentially important to the understanding of sudden occurrences of dangerous rip currents on natural beaches. Collaborations with the National Weather Service Wilmington, who issues surf zone forecasts, including daily rip current outlook for North and South Carolina beaches, is proposed and will be pursued.

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