

**ANNUAL REPORT**  
**For Calendar Year 2006**

**NEW ENGLAND TRANSPORTATION CONSORTIUM**

**NETCR 68**

**April 2007**

This report was sponsored by the New England Transportation Consortium, a cooperative effort of the Departments of Transportation and the Land Grant Universities of the six New England States, and the U.S. Department of Transportation's Federal Highway Administration.

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## **NEW ENGLAND TRANSPORTATION CONSORTIUM**

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## A. INTRODUCTION

The New England Transportation Consortium (NETC) is a cooperative effort of the transportation agencies of the six New England States. Through the Consortium, the states pool professional, academic and financial resources for transportation research leading to the development of improved methods for dealing with common problems associated with the administration, planning, design, construction, rehabilitation, reconstruction, operation and maintenance of the region's transportation system.

## B. 2006 HIGHLIGHTS

### 1. **THE CONSORTIUM COMPLETED THE MOVE OF ITS COORDINATOR'S OFFICE TO THE UNIVERSITY OF MASSACHUSETTS DARTMOUTH'S ADVANCED TECHNOLOGY AND MANUFACTURING CENTER IN FALL RIVER, MASSACHUSETTS:**

Contact information for the office is:

New England Transportation Consortium  
C/o Advanced Technology and Manufacturing Center  
University of Massachusetts Dartmouth  
151 Martine Street  
Fall River, MA 02723

### 2. **FUNDING APPROVED FOR NEW RESEARCH TO ADDRESS HIGH PRIORITY REGIONAL TRANSPORTATION NEEDS:** The NETC Advisory Committee approved funding for four (4) research projects, totaling \$450,000, to be initiated in FY 2007 to address the following high priority regional transportation research needs:

- Estimating and Predicting Traffic Conditions for Traveler Information and Emergency Response.
- Exploring the Potential for Deployment of Intelligent Intersections in New England
- Determining the Optimum Distance for a Lane-Drop Downstream from a Signalized Intersection
- Determine the Variations in Performance-Related Properties of Recycled Pavement Layers That Result from Seasonal Changes in Temperature and Moisture Content In Order to Improve the Performance and Longevity of Recycled Pavements.

### 3. **NETC TO UNDERTAKE TECHNOLOGY TRANSFER/DEMONSTRATION PROJECT ON THE USE OF ADVANCED COMPOSITE MATERIALS FOR NEW ENGLAND'S HIGHWAY INFRASTRUCTURE:** The NETC Advisory Committee approved \$25,000 in funding for a Technology Transfer/Demonstration project entitled "Advanced Composite Materials in New England's Transportation Infrastructure: Phase I Implementation Project of NETC 01-1". The objective of the project is to demonstrate the feasibility and positive impact of using Advanced Composite

Materials in a traditional/common element of New England's transportation infrastructure, leading to their increased use in future projects.

**4. RESEARCH FINDINGS ON: ADVANCED COMPOSITE MATERIALS, EROSION CONTROL, BRIDGE RAIL TRANSITIONS, BRIDGE EXPANSION JOINTS, IMPLEMENTATION OF TRAVELER INFORMATION SYSTEMS AND SUBGRADE SUPPORT VALUES FOR NEW ENGLAND SOILS PUBLISHED AND DISTRIBUTED:** Findings from the following research projects were distributed to New England's State transportation agencies and universities, the Federal Highway Administration, the AASHTO Region 1 Research Advisory Committee, the National Technical Information Service, and the National Transportation Library:

- 99-1: "NCHRP Report 350 Testing and Evaluation of NETC Bridge Rail Transitions"
- 01-1: "Advanced Composite Materials for New England's Transportation Infrastructure: A Study for Implementation and Synthesis of Technology and Practice"
- 02-2: "Formulate Approach for 511 Implementation in New England"
- 02-3: "Establish Subgrade Support Values for Typical Soils in New England"
- 02-6: "Sealing of Small Movement Bridge Expansion Joints"
- 03-3 Phase 2: "Design Considerations for a Prototype Erosion Control Testing Plot"

**5. TECHNOLOGY TRANSFER:**

- **Requests for Information, Technical Assistance and Copies of Final Reports Were Received from the Following:**
  - **Vermont Agency of Transportation:** Technical advice on bridge rail post bolt problem
  - **Rhode Island Department of Transportation:** Copy of NETC Final Report "New England Vehicle Classification and Truck Weight Program, Phase I."
  - **State of Connecticut, State Library:** NETC Annual Reports for Calendar Years 2003, 2004.
  - **Delaware Department of Transportation:** Copy of NETC Final Report "Establish Subgrade Support Values for Typical Soils in New England" Phase I."
  - **Ohio Department of Transportation:** Copy of NETC Final Report "Effective Visualization Techniques for the Public Presentation of Transportation Projects"
  - **Ministry of Transportation, Province of Ontario Canada** – Schematic drawings of NETC Bridge Rails.
  - **Department of Civil & Environmental Engineering, University of Massachusetts Amherst:** Copy of NETC Final Report "New England Vehicle Classification and Truck Weight Program, Phase I."

- **Weyant's Transport, Inc.:** Copy of "NETC Handbook for Use by the Trucking Industry to Utilize the NETC Common Truck Permit Procedures for Certain Non-Divisible Oversize/Overweight Vehicles Traveling On State Highways."
- **Eight Papers Arising from NETC Sponsored Research were Presented at Technical Conferences or Published in Technical Journals by NETC Researchers:**
  - "Geogrid Reinforced Pavement Structure in a Cold Region," Helstrom, C.L., Humphrey, D.N., and Hayden, S.A., Proceedings of the 13th International Conference on Cold Regions Engineering, ASCE, Orono, Maine, 12 pp., 2006
  - "Resilient Modulus of Subgrade Soils A-1-b, A-3, and A-7-6 using LTPP Data: Prediction Models with Experimental Verification," Joshi, Shraddha, and Malla, *Proceedings, ASCE GeoCongress 2006*, (Atlanta, GA, Feb. 26-March 01, 2006), ASCE, Reston, VA; Feb. 2006, 6p (CD ROM).
  - "Laboratory Evaluation of Weathering and Freeze-Thaw Effects on Silicone Foam Bridge Joint Sealant," Shrestha, M.R., Malla, R.B., Boob, S. and Shaw, M.T., Paper #369, *Proceedings, SEM 2006 Annual Conference and Exposition* (St. Louis, MO, June 04-07, 2006), SEM, Bethel, CT, June 2006, 8p (CD ROM).
  - "Development and Laboratory Analysis of Silicone Foam Sealant for Bridge Expansion Joints," Malla, R., Shaw, M., Shrestha, M., and Brijmohan, S., *Journal of Bridge Engineering*, ASCE, Reston, VA, July 2006.
  - "A New Admixture to Mitigate Corrosion Problems," Civjan, S.A., and Crellin, B.J., *Concrete International*, Volume 28, No. 8, Pp. 78-82.
  - "Development and Evaluation of a Field Permeameter as a Longitudinal Joint Quality Indicator," Mallick, R.B., and Daniel, J.S., *International Journal of Pavement Engineering*, Vol. 7, No. 1, March 2006. pp. 11-21.
  - "Longitudinal Joint Permeameter: Non-Destructive Test for QC," Daniel, J.S., a presentation to PennDOT Bituminous Technician Certification Program, March 14, 2006.
  - "Using Land Use Data to Estimate Exposure for Improving Road Accident Prediction," Jonsson, T., Ivan, J.N., Zhang, C., presented at 32<sup>nd</sup> Annual Traffic Records Forum, Palm Desert CA, Aug. 3, 2006.
- **Research Needs Statement Submitted to NCHRP for Consideration for Funding:** A Research Needs Statement entitled "Effects of Pavement Markings on Pavement Performance" was submitted to NCHRP for consideration for funding at the national level.

## **C. PROGRESS OF ACTIVE PROJECTS**

**PROJECT NUMBER: 00-8**

**PROJECT TITLE:** Performance and Effectiveness of a Thin Pavement Section Using Geogrids and Drainage Geocomposites in a Cold Region

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Dana N. Humphrey, Department of Civil and Environmental Engineering, University of Maine, Orono.

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 07/01/2001

**END DATE:** 06/30/2005

### **PROJECT OBJECTIVES:**

The objective of this project is to construct twelve experimental test sections to evaluate the performance and effectiveness of several alternative cold regions pavement designs. These designs involve the use of geogrids and/or drainage geocomposite as an integral member in a thin pavement section. The test sections will be constructed as part of a Federal/State, Maine Department of Transportation highway reconstruction project. Pavement sections will be evaluated for: 1) the influence of the location of a geogrid in a relatively thin pavement section on pavement performance; 2) the influence of a drainage geocomposite in a relatively thin pavement section on pavement performance; 3) the influence of a drainage geocomposite in a pavement reclamation application on pavement performance; 4) the influence of using both a geogrid and drainage geocomposite in a relatively thin pavement section on pavement performance; and 5) comparing the performance of a geogrid and/or drainage geocomposite in a relatively thin pavement section to a typical standard thick pavement section.

### **PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

The instrumentation for twelve test sections were fabricated and installed as part of reconstruction of Route 9/126 in Monmouth-Litchfield, Maine. Installation occurred in September, 2001 and July, 2002. In addition, flow meters to measure outflow from the drainage geocomposites were installed in March, 2003.

Instrumentation installed in the 2001 and 2002 construction seasons included 120 strain gages attached to geogrid to monitor the in-place deformation of the grid, 16 vibrating wire piezometers to measure pore water pressures in the subbase course and subgrade soils in sections with drainage geocomposite, and 12 thermocouple strings with twelve individual thermocouples in each string to monitor the depth of frost penetration. The strain gages were attached directly to the ribs of the geogrid. They were installed in pairs – one on top and one on bottom of the rib. This allows the elongation of the rib to be



separated from bending. They were protected by an epoxy coating. The piezometers have a measurement range of 0 to 34 kPa (0 to 5 psi) and an accuracy of  $\pm 0.17$  kPa ( $\pm 0.025$  psi). This allows heads as low as 1.5 mm (0.06 in.) to be measured.

A new system to measure flows from sections with drainage geocomposite was used. In previous projects tilt buckets were used to measure flow, however, these proved to be unreliable at low flow rates. Preliminary flow rate observations on the Litchfield-Monmouth project showed that the flow rates would be low. The flow meter that was selected was an Omega FP5600, capable of measuring flows ranging from 2 to 45 L/min (0.5 gpm to 12 gpm). The principle of operation is that the flowing water turns a propeller. Each full revolution of the propeller causes a signal to be sent to the datalogger. The number of signals per unit time is directly correlated with the flow rate. In March, 2003, they were installed in insulated protective housings at six of the drain pipe discharges with access to dataloggers. These proved to be problematic due to precipitation of iron oxides in the interior of the flow meters. At four locations there is no access to data loggers. At these locations water meters, similar to those used to monitor water consumption by homes, were used to record the cumulative volume of outflow. These were read manually every two weeks and converted to an average flow rate for the period. In general, the recorded rates of outflow have been low for each of the drain pipe discharges.

Most of the instruments were attached to an automatic datalogger that takes and stores hourly readings. The readings are downloaded bi-weekly via modem. To analyze the data, the 24 hourly readings are averaged. This eliminates most of the electronic noise, or random scatter, in the data, which allows for easier identification of time-dependent trends. For instrumentation not attached to a datalogger, bi-weekly manual readings were generally taken. FWD readings were taken weekly during the Spring, 2004 thaw.

A performance evaluation was made based on data gathered through completion of monitoring in June, 2005. This included testing strain gages installed on geogrid to establish a relationship between force per unit width and measured strain. In addition, field data recorded manually and by the dataloggers was analyzed. This included preparation of plots of geogrid strain, subgrade and subbase pore pressures, and frost penetration versus time.

Comments on the draft report were received and incorporated into the report. The report details construction of the project, and findings and conclusions based on data gathered through completion of monitoring. This report includes the literature review for the project and data gathered from Maine DOT files that are related to the project.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“Geogrid Reinforced Pavement Structure in a Cold Region,” Helstrom, C.L., Humphrey, D.N., and Hayden, S.A., Proceedings of the 13th International Conference on Cold Regions Engineering, ASCE, Orono, Maine, 12 pp., 2006.

**PROJECT NUMBER: 01-1**

**PROJECT TITLE:** Advanced Composite Materials for New England's Transportation Infrastructure: A Study for Implementation and Synthesis of Technology and Practice

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):**

P.I. Sergio F. Breña, Co. P.I. Scott A. Civjan , University of Massachusetts, Amherst

**STATUS:** Completed

**INITIAL AGREEMENT DATE:** 08/01/2003

**END DATE:** 12/31/2004

**PROJECT OBJECTIVES:**

1. To increase the effective use of FRP composites in infrastructure for use in New England through the creation of a network for information exchange.
2. Provide a synthesis of current practice on the use of FRP products in transportation infrastructure within New England.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

Final report completed May 2006.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

"Advanced Composite Materials for New England's Transportation Infrastructure: A Study for Implementation and Synthesis of Technology and Practice," Breña, S.F., Civjan, S.A., and Goodchild, M., May 2006, NETCR62.

**PROJECT NUMBER: 02-1**

**PROJECT TITLE:** Relating Hot Mix Asphalt Pavement Density to Performance

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Walaa S. Mogawer, UMass Dartmouth; Rajib Mallick, Worcester Polytechnic Institute; Jo Sias Daniel, University of New Hampshire

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 09/01/2003

**END DATE:** 7/31/2007

**PROJECT OBJECTIVES:** The objective of the proposed study is to determine relationship between pavement density and performance through testing of pavements at different levels of in-place density with accelerated pavement loading equipment and environmental simulation. Another objective is to use the obtained relationship to determine pay adjustments for different densities.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

UNH continued testing of the SPT specimens as outlined in the proposal.

UMass Dartmouth reviewed the fatigue and rutting data generated by WPI in order to determine what specific testing remains for this study.

UMass Dartmouth commenced formation of a work plan to complete the remainder of the work for this project.

UMass Dartmouth received MMLS related testing equipment necessary to duplicate the MMLS testing procedures conducted at WPI for this study.

UMass Dartmouth was able to find a contractor in Massachusetts willing to supply the required 800 pounds of 12.5mm Superpave mix for this project. The mix was obtained in summer of 2006. The mix had average air voids of 3.3%, VMA of 14.7%, and VFA of 77.8%. UMass Dartmouth will conduct more volumetric testing on the mix prior to slab construction.

UMass Dartmouth created a testing mold required to conduct fatigue testing in the MMLS. The MMLS was also calibrated and routine maintenance was performed in anticipation of testing.

UMass Dartmouth continued to setup the data acquisition system required to collect strain gage data, temperature data, and load cycle data for each slab test.

UMass Dartmouth requested a no-cost time extension until July 31<sup>st</sup>, 2007. The

extension was approved in November 2006.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO  
THIS PROJECT FROM THE START OF THE PROJECT THROUGH  
DECEMBER 31, 2006: None**

**PROJECT NUMBER: 02-2**

**PROJECT TITLE:** Formulate Approach for 511 Implementation in New England

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Paul Shuldiner, Director, University of Massachusetts Transportation Center, Department of Civil and Environmental Engineering, Jeremy Siviter, Senior Systems Engineer, IBI Group

**STATUS:** Completed

**INITIAL AGREEMENT DATE:** 08/01/2002

**END DATE:** 05/31/2005

**PROJECT OBJECTIVES:**

The overall goal of this project is to develop a multi-faceted regional 511 implementation strategy that will address the following objectives:

- Identify minimum information requirements for a New England regional 511
- Identify the data availability existing within the region to support a minimum level 511 implementation
- Document the regulatory environment and processes that must be implemented for implementation of 511 in each of the New England states
- Identify lessons learned by early 511 adopters and ensure they are integrated in to a regional strategy
- Identify the different options for implementing various system components
- Document business plan approaches that can be used by the New England states to implement a regionally consistent 511 system

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

Final report completed October 2005.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

Randy Knapick (IBI Group) attended an I-95 Corridor Coalition 511 Peer-to-Peer Workshop in Philadelphia, PA on March 1, 2005 to report on this project and to talk with member agencies about their respective 511 deployment and integration issues, and to hear an update briefing on the status of the national 511 deployment program.

Gregg Loane and Randy Knapick (IBI Group) gave a formal presentation about the research problem, methodology, and recommendations, and also answered questions from participants at the I-95 Corridor Coalition Traveler Information Program Track meeting in Philadelphia, PA on June 14, 2005. The team spoke with Coalition members to identify lessons learned and follow-up research themes to be explored through a

planned 511 study to be conducted by the I-95 Corridor Coalition.

“Formulate Approach for 511 Implementation in New England,” Shuldiner, P., Loane, G., and Knapick, R., October 2005, NETCR44.

**PROJECT NUMBER: 02-3**

**PROJECT TITLE:** Establish Subgrade Support Values for Typical Soils in New England

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** PI: Ramesh B. Malla, Ph.D., Associate Professor, Department of Civil & Environmental Engineering, University of Connecticut

**STATUS:** Completed

**INITIAL AGREEMENT DATE:** 08/01/2002

**END DATE:** 07/31/2005

**PROJECT OBJECTIVES:**

The objective of this research is to collect all relevant data, and based on these findings, develop typical values or a range of typical values for subgrade soils found in New England based on AASHTO soil classification.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

Final report completed April 2006.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“Resilient Modulus Prediction Models for Some New England Subgrade Soils,” Malla, R. and Joshi, S., *Electronic Proceedings* of the 2005 Joint ASCE/ASME/SES Conference on Mechanics and Materials (McMat 2005), Baton Rouge, LA, June 1-3, 2005.

“Resilient Modulus of Subgrade Soils A-1-b, A-3, and A-7-6 using LTPP Data: Prediction Models with Experimental Verification,” Joshi, Shraddha, and Malla, R., *Proceedings, ASCE GeoCongress 2006*, (Atlanta, GA, Feb. 26-March 01, 2006), ASCE, Reston, VA; Feb. 2006, 6p (CD ROM).

“Establish Subgrade Support Values for Typical Subs in New England,” Malla, R. B., and Joshi, S., April 2006, NETCR57.

**PROJECT NUMBER: 02-6**

**PROJECT TITLE:** Sealing of Small Movement Bridge Expansion Joints

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Ramesh B. Malla, University of Connecticut; Montgomery Shaw, University of Connecticut

**STATUS:** Completed

**INITIAL AGREEMENT DATE:** 08/01/2003

**END DATE:** 07/31/2005

**PROJECT OBJECTIVES:** The main objective of this project is to conduct research, based on analysis of relevant existing expansion joint sealing systems that will contribute to the development of most durable joint sealing material design for small movement bridge expansion joints in New England States. This project will look into selection of an appropriate sealing material (recently developed polymers) and ascertain its suitability by laboratory validation testing.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

Final report completed June 2006.

**REPORTS/PAPERS PUBLISHED AND PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“Silicone Foam Sealant for Bridge Expansion Joints,” Malla R. B., Shaw M. T., Shrestha M. R., Boob S., McMat 2005 Mechanics and Materials Conference Baton Rouge, Louisiana, June 1-3, 2005.

“Experimental Evaluation of Mechanical characteristics of Silicone Foam Sealant for Bridge Expansion Joints,” Malla R. B., Shaw M. T., Shrestha M. R., Boob S., Society for Experimental Mechanics Annual Conference Portland, Oregon, June 7-9, 2005.

“Development and Experimental Evaluation of Silicone Foam Sealant For Small Bridge Expansion Joints,” Matu Shrestha, M.S. Thesis, Dept. of Civil & Environmental Engineering, University of Connecticut, Storrs, CT, September 2005.

“Laboratory Evaluation of Weathering and Freeze-Thaw Effects on Silicone Foam Bridge Joint Sealant,” Shrestha, M.R., Malla, R.B., Boob, S. and Shaw, M.T., Paper #369, *Proceedings, SEM 2006 Annual Conference and Exposition* ( St. Louis, MO, June 04-07, 2006), SEM, Bethel, CT, June 2006, 8p (CD ROM).

“Sealing of Small Movement Bridge Expansion Joints,” Malla, R.B., Shaw, M.T., Shrestha, M.R. and Boob, S., June 2006, NETCR58.



“Development and Laboratory Analysis of Silicone Foam Sealant for Bridge Expansion Joints,” Malla, R., Shaw, M., Shrestha, M., and Brijmohan, S., *Journal of Bridge Engineering*, ASCE, Reston, VA, July 2006.

**PROJECT NUMBER: 03-1**

**PROJECT TITLE:** Ability of Wood Fiber Materials to Attenuate Heavy Metals Associated with Highway Runoff

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Allison MacKay, University of Connecticut

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 08/23/2003

**END DATE:** 05/31/2006

**PROJECT OBJECTIVES:** The objective of this research is to identify the key parameters that affect the efficacy of wood fibers for removing typical heavy metal contaminants from roadway runoff. Woody materials constitute a cheap, abundant material with the potential to attenuate the diverse suite of contaminants associated with roadway runoff. Laboratory column studies will be conducted to assess the effects of wood type and particle size, flow rate, wet-dry cycles, salt concentration and wood-aging effects on contaminant retention. Results of this research will be used to evaluate the heavy metal-attenuation effectiveness of current stormwater flow management techniques that incorporate woody materials, such as mulches used in slope stabilization and berm construction, and will be used to design remedial structures incorporating woody materials to be used for stormwater management in future roadway projects.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

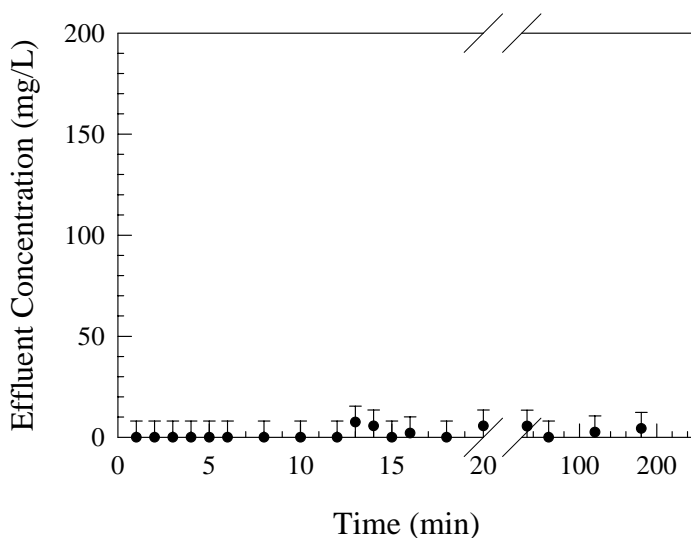
Heavy metals in roadway runoff may be present in either dissolved or particle-associated forms. Evaluation of factors controlling dissolved copper removals from runoff with wood chips were completed in 2005. During 2006, experiments were undertaken to evaluate particle-associated heavy metals from roadway runoff using wood chips. Particle-associated heavy metals would be removed from the runoff if the particles mobilized from the roadway surface are retained within the pore spaces of the wood chips. Roadway particles were anticipated to be removed within wood columns by gravitational settling as the flow followed tortuous paths around the wood chips. Particle removal was assessed using simulated runoff containing fine silica particles (17  $\mu\text{m}$  median diameter) with similar gravitational settling velocities (2.8 m/h) as typical suspended solids observed in roadway runoff.

Wood chips were observed to effectively attenuate silica particle concentrations in the simulated runoff. Initially, a representative concentration of 200 mg/L silica particles was introduced to columns packed entirely with wood chips. The effluent concentrations of particles suggested complete retention of particles within the wood column (Fig. 1); however, a large uncertainty was introduced into this conclusion because of the need to quantify effluent silica particle concentrations near the method detection limit. Consequently, the column experiments were repeated with a concentration of 2000 mg/L silica particles, about an order of magnitude greater than typically observed for roadway

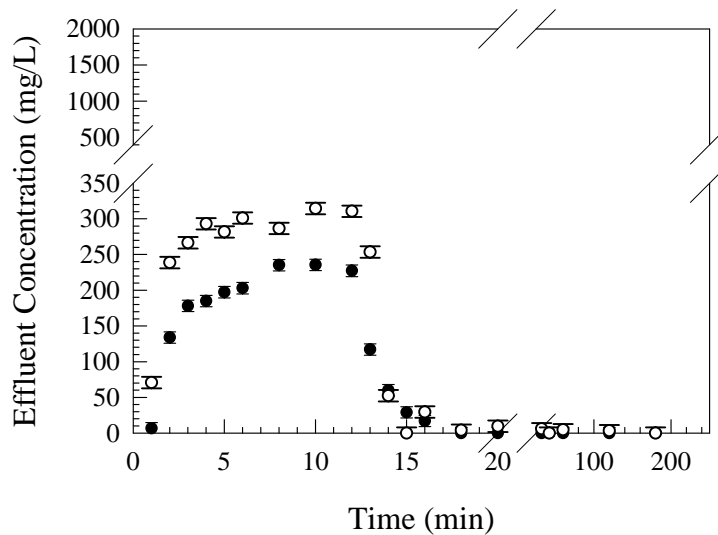
runoff. Effluent concentrations of silica particles were greatly reduced after passage through the wood column (Fig. 2). Integration of the breakthrough curves indicated that 85 to 89% of the silica particle mass was retained in the column.

By inference from the silica particle removals in the wood columns, greater than 85% of the particle-associated heavy metal mass also would be retained by the wood chips. These percentage removals of particle-associated heavy metals are greater than for dissolved copper removal with untreated wood chips (< 5%) and similar to dissolved copper removal with aged wood chips (> 80 % after 6 months). Therefore, aged wood chips could be effective for attenuating both dissolved and particle-associated heavy metals from roadway runoff. Further investigations of the wood chip capacity are required to estimate appropriate field deployment times.

### Figures.



**Figure 1.** Breakthrough curve for silica particle removal by wood chips. Silica particles were introduced to the column at a concentration of 200 mg/L for 10 min, a time equivalent to 0.25 pore volumes, and followed by clean water for 5 pore volumes.



**Figure 2.** Replicate breakthrough curve for silica particle removal by wood chips. Silica particles were introduced to the column at a concentration of 2000 mg/L for 10 min, a time equivalent to 0.25 pore volumes, and followed by clean water for 5 pore volumes.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:** None

**PROJECT NUMBER: 03-2**

**PROJECT TITLE:** Field Studies of Concrete Containing Salts of an Alkenyl-Substituted Succinic Acid

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Scott Civjan, University of Massachusetts, Amherst

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 09/01/2004

**END DATE:** 08/31/2007

**PROJECT OBJECTIVES:**

The overall objective of this project is to determine the field applicability of using DSS in concrete for transportation structures. Specifically the study will develop mixing and placing procedures for concretes containing DSS and will study how well DSS added to concrete in highway and bridge structures protects against reinforcement corrosion and freeze-thaw damage. Field placements using DSS will be made in various New England states. Procedures for long term monitoring will be implemented. In addition, recommendations for laboratory and field testing to address any concerns with long term performance will be developed.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

**Task 1a - Literature Review**

Periodic updates to literature review included updating information from Hycrete and evaluation of University of Kansas research report. The research team is not aware of any other published information on Hycrete in this time period.

**Task 1b - Determine Potential Sites for Field Implementation**

Contact was made with committee several times through the year requesting site recommendations. Paul D'Attilio followed up on requesting implementation projects as well. Requests were made through state representatives at the NETC meetings to push for field implementation projects. Several conversations with Hycrete representatives regarding the new structures they have been successful at implementing and ways that they have accomplished this.

Vermont provided construction at the Hartland Bridge as an implementation project (Curb). Meetings have been set up with Massachusetts and Maine offices to discuss potential projects. New York State has interest in precast concrete, so project with culvert type structure is possible and will be discussed in the next quarter. New Hampshire had originally submitted an IBRC request for a project, but there has not been any indication to the PI's whether this is expected to be funded. Connecticut does not foresee an implementation project during the course of the NETC 03-2 project. Rhode Island has not responded.

**Task 2 – Large-Scale Mixing**

Second (final) trial completed at Tilcon.

Old-Castle Precast plant in New York State used as a site to complete control self consolidating mix and similar mix with Hycrete added.

Pending any further requests from the advisory council or new mixture designs of interest this completes the large-scale mixing portion of the project.

**Task 3 - Field Placement**

Curb pour completed at Hartland, VT new bridge construction site. Approximately ½ of curb includes a Hycrete mixture design, with standard mixture design for the remainder. Wiring was attached prior to concrete placement to allow corrosion monitoring.

**Task 4 - Standardized Testing**

Testing of Carroll and TilCon (2<sup>nd</sup> series) and Old-Castle mix designs have been completed. Testing of Hartland Bridge (VT) mixes for compressive strength has been completed.

**Task 5 - Develop Specifications**

Sample specifications have been requested from DOT's and Hycrete. 4 specifications were received.

**Task 6 - Develop Monitoring Plan**

The Germann Instruments monitoring equipment have been used by committee members in the past and were decided upon for monitoring testing, along with standard half-cell readings. Monitoring methods used with these instruments have been obtained. GalvaPulse instrument has been borrowed.

Monitoring plan was prepared and implemented at the Vermont curb field implementation site..

**Task 7 - Prepare Final Report**

Draft sections for background, large scale mixing sections, and test results are being completed.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“Hycrete – DSS An Innovative Admixture for Concrete: An Update on NETC 03-2,” Presentation: Civjan, Scott A., and Crellin, Benjamin, 16th Annual NE Materials and Research Meeting Concord, NH. June 7, 2005.

“Hycrete Concretes: An Update on NETC 03-2,” Civjan, Scott A., and Crellin, Benjamin, Presentation made to the Connecticut DOT. November 2, 2005.

“A New Admixture to Mitigate Corrosion Problems,” Civjan, S.A., and Crellin, B.J., *Concrete International*, Volume 28, No. 8, Pp. 78-82.

**PROJECT NUMBER: 03-5**

**PROJECT TITLE:** Evaluation of a Field Permeameter as a Longitudinal Joint Quality Indicator

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Jo Daniel, University of New Hampshire

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 09/01/2003

**END DATE:** 02/28/2006

**PROJECT OBJECTIVES:** The main objective of this research is to evaluate a field permeameter as a tool to evaluate the quality of longitudinal joints. This will be accomplished by performing field permeability testing using a permeameter developed as part of the study. Permeability and core density testing will be performed at various construction projects around New England and the performance of the longitudinal joints will be evaluated over the length of this project.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

The research has been completed. The draft final report was submitted to the technical committee in October 2006.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“Development of a Longitudinal Joint Permeameter as a QC/QA Tool for HMA Pavements,” Daniel, J.S., a Presentation to the Petersen Asphalt Research Conference, Cheyenne, WY, June 2005.

“Longitudinal Joint Permeameter: New Non-Destructive Pavement Joint Test,” Daniel, J.S., a Presentation to the North East Asphalt User/Producer Group Meeting, Burlington, VT, October 2005.

“Longitudinal Joint Permeameter: Non-Destructive Test for QC,” Daniel, J.S., a presentation to PennDOT Bituminous Technician Certification Program, March 14, 2006.

“Development and Evaluation of a Field Permeameter as a Longitudinal Joint Quality Indicator,” Mallick, R.B., and Daniel, J.S., International Journal of Pavement Engineering, Vol. 7, No. 1, March 2006. pp. 11-21.



**PROJECT NUMBER: 03-6**

**PROJECT TITLE:** Fix It First: Utilizing the Seismic Property Analyzer and MMLS to Develop Guidelines for the Use of Polymer Modified Thin Lift HMA vs. Surface Treatments

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Walaa S. Mogawer, UMass Dartmouth; Jo Sias Daniel, University of New Hampshire

**STATUS:** New

**INITIAL AGREEMENT DATE:** 04/01/2006

**END DATE:** 10/30/2008

**PROJECT OBJECTIVES:**

- Define and compare thin lift overlay maintenance mixes and surface treatments currently used in the New England States.
- Evaluate the thin lift overlay maintenance mixes and surface treatments currently used in the New England States and compare to those currently used worldwide.
- Determine the current New England DOT procedures for picking rehabilitation methodologies.
- Perform and evaluate non-destructive testing to better determine the optimum time to apply surface treatments or thin lift overlay mixes to the existing pavements in order to properly prioritize rehabilitation projects.
- Evaluate the benefits and drawbacks of using PMA thin lift mixes versus surface treatments with lab testing.
- Evaluate the cost comparisons between PMA thin lift mixes and surface treatments.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

None

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:** None

**PROJECT NUMBER: 03-7**

**PROJECT TITLE:** Basalt Fiber Reinforced Polymer Composites

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Richard Parnas and Montgomery Shaw, University of Connecticut

**STAUTS:** Continuing

**INITIAL AGREEMENT DATE:** 11/16/03

**END DATE:** 11/15/05

**PROJECT OBJECTIVES:** We propose to investigate the usage of basalt fibers in low cost composites for civil infrastructure applications requiring excellent mechanical properties and long lifetimes. Basalt fibers have great potential as reinforcement in both polymer materials and in concrete. However, this proposed research will focus on the use of basalt fiber reinforced polymer composites.

A range of basic mechanical tests will evaluate polymer composites reinforced with basalt fibers. A limited number of companion tests will also be done with glass-reinforced composites using the same polymer as the basalt specimens to permit direct comparison between the two reinforcing materials. Subsequent tests will examine effects of environmental exposure on the composite material behavior.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

**1. ASTM 791 Flexure Test**

Table 1 gives the comparison of the three fabrics. The composites have the same fiber volume fraction, approximately 15.7%, in the weft direction which is the direction the flexure test was done.

**TABLE 1 Comparison of basalt and glass fabrics (8, 18)**

<b>Properties</b>	<b>Basalt Fabric</b>	<b>E-Glass BGF 443</b>	<b>E-Glass BGF 1527</b>
<b>Areal Density, g/m<sup>2</sup></b>	<b>750</b>	<b>425.5</b>	<b>425.5</b>
<b>Filament Diameter, micron</b>	<b>9</b>	<b>6</b>	<b>9</b>
<b>Yarn Linear Density, tex (g/km)</b>	<b>330</b>	<b>134.07</b>	<b>297.63</b>
<b>Weave pattern</b>	<b>Twill 3/1</b>	<b>Twill 1*3 RH</b>	<b>Plain weave</b>
<b>Yarn Balance (warp/weft), count/dm</b>	<b>1.53 = (119/78)</b>	<b>1.47 = (173/118)</b>	<b>1 = (67/67)</b>
<b>Layers used in the composite</b>	<b>3</b>	<b>5</b>	<b>4</b>

Results of the flexure tests are shown in Table 2 below, along with the 95% Confidence Intervals.

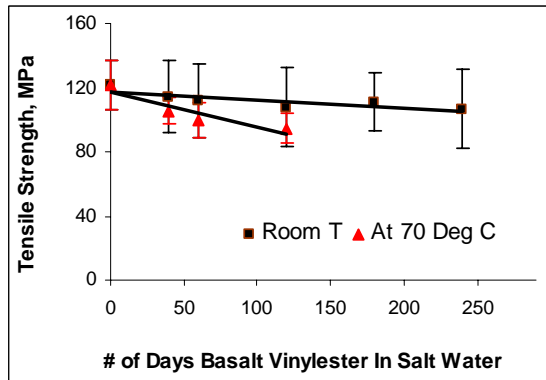
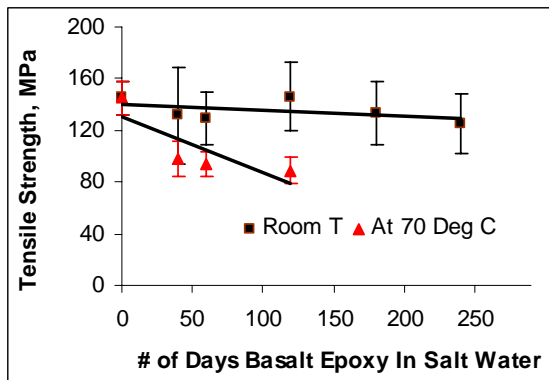
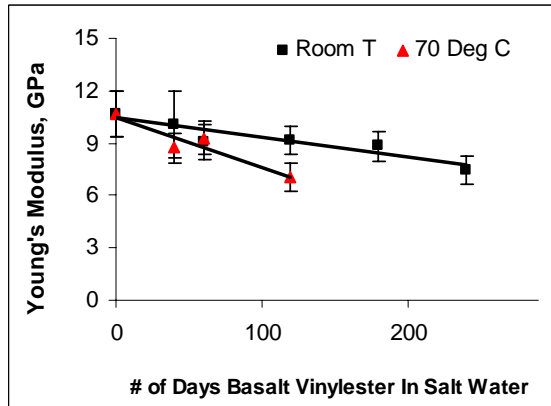
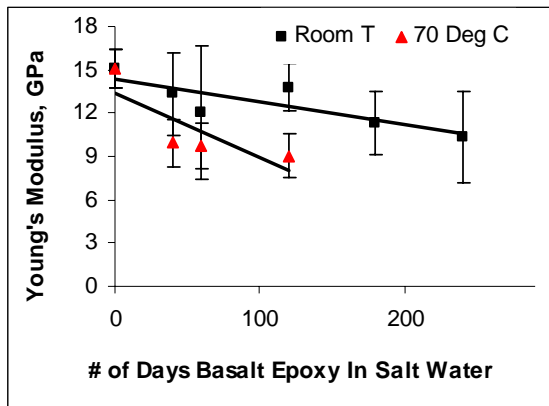
**Table 2. Comparison of results from flexure test**

	Young's modulus, GPa	Flexure Strength, MPa
<b>Basalt Epoxy</b>	<b>13.37 ± 1.40</b>	<b>204.56 ± 14.70</b>
<b>Basalt Vinylester</b>	<b>10.88 ± 0.70</b>	<b>195.79 ± 5.18</b>
<b>Glass (BGF 443-450) Epoxy</b>	<b>16.49 ± 0.57</b>	<b>160.56 ± 15.34</b>
<b>Glass (BGF 1527-500) Epoxy</b>	<b>12.58 ± 0.85</b>	<b>180.38 ± 24.63</b>
<b>Glass (BGF 1527-350) Epoxy</b>	<b>13.40 ± 1.33</b>	<b>225.81 ± 19.85</b>

Note: BGF 443-450: fabric BGF 443 was heat-treated at 450 °C before use, BGF 1527-500: fabric BGF 1527 was heat-treated at 500 °C before use, BGF 1527-350: fabric BGF 1527 was heat-treated at 350 °C before use. Heat treatment was to remove the finish on the fabric. High temperature, 450 °C and 500 °C damaged glass fabric, lowered the strength but not modulus.

## 2. Aging test

Exposure of the basalt composites to saturated salt water at 70 °C is presented below for exposure times up to 120 days. Tensile tests are being conducted (ASTM 3039) to assess the effects of exposure to salt water and other environments. The complete data set will be provided in the final report.



Obviously at higher temperature basalt composites degraded faster in the beginning and then seemed to flatten, while at room temperature the modulus dropped gradually.

### 3. Dynamic contact angle test

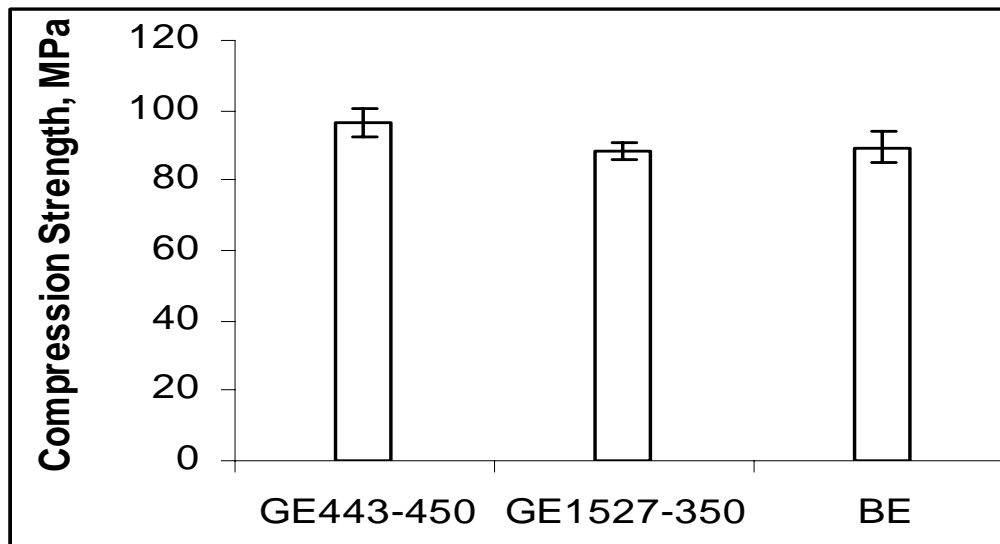
Dynamic contact angles, 95 % confidence interval of big basalt fiber, small basalt fiber and glass fiber were measured using the same fluid, diluted corn syrup, with surface tension about 79.724 dyn/cm.

	Approximate Diameter, mm	Advancing contact angle, Deg	Receding contact angle, Deg
Big Basalt fiber	1~2	72.17 ± 3.72	39.10 ± 1.02
basalt fiber	0.070	70.22 ± 3.84	0
Small glass fiber	0.009	65.42 ± 5.28	0

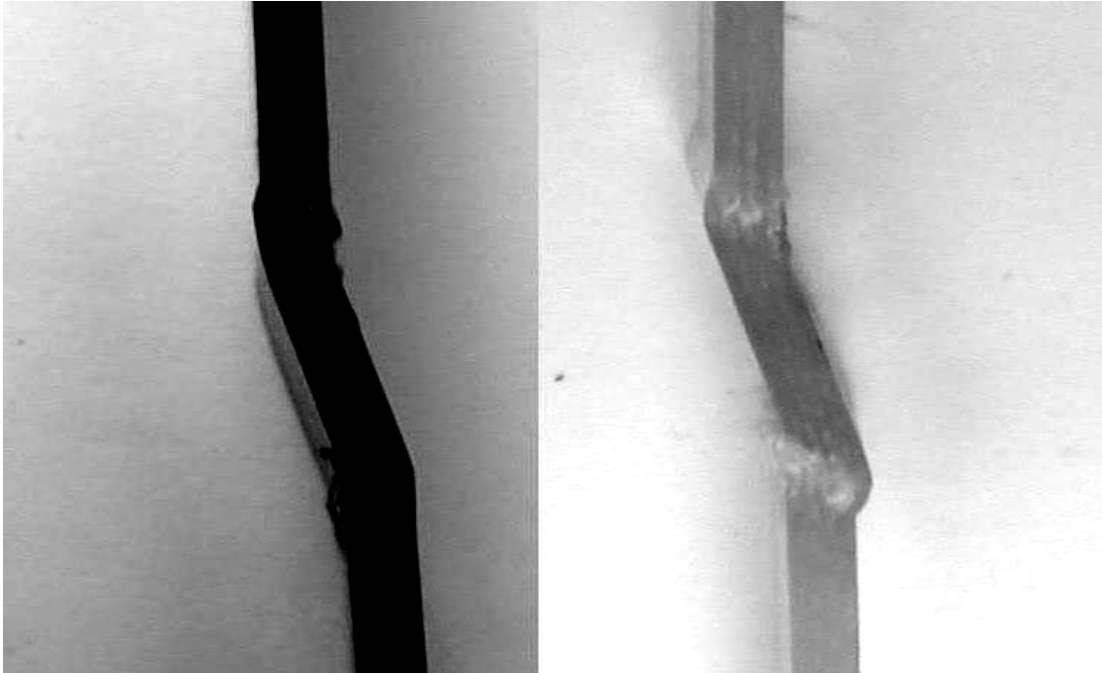
The results showed that dynamic contact angle measurement can not give any difference about polarity between the two different fibers.

### 4. ASTM 3410-75, composite compression test results

Compression results are shown in figure 1 (a). Although high temperature heat treatment reduced the composite tensile strength due to fiber damage, such damage has negligible effect on composite compression strength (1). So, no difference in compression strength is shown between GE 1527-350 and GE 1527-500. Also, no difference appeared between glass-epoxy and basalt-epoxy composites. Figure 1 (b) shows a failed basalt epoxy specimen in compression and all the other specimens (including basalt epoxy and glass epoxy) failed in the same way. This is a classic fracture pattern in compression, consisting of fiber microbuckling to form a “kink band” (2, 3-4). Such fiber buckling and kink band formation are caused by local shear instability between fiber and matrix (5). The similar compressive and short beam shear strengths observed for BE and GE443 suggest that many properties of the interfacial region around the basalt and glass fibers are similar in an epoxy matrix.



BE: basalt epoxy, GE443-450: glass epoxy with glass fabric-443 heat treated at 450 °C before use, GE1527-350: glass epoxy with glass fabric-1527 heat treated at 350 °C.



Failed specimens in compression, basalt epoxy (left) and glass epoxy (GE 1527-350)

**5. Completed tension-tension fatigue testing, ASTM D 3479/D 3479M – 96**

Frequency used: 0.5 Hz

Minimum load: 500 N

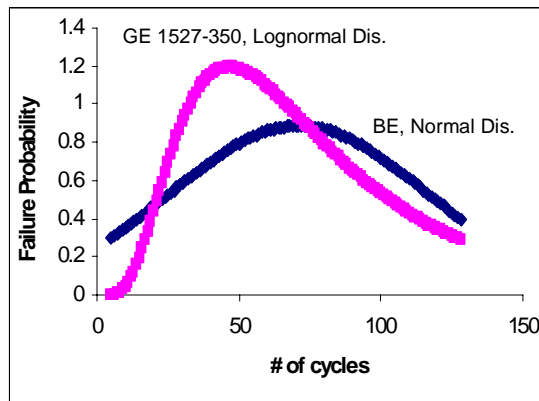
Maximum load: ~ N corresponding to 65%, 50% and 40% of the material ultimate strength.

The following table shows the number of cycles for the material to break under a certain load (for example, 65% of the ultimate strength). The number in each cell represents (average  $\pm$  standard deviation) from several replicated measurements. Basalt epoxy composites appear to have much better fatigue behavior than the glass epoxy counterpart.

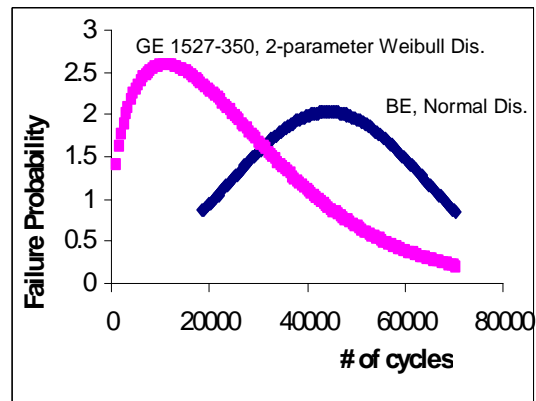
The ultimate strength of basalt epoxy is 160 MPa, and that for GE 1527-350 is 210 MPa.

	65 % of ultimate strength	50 % of ultimate strength	40 % of ultimate strength
Basalt Epoxy (compression molded)	72 $\pm$ 45	44364 $\pm$ 19649	2 data: 531990, 638680
Basalt Epoxy (RTM)	59 $\pm$ 24	26410 $\pm$ 23585	2 data: 330826, 213215
Glass Epoxy (GE 1527-350) (compression molded)	80 $\pm$ 63	25677 $\pm$ 21538	41601 $\pm$ 8903

The most appropriate distribution functions were fit to the data at 65% and 50% of ultimate strength, and notable differences emerge between the BE and GE materials.



Fatigue distribution at 65% of ultimate



Fatigue distribution at 50% of ultimate

**6. Final Report:** The Draft Final Report was submitted to the Project Technical Committee for review.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“Preliminary Investigation of Basalt Fiber Composite Properties for Applications in Transportation,” Q. Liu, M.T. Shaw, R.S. Parnas, A. McDonnell, Transportation Research Board Annual Meeting, January, 2005, Washington, DC, paper 05-1117, session 487.

“Investigation of Basalt Fiber Composite Mechanical Properties for Applications in Transportation,” Q. Liu, M.T. Shaw, R.S. Parnas and A.M. McDonnell, Polymer Composites, 27(1), 41-48, 2006.

“New Set-Up For In-Plane Permeability Measurement,” Q. Liu, R. S. Parnas and H. S. Giffard, Composites Part A, submitted.

“Investigation of Basalt Fiber Composite Aging Behavior for Applications in Transportation,” Q. Liu, M. T. Shaw, R. S. Parnas, A.M. McDonnell, Polymer Composites (*in press*).

“Basalt Fiber Reinforced Polymer Composites,” Q. Liu, R.S. Parnas, M.T. Shaw, A.M. McDonnell, SAMPE, Seattle, WA, November 2005.

“New Set-up for Permeability Measurement,” Q. Liu, R.S. Parnas, SAMPE, Seattle, WA, November 2005.

**PROJECT NUMBER: 04-1**

**PROJECT TITLE:** Recycling Asphalt Pavements Containing Modified Binders

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** James Mahoney,  
Connecticut Transportation Institute, University of Connecticut

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 08/23/2005

**END DATE:** 08/22/2007

**PROJECT OBJECTIVES:**

Phase 1

The first objective of this Phase of the research is to provide a universally accepted definition of what constitutes a modified asphalt binder. The second objective of this Phase is to determine what types of modified asphalt binders are currently being used in the region. This will include contacting State Transportation Agencies as well as asphalt binder suppliers.

Phase 2

The objectives of the second Phase of this project will attempt to address incompatibilities that may arise when RAP containing modified asphalt binder is used in a new HMA pavement that contains a virgin modified asphalt binder. This Phase of the project will also provide guidance as to the proper amount of RAP that can be added to the HMA without causing problems. (A proposed revision to the Phase 2 project objective has been submitted to the technical committee chair for this project.)

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

- Phase 1 of this project has been completed. The Phase 1 report has been accepted by the technical committee.
- A slight revision of the Phase 2 work plan has been proposed by the technical committee and principal investigator. The initiation of Phase 2 of this project is pending authorization by NETC.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:** None

**PROJECT NUMBER: 04-2**

**PROJECT TITLE:** Driver-Eye-Movement-Based Investigation for Improving Work-Zone Safety

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Donald L. Fisher, University of Massachusetts, Amherst and Mike Knodler, University of Massachusetts, Amherst

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 03/01/2005

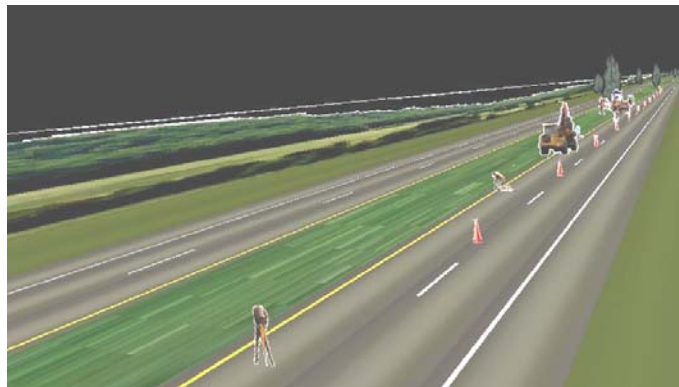
**END DATE:** 01/31/2007

**PROJECT OBJECTIVES:**

1. Determine how driver eye movements vary with different work zone designs
2. Develop recommendation for more effective use of existing work zone traffic control devices.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2005:**

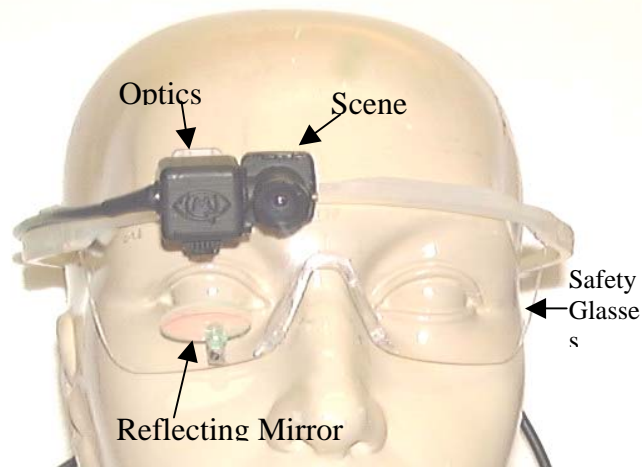
**Driving Simulator Experiment.** We have completed the first driving simulator experiment. We built 112 miles of simulated rural highway that looks very similar to the real highway that will be used. The work zones that appear in virtual world contain all of the features of real work zones, including cones, workers, and machines (photograph below, right). This simulated rural highway is projected onto three screens that subtend 150° of visual angle in front of the driver. Drivers maneuver through the virtual world while sitting in a real, 1995 Saturn sedan (see photograph below, left). They are outfitted with an eye tracker which overlays on the video of what they are viewing a cursor that indicates the exact position in the scene at which they are looking at each moment in time.





Participants. A total of 38 drivers between the ages of 18 and 59 years participated in the experiment. The average age of each group was 26.4 years.

Experimental Design and Procedure. Two sets of 16 scenarios were created. Four factors were varied orthogonally within each set: (1) the activity in the work zone (present or absent), (2) the location of the work zone (left or right side), (3) the requirement to change lanes in order to move through the work zone (required or not required), and (4) the presence of a vehicle in the left side view or rear view mirror when a lane change is required (present or absent). The manner in which the 16 work zones were presented to participants was counterbalanced across scenarios so the approach (right or left), work zone location (right or left), activity within the work zone (equipment within the work zone or an empty work zone), and whether there was a following vehicle or not, all seemed to vary randomly. Each participant drove four 14-mile blocks with 4 scenarios each, in two of the 14-mile blocks doing the simulated cell phone task and two were not doing the task. Half of the participants engaged in a simulated, hands-free cell phone task in the first and third blocks; the other half in the second and fourth blocks. Additionally, in each of the 16 scenarios the lead car slowed. In eight of each group of 16 scenarios, the lead car braked without warning (presumably because of unforeseeable hazards). In the other eight scenarios the participant driver was given cues that they would be stopping ahead. Such cues would be pedestrians



crossing the road several vehicles ahead, a stopped (taller) vehicle ahead, or a vehicle emerging from the work zone ahead of a lead vehicle. The cued and uncued scenarios occurred equally often in the right and left work zones and equally often in the work zones with and without activity. All drivers wore a head mounted eye tracker (photograph, above) manufactured by ASL. The head mounted eye tracker used in the field studies overlays gaze position on the a video record of what the driver is scanning.

Results. Analysis of the vehicle data indicated that drivers on the cell phone were closer to a vehicle slowing in the work zone when they first braked, were traveling faster when they were within 49 feet (15 m) of the slowing vehicle, and were more likely to brake hard. Analyses of the eye tracker data were also undertaken. Mirror glances were recorded for lane changes in responses to other vehicles, to work zone transitions (the start of cones) and to signs directing them to move right or left. If a driver failed to glance into the mirror, he or she was much more likely to be on the cell phone than not. Additionally, the spread of the middle 50% of the glances on the horizontal axis was much smaller (by a factor of two almost) for drivers on the cell phone than it was for drivers not on the cell phone. The results strongly suggest that cell phone use reduces situational awareness and will increase the two major types of crashes in work zone activity areas, which are rear end and sideswipe collisions.

**Field Study.** We have just completed an experiment in the field. Twenty-four drivers navigated a closed one mile road on campus a total of four times, in part of which a work zone with barrels was set up. Vehicle data was captured and stored in real time. The vehicle itself was instrumented with three cameras (in addition to the eye tracker), one on the driver's foot, one on the speedometer and one aimed at the readout from a forward facing laser rangefinder that measured the following distance. The driver wore the same eye tracker in the field study that was used in the simulator study. On two of the loops, the driver was engaged in a simulated hands-free cell phone task (the same one that was used in the simulator); on the other two loops the driver was not so engaged. A lead vehicle was always ahead of the participant driver. Cues that the lead vehicle would stop were used on two of the loops. In this case, a human like mannequin (on a short platform with wheels) was pulled across the work zone when the lead vehicle closed to within 100 feet. The thought was that a pedestrian (i.e., mannequin) entering the path of a lead vehicle should alert an attentive driver that he or she may have to slow for a lead vehicle soon. The lead vehicle never actually decelerated, but the driver of the lead vehicle activated the brake lights half the time that the mannequin was pulled across the road and half the time that the mannequin remained in the work zone. All mannequins wore traffic safety vests with florescent and retroreflective materials. The results are now being analyzed.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“Human Factors: Understanding & Evaluating Driver Response,” Muttart, J.W., Anne Arundel County Police Special Operations Building, Sponsored by the Maryland Association of Traffic Accident Investigators, Hanover, MD. March 20 - 23, 2006.

“Understanding and Quantifying Driver Response,” Muttart, J.W., Texas Association of Accident Reconstructionist Specials, Houston, TX, February 17 & 18, 2006.

“Using Event Data Recorder Information for Driver Response Research and Intelligent Transportation Systems in Rear End Collision,” Muttart, J.W., CDR Users Conference, Dallas, TX. February 13, 2006.

“Human Factors: Understanding & Evaluating Driver Response,” Muttart, J.W., Canadian Association of Traffic Accident Investigators & Reconstructionists, Fredericton, NB, Canada. July 10 - 13, 2006.

“Driving Simulator Evaluation of Situational Awareness during Hands-Free Communication,” Muttart, J.W., New England Institute of Transportation Engineers Technology Day, Amherst, MA. July 20, 2006.

“Accounting for Moderate Driver Distractions in Work Zones,” Muttart, J.W., Factors, Formulae, Forensic, Technology, & Training Conference, Houston, TX. September 17, 2006.

“Driving Simulator Evaluation of Situational Awareness during Hands-Free Communication Tasks,” Muttart, J.W., Research paper submitted to the Transportation Research Board and accepted as a presentation to be given 1/21/07 in Washington, DC.

**PROJECT NUMBER: 04-3**

**PROJECT TITLE:** Estimating the Magnitude Of Peak Flows for Steep Gradient Streams in New England

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Jennifer Jacobs and Thomas Ballestero, University of New Hampshire and Richard Vogel, Tufts University

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 10/01/2004

**END DATE:** 03/31/2008

**PROJECT OBJECTIVES:** The main objective of this research is to develop a set of regional regression relationships to predict flood flows for steep slope watersheds from basin characteristics. The regression relationships will be developed using standard USGS regional hydrologic methods. We propose to identify target watersheds in the New England region and to develop a database of physical basin parameters and historical streamflow necessary for the statistical analysis. Regression analyses will be conducted to identify explanatory variables and to develop regression relationships for average daily flow and 2-, 10-, 25-, 50-, and 100-year peak flow recurrence interval events. As appropriate, the New England states will be divided into subregions.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

The Literature Review was presented to the committee and feedback was provided. The watershed selection was completed. A database of 204 watersheds were selected for this study (Figure 1). The main channel slope for these 204 watersheds ranges from 50 – 625 ft/mile (Figure 2). All historical streamflow statistics and basin characteristics were developed for each watershed. A database of supporting values was developed. The regression analyses were conducted using the finalized flow and watershed characteristics. A preliminary set of equations was identified. The regression analysis will continue in the next year.

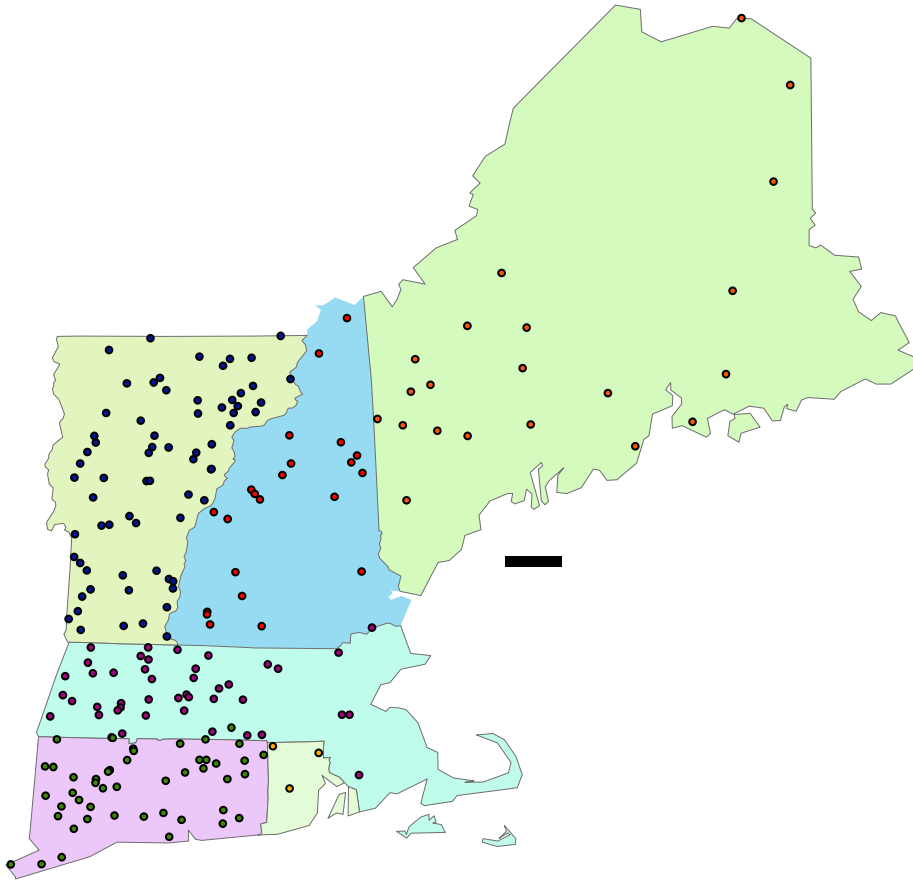


Figure 1. Distribution of watersheds throughout New England.

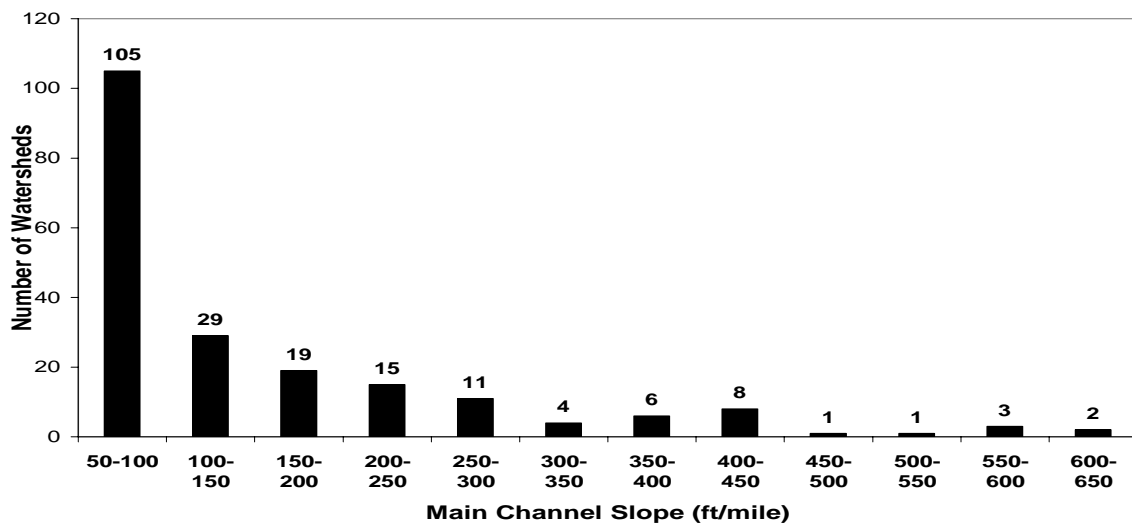


Figure 2. Range of Main Channel Slopes of Selected Watersheds

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO  
THIS PROJECT FROM THE START OF THE PROJECT THROUGH  
DECEMBER 31, 2006:**

2006 Maine Water Conference, Augusta, ME, March 22, 2006. Poster presentation.

**PROJECT NUMBER: 04-4**

**PROJECT TITLE:** Determining the Effective PG Grade of Binder in RAP Mixes

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** PI: Jo Daniel, University of New Hampshire; Co-PI: Walaa Mogawer, UMass Dartmouth

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 10/01/2004

**END DATE:** 03/31/2008

**PROJECT OBJECTIVES:** The main objective of this research is to develop a method to determine or estimate the binder grade in mixtures designed with RAP from the properties of the mixture itself.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

During the first quarter of 2006, the project was delayed as the asphalt mixing and testing laboratories moved into new facilities. The larger lab space allows all equipment to be located in one place and streamlines specimen mixing and compacting.

The aggregate stockpiles for this project were sieved and separated into the respective sizes. The mix designs for all RAP conditions were completed and verified. The mix design details can be found in Table 1.

Table 1. Mix Design Summary

**Mix Design Summary**

<b>Rap Content</b>	<b>Asphalt Content</b>	<b>VMA %</b>	<b>VFA %</b>
<b>Criteria</b>	N/A	13.0 min	65-78
<b>Control</b>	6.0	17.4	77.0
<b>10%</b>	5.7	17.2	74.0
<b>25%</b>	5.3	17.0	76.9
<b>40%</b>	5.1	18	70.0

Specimen fabrication was completed for the control and 10% RAP conditions and dynamic modulus testing began for these mixtures. Binder testing on all of the mixtures is underway.

The field cores were tested for Gsb, and two specimens were broken down to determine the Gmm. The two specimens that were broken down had strength testing conducted. The results are shown below in table 2. The remaining field cores will be subject to dynamic modulus and strength testing.

Table 2. Properties of Field Cores

**Summary of Properties**

	Gmb	Gmm	Va	Strength (kPa)
FC 1	2.487	2.632	5.5	1241.2
FC 2	2.444	2.640	7.4	
FC 3	2.493	2.640	5.6	
FC 4	2.458	2.640	6.9	
FC 5	2.489	2.640	5.7	
FC 6	2.425	2.649	8.4	1379.8
FC 7	2.441	2.640	7.5	
FC 8	2.465	2.640	6.6	
FC 9	2.429	2.640	8.0	
FC 10	2.479	2.640	6.1	

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:** None



**PROJECT NUMBER: 04-5**

**PROJECT TITLE:** Network-Based Highway Crash Prediction Using Geographic Information Systems

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** John N. Ivan, University of Connecticut and Per Gårder, University of Maine, Orono

**STATUS:** Continuing

**INITIAL AGREEMENT DATE:** 08/23/2004

**END DATE:** 03/31/2007

**PROJECT OBJECTIVES:** The objectives of this project are to estimate network-based crash prediction models that will predict the expected crash experience in any given geographic area as a function of the highway link, intersection and land use features observed in the area. The result will be a system of GIS programs that permit a polygon to be drawn on a map, or a set of links and intersections to be selected, and then predict the number of crashes expected to occur on the selected traffic facilities. These expected values can then be compared with observed values to identify locations that are particularly dangerous and require attention for improving safety. Alternatively, this tool could be used to estimate the safety impacts of proposed changes in highway facilities or in different land development scenarios. Another project objective is to demonstrate the value of the resulting system in helping planners and engineers to consider road safety when conducting transportation and land use planning and design and policy-making. This will be done by presenting and demonstrating the resulting model system at a workshop given to each of the New England State DOT's.

The particular novelty with the approach is that land use data by zone is used for accident prediction models for roads on a link level. The land use is used for enhancing the estimates of exposure to accidents by taking into account the amount of traffic that can be expected in and out of areas, exiting and entering the state routes for which the models are developed.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

**Literature survey**

A literature survey with a special focus on the use of GIS and land use data in accident modeling has been compiled. New references are added continuously for the duration of the project.

**Data acquisitions and compilation**

Data for the region around Hartford, Connecticut has been compiled, including:

- land use data (number of residents, retail-employees and non-retail employees by Traffic Analysis Zone (TAZ), obtained from CRCOG<sup>1</sup>)

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<sup>1</sup> Capitol Region Council Of Governments, the planning authority of the Hartford region, CT

- land cover data (maps detailing land development developed by CLEAR<sup>2</sup> from aerial photos)
- traffic flow data on state routes for 1996-2004 (obtained from ConnDOT)
- accident data for state routes for 1996-2003 (obtained from ConnDOT, 2004 data will be added when available)
- road characteristics (obtained from CRCOG and ConnDOT)

Similar data, but excluding land cover maps, has been acquired from MaineDOT for the Maine state route network and TAZs.

### **Procedure for allocating zonal data to links**

As part of the project a procedure has been developed for allocating zonal data. The full procedure consists of three sub-procedures: 1) The splitting of links into shorter segments that either are fully located within one zone or act as a border between the same two zones for their entire length, 2) Identification of all link segments either adjacent to or interior to each zone, and 3) Allocation of the zone attributes (population and employment) to the links associated with each zone, according to attributes of the zones and the links, as well as other information describing the area. Step 2 has been necessitated by the situation that the link layers and TAZs don't line up. This, in its turn, is due to that they originally were coded on different occasions.

### **Estimation of Accident Prediction Models**

Accident prediction models have been estimated for the following contexts:

1. Major intersections (between state roads with AADT and accident data available)
2. Segments between major intersections
  - a. Two-lane rural roads
  - b. Two-lane urban/suburban roads
  - c. Four-lane undivided roads
  - d. Four-lane divided roads
3. Minor intersections on segments between major intersections
  - a. Two-lane rural roads
  - b. Two-lane urban/suburban roads
  - c. Four-lane undivided roads
  - d. Four-lane divided roads

There were not enough major intersections in the dataset to subdivide them by type of road. The descriptor variables used, in addition to the population and employment variables, include road width and speed limit for the segment and minor intersection models and number of lanes for the major intersection models. For the minor intersection models, trip generation (estimated from the population and employment values using ITE rates) proved to be result in the best model fit.

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<sup>2</sup> Center for Land use Education And Research at University of Connecticut, [www.clear.uconn.edu](http://www.clear.uconn.edu)

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“A Procedure for Allocating Zonal Attributes to a Link Network in a GIS Environment,”  
Jonsson, T., Deng, Z., Ivan, J.N., presented at 85th TRB Annual meeting, Jan. 2006,  
Paper No.: 06-2561.

“Using Land Use Data to Estimate Exposure for Improving Road Accident Prediction,”  
Jonsson, T., Ivan, J.N., Zhang, C., presented at 32<sup>nd</sup> Annual Traffic Records Forum, Palm  
Desert CA, Aug. 3, 2006.

**PROJECT NUMBER: 05-1**

**PROJECT TITLE:** Development of Supplemental Resistance Method for the Design of Drilled Shaft Rock Sockets

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Thomas C. Sanford,  
University of Maine

**STATUS:** New

**INITIAL AGREEMENT DATE:** 1/1/2006

**END DATE:** 12/31/2007

**PROJECT OBJECTIVES:** The objective of this study is to produce a drilled shaft design method for evaluating the now unused side shear or end bearing to supplement the AASHTO allowable load. The magnitude of unused side shear or end bearing corresponding to the AASHTO allowable load will be the magnitude that occurs at the same shaft movement as the allowable load. This method should reflect different rock socket geometry and different rock properties typical of New England. The method should be based on past load tests and be robust and easy-to-use.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

First draft of literature review sections for Osterberg Cell and for construction effects on capacity completed. Gathered methods to estimate side and end capacity. Also gathered material on bedrock geology of New England. Began gathering material on load tests.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:** None

**PROJECT NUMBER: 05-3**

**PROJECT TITLE:** Practicable Calibration Procedures to Enhance the Accuracy of Analytical and Microsimulation Software for Modern Four-Legged Single-Lane Roundabouts

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** Adel E. Sadek, University of Vermont, Per Garder, University of Maine and Lisa Aultman-Hall, University of Connecticut

**STATUS:** New

**INITIAL AGREEMENT DATE:** 1/1/2006

**END DATE:** 12/31/08

**PROJECT OBJECTIVES:**

To ensure the effective implementation and operation of roundabouts, however, the transportation community is in need of accurate modeling tools to aid in planning, design and analysis of roundabouts. Transportation professionals charged with the task of the operational analysis of existing and future roundabouts have a wide range of available models and software, which vary in their modeling approach, capabilities and graphical representation. These tools, however, can be broadly divided into two groups: (1) analytical models such as aaSIDRA and RODEL; and (2) microscopic simulation models, such as PARAMICS and VISSIM.

Transportation professionals attempting to analyze and design roundabouts are confronted with a number of questions that remain unanswered. These questions include: (1) which software is best suited to analyze a given existing or future roundabout; (2) how accurate the software outputs are compared to field data; and (3) how the accuracy of these models can be improved within reasonable budget and time constraints. The current project is designed to help transportation professionals answer these questions.

Specifically, for the analytical models, the research will: (1) assess the accuracy of the two most widely used analytical models for roundabouts analysis (i.e. aaSIDRA and RODEL) by comparing their estimates of queue lengths and delay against field measurements (this comparison will be conducted for a wide range of traffic characteristics and for two different geometric configurations); (2) investigate how to enhance the accuracy of the two models' estimates by calibrating the models using location-specific parameters; and (3) formulate a step-by-step procedure for calibrating the models. This procedure will include a detailed description of the relevant data required for calibration, as well as an estimate of the effort needed.

For microscopic simulation models, the research will first select the most appropriate microscopic simulation model for modeling roundabouts, and then do the following: (1) assess the accuracy of the model against field observations; (2) determine

those model parameters that have the most significant impact on the results, and should therefore be the focus of the calibration process; and (3) develop a detailed procedure for the calibration of microscopic parameters to roundabouts operations. The scope of the project is limited to four-legged, single lanes roundabouts.

### **PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

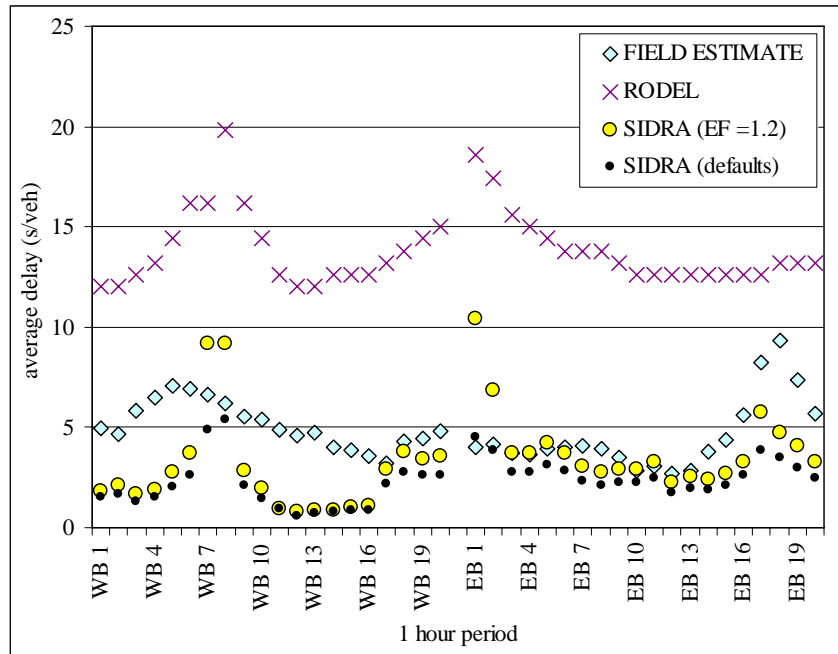
- 1) A comprehensive inventory of New England roundabouts has been compiled. The inventory contained information regarding the location of the roundabout, its geometric configuration, the number of legs and number of lanes, the year the roundabout was built, and the traffic volumes at the roundabout. From the inventory, it was determined that the Nashua, NH roundabout seemed to be the best candidate for the project, and was thus selected as our first study roundabout.



**The Nashua Roundabout**

- 2) A video-conference was held on June 8 between the project's principal investigators and the project's technical committee to review the project's progress and to get the project technical committee's approval on the selected roundabout.
- 3) The Nashua roundabout was videotaped for a total of twelve hours worth of data. The data were recorded in two six hour sessions (6-12 am and 12-6 pm). From the videotapes, the research team extracted volume, stopped delay, and queue lengths information from the video-tapes. Data extraction and reduction proved to be a very labor intensive process, especially given the fact that we had to deal with four videotapes from the four cameras for each time period, and had to ensure that the four cameras are synchronized. To accomplish the task in a timely manner, we had to employ a total of four students for the task, which still almost took the whole summer to complete.
- 4) The field measured delay was then compared to output from corresponding periods using aaSIDRA and RODEL. The results are shown in the Figure below. As can be seen, aaSIDRA estimates seem to be close to the field measurements, but the accuracy varies by approach. On the other hand, RODEL seems to overestimate the delay. Specifically, the average error was 1.4 seconds for SIDRA, and about 9 seconds for RODEL. A TUKEY's paired t-test was performed on the data, revealing that the average error for aaSIDRA is significantly lower than that for RODEL at the 0.05 level.

## Average Delay Comparison: aaSIDRA and RODEL vs. Field Estimate



An attempt to calibrate the aaSIDRA results was made using the available “environmental factor” (EF). This parameter varies gap acceptance values used in the model. After some trial and error, an EF of 1.2 gave even closer values to the field measurements; however some spiking of the results occurred for a few data points (see above). Varying the Entry/Circulating Flow Adjustment values in the aaSIDRA configuration window had insignificant effect on the results.

### REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:

“Assessing the Accuracy of Roundabouts Analysis Procedures against Field Observations: Preliminary Results from a Case Study in Northern New England,” Smith, M.C., Sadek, A.W., Johnson I., Aultman-Hall L., and Garder P., 2007, Proceedings of the *Annual Transportation Research Board Meeting*, TRB, National Research Council, Washington, D.C.

**PROJECT NUMBER: 05-6**

**PROJECT TITLE:** Employing Graphic-Aided Dynamic Message Signs to Assist Elder Drivers' Message Comprehension

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** J. H. Wang, University of Rhode Island

**STATUS:** New

**INITIAL AGREEMENT DATE:** 1/1/2006

**END DATE:** 12/31/2007

**PROJECT OBJECTIVES:**

- Review and evaluate existing research and literature related to the use of graphic-aided DMSs and the effects of such uses on elder drivers.
- Examine the feasibility of employing graphics in DMS messaging to assist drivers' comprehension of the message with a particular focus on elder drivers.
- Compile and or develop a library of graphic-aided text messages if such use were determined to be both feasible and beneficial.
- Make recommendations to identify, re-design, or create elderly friendly dynamic message signs that are effective for the driving population as a whole.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

A comprehensive review was performed on existing researches, publications, manuals, and articles, both in the US and internationally, related to the application and use of graphic symbols/pictograms for dynamic message signs. A review of any "Best Practices" documentation created by state DOT's and agencies was conducted and a partial summary of these documents per state DOT's or agencies for the use of graphics, both static and dynamic, in use with dynamic message signs was created. A computer-based questionnaire to collect drivers' opinions and preferences regarding the use of graphics in DMS was developed. It is planning to start the survey in February 2007.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

A presentation was given to the Rhode Island DOT on November 16, 2006.



**PROJECT NUMBER: 05-7**

**PROJECT TITLE:** Warrants for Exclusive Left Turn Lanes at Unsignalized Intersections and Driveways

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** John N. Ivan, University of Connecticut and Adel E. Sadek, University of Vermont

**STATUS:** New

**INITIAL AGREEMENT DATE:** 5/23/2006

**END DATE:** 11/22/2007

**PROJECT OBJECTIVES:**

The primary objective of this project is to consider accident and operational experience to develop a set of warrants prescribing conditions under which it is and is not appropriate to install exclusive left turn lanes at unsignalized intersections and driveways. The resulting warrants will balance both safety and operational considerations. Empirical Bayes analysis and negative binomial modeling will be used to compare the accident experience at unsignalized intersections with and without exclusive left turn lanes, especially noting the contributions of other conditions (e.g., volume level, land use, driveway density, and roadway geometry). Traffic simulation will be used to estimate delay to through and left-turning vehicles at these same intersections, again noting the contributions of these other conditions. The resulting warrants will then consider not only traffic volumes, but also observed safety experience and other pertinent characteristics of the intersection or driveway.

A secondary objective is to examine the safety experience at unsignalized intersections and driveways with existing exclusive left turn lanes to see what can be learned about how to design them to be safer. This will involve observing all of the geometric characteristics of the sites studied, along with the precise application of traffic control devices used, including pavement markings and signage, as well as lane and pavement width. Then, in addition to the warrants developed, we will also prepare guidelines for how to physically design and control exclusive left turn lanes to maximize safety for all road users.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

**Current practice survey**

A survey was designed and distributed to gather input about current practice regarding adding left turn lanes at unsignalized intersections. We have only received 14 surveys to date, three reported to be from New England highway agencies, but four did not give contact information, so they may or may not be from New England.

**Safety warrants**

Data collection and analysis in Connecticut focus on the safety aspects associated with developing the left-turn lane warrants. A list of 60 intersections has been prepared so as

to include equal numbers of intersections in each of the subcategories, namely: with/without left turn lanes, 3 or 4 approach legs, rural versus non-rural settings, and number of through lanes. Six intersections have been videotaped for a period of four hours consisting of two peak hours and two off-peak hours. Half of the intersections are with a left-turn lane and the other half without. The videos are prepared for use in calibrating the operational analysis done in Vermont.

Accident records for the 60 intersections selected in Connecticut for safety analysis were collected for years 1999 through 2004. For each intersection, the ConnDOT photolog was consulted to confirm that the design during the 6-year period was unchanged with respect to the presence or absence of a left turn lane. Preliminary analysis has also been completed to identify for 12 intersections which accidents are likely to be related to the left turn lane in the study intersection as opposed to nearby intersections or driveways.

### **Operational warrants**

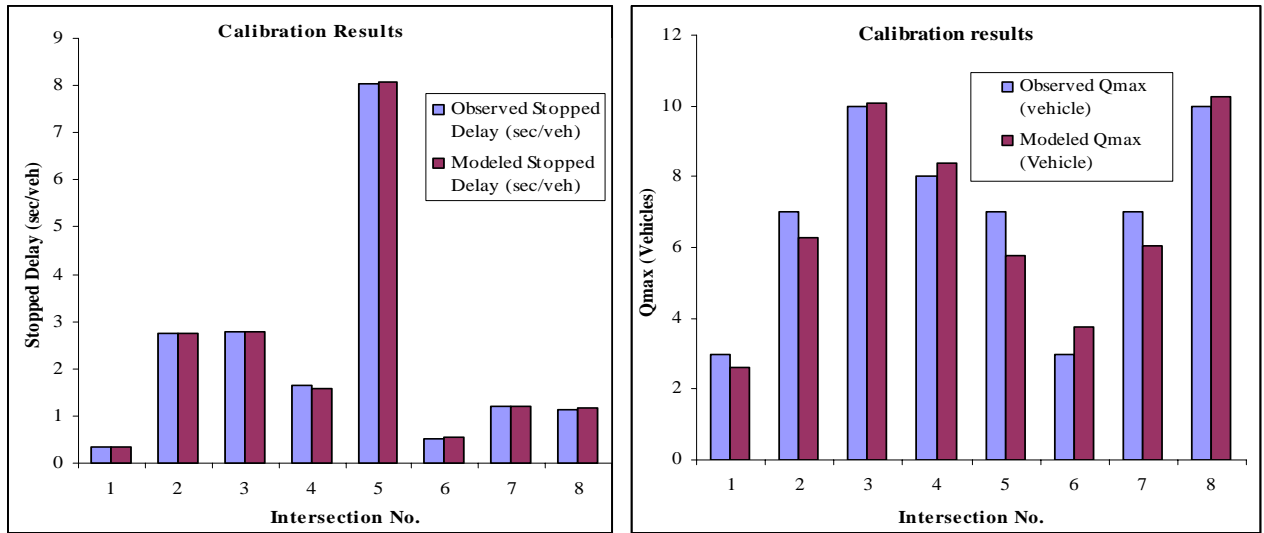
In Vermont, the data collection and analysis focus on the operational aspects associated with the development of left-turn lane warrants for unsignalized intersections. As was mentioned in the previous progress report, data collection and reduction were completed at a total of 10 unsignalized intersections distributed throughout Chittenden County, Vermont, and representative of various configurations (i.e. two-lane vs. multi-lane roads) as well as various driving environments (i.e. urban vs. sub-urban vs. rural). For each intersection, the following data were extracted: (1) Advancing, opposing and left turning volumes; (2) Basic geometric information (number of lanes, lane channelization and operating speed); (3) the discharge headway from a queue; (4) Average and maximum queue length during the one hour of observation; (5) Stopped delay at the subject link; and (6) Gap acceptance behavior.

The study then proceeded to develop and calibrate microscopic traffic simulation models for each intersection in CORSIM. Thirty different runs with different seed numbers were performed using the CORSIM Script tool, and the results from these runs were averaged to get a more accurate picture of the CORSIM's reported performance measures. For calibration, the gap acceptance distribution, the discharge headway and the vehicle entry distribution for each intersection were adjusted based on the values obtained from the videotapes. For each intersection, the model's output (i.e. the average of 30 runs) was then compared against several field measurements. Excellent calibration results were obtained as evidenced by Figure 1 which compares the average stopped delay and maximum queue length (as determined from the 30 CORSIM runs) to the values measured from the field. As can be seen, the values are almost identical for all eight sites.

To develop the warrants, we focused first on one road category (namely the 2-lane urban case) and generated a set of 150 random operational scenarios, each representing a certain combination of advancing volume, opposing volume, left-turn percentage and speed. In generating these scenarios, advancing and opposing volumes were randomly varied between 100 and 800 vehicles/hr/lane, left-turn percentage was varied between 3% and 30%, and speed was varied between 40 and 60 mph. For each scenario, two cases were simulated once without a left-turn lane and another with a left-turn installed. As before, each case was run for 30 times, each time with a different seed numbers and the

results were averaged over the 30 runs. The output from all these runs was a dataset which for each operational scenario gave the estimated values for the following performance measures: control delay (sec/veh), percent stops, fuel consumption (mpg), Carbon monoxide (CO), Nitrogen oxide (NO) and Hydrocarbon (HC) emissions (gram/mile) for two cases, without a left-turn lane and with a left-turn lane. Initial efforts were also made toward developing Neural Network models to generalize the results obtained. These NNs would form the basis for developing the warrants, as well as developing a Decision Support System for estimating the benefits of installing exclusive left turn lanes at unsignalized intersections.

**Figure 1 - Results of the Calibration Procedure**



Subsequently, we generated the different operational scenarios for the different road categories (2-lane urban, 4-lane urban and 2-lane rural). For each road category, 150 random operational scenarios, each representing a certain combination of advancing volume, opposing volume, left-turn percentage and speed were generated. In generating these scenarios, advancing and opposing volumes were randomly varied between 100 and 800 vehicles/hr/lane, left-turn percentage was varied between 3% and 30%, and speed was varied between 40 and 60 mph. For each scenario, two cases were simulated once without a left-turn lane and another with a left-turn installed. As before, each case was run for 30 times, each time with a different seed numbers and the results were averaged over the 30 runs. The output from all these runs was a dataset which for each operational scenario gave the estimated values for the following performance measures: control delay (sec/veh), percent stops, fuel consumption (mpg), Carbon monoxide (CO), Nitrogen oxide (NO) and Hydrocarbon (HC) emissions (gram/mile) for two cases, without a left-turn lane and with a left-turn lane.

Following this, Neural Network (NN) models were developed to generalize the results obtained. These NNs form the basis for developing the warrants, as well as developing a Decision Support System (DSS) for estimating the benefits of installing exclusive left turn lanes at unsignalized intersections. The DSS is designed to predict the likely benefits of left-turn lane installations in terms of reductions in control delay, stops,

fuel consumption and emissions. A paper summarizing the work done to develop the NN DSS will be presented at the Transportation Research Board (TRB) meeting in January.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:**

“A Decision Support System for Predicting the likely Benefits of Left-turn Lane Installation,” Ranade, S., Sadek, A.W. and Ivan, J., 2007, Accepted for presentation at the TRB Annual meeting, January 2007, being considered for publication in *Transportation Research Record*.

**PROJECT NUMBER: 05-8**

**PROJECT TITLE:** Evaluation and Implementation of Traffic Simulation Models for Work Zones

**PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):** John Collura, University of Massachusetts

**STATUS:** New

**INITIAL AGREEMENT DATE:** 1/1/2006

**END DATE:** 12/31/07

**PROJECT OBJECTIVES:**

1) assess the strengths and limitations of readily available computer based simulation models designed to evaluate the impacts of alternative work zone strategies; 2) make recommendations for the use of such simulation models on roadway reconstruction and rehabilitation projects in New England and New York State; and 3) conduct the necessary technology transfer activities in order to ensure that the results of this project are disseminated and provided directly to potential simulation model users, including transportation engineers and planners in New England and New York State.

**PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2006:**

Work on this 24 month project began effectively in August 2006. During this 5 month period the Literature Review (Task 1) focused on the identification of PC based simulation models to assist State DOTs in the evaluation of alternative work zone strategies. Examples of such models include QuickZone and CA4PRS. In addition, the data requirements of these models were identified and incorporated into the assessment of the strengths and weaknesses of these models and their potential use by State DOTs.

**REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2006:** None

## D. FINANCIAL STATUS OF PROJECTS ACTIVE DURING 2006

**D.1 FINANCIAL STATUS OF ACTIVE PROJECTS:**  
**Table 1: Financial Status of Projects Active During 2006**  
**(As of December 28, 2006 )**

NO.	PROJECT TITLE, PI, UNIVERSITY	APPROVED BUDGET	INVOICES APPROVED FOR PAYMENT	PROJECT BALANCE
00-8	Performance and Effectiveness of a Thin Pavement Section Using Geogrids and Drainage in a Cold Region, <i>D.Humphry, University of Maine, Orono</i>	\$150,000.00	\$140,240.44	\$9,759.56
01-1	Advanced Composite Materials for New England's Highway Infrastructure: A Study for Implementation and Synthesis of Technology and Practice, <i>S. Brena, S. Civjan, University of Massachusetts, Amherst</i>	\$53,339.00	\$47,559.47	\$5,779.53
02-1	Relating Hot Mix Asphalt Pavement Density to Performance, <i>W. Mogawer, University of Massachusetts, Dartmouth, R. Mallick, Worcester Polytechnic Institute, J. Daniels, University of New Hampshire</i>	\$103,524.00	\$87,763.63	\$15,760.37
02-2	Formulate Approach for 511 Implementation in New England, <i>P. Shuldiner, University of Massachusetts, Amherst</i>	\$84,013.00	\$80,971.35	\$3,041.65
02-3	Establish Subgrade Support Values for Typical Soils in New England, <i>R. Malla, University of Connecticut</i>	\$80,000.00	\$79,936.86	\$63.14
02-6	Sealing of Small Movement Bridge Expansion Joints, <i>R. Malla, M. Shaw, University of Connecticut</i>	\$74,996.00	\$74,982.81	\$13.19
03-1	Ability of Wood Fiber Materials to Attenuate Heavy Metals, <i>A. MacKay, University of Connecticut</i>	\$72,000.00	\$57,079.86	\$14,920.14
03-2	Field Studies of Concrete Containing Salts of an Alkenyl-Substituted Acid, <i>S. Civjan, University of Massachusetts Amherst</i>	\$140,000.00	\$65,521.88	\$74,478.12
03-5	Evaluation of a Field Permeameter as a Longitudinal Joint Quality Indicator, <i>J. Daniel, University of New Hampshire</i>	\$77,646.00	\$65,887.78	\$11,758.22
03-6	Fix It First: Utilizing the Seismic Property Analyzer and MMLS to Develop Guidelines for the Use of Polymer Modified Thin Lift HMA vs. Surface Treatments	\$99,927.00	\$0.00	\$99,927.00
03-7	Basalt Fiber Reinforced Composites, <i>R. Parnas, M. Shaw, University of Connecticut</i>	\$65,791.00	\$55,690.66	\$10,100.34
04-1	Recycling Asphalt Pavements Containing Modified Binders, <i>J. Mahoney, University of Connecticut</i>	\$109,918.00	\$0.00	\$109,918.00
04-2	Driver-Eye-Movement-Based Investigation for Improving Work-Zone Safety, <i>D. Fisher, University of Massachusetts Amherst</i>	\$74,491.00	\$46,630.91	\$27,860.09

**D.1 FINANCIAL STATUS OF ACTIVE PROJECTS:**  
**Table 1: Financial Status of Projects Active During 2006**  
**(As of December 28, 2006 )**

<b>NO.</b>	<b>PROJECT TITLE, PI, UNIVERSITY</b>	<b>APPROVED BUDGET</b>	<b>INVOICES APPROVED FOR PAYMENT</b>	<b>PROJECT BALANCE</b>
04-3	Estimating the Magnitude of Peak Flows for Steep Gradient Streams in New England, <i>J. Jacobs , T. Ballestero, University of New Hampshire, R. Vogel, Tufts University</i>	\$120,000.00	\$91,530.85	\$28,469.15
04-4	Determining the Effective PG Grade of Binder in RAP Mixes, <i>J. Daniel, University of New Hampshire, W. Mogawer, University of Massachusetts Dartmouth</i>	\$130,876.00	\$56,017.15	\$74,858.85
04-5 Phase 1	Network-Based Highway Crash Prediction Using Geographic Information Systems, <i>J. Ivan, University of Connecticut, P. Garder, University of Maine Orono</i>	\$130,000.00	\$126,658.38	\$3,341.62
04-5 Phase 2	Network-Based Highway Crash Prediction Using Geographic Information Systems, <i>J. Ivan, University of Connecticut, P. Garder, University of Maine Orono</i>	\$3,341.00	\$0.00	\$3,341.00
05-1	Development of Supplemental Resistance Method for the Design of Drilled Shaft Rock Sockets, <i>T. Sandford, University of Maine</i>	\$99,910.00	\$0.00	\$99,910.00
05-3	Practicable Calibration Procedures to Enhance the Accuracy of Analytical and Microsimulation Software for Modern Four-Legged Single-Lane Roundabouts, <i>A. Sadek, University of Vermont, P. Garder, University of Maine, L. Aultman-Hall, University of Connecticut</i>	\$75,000.00	\$0.00	\$75,000.00
05-6	Employing Graphic-Aided Dynamic Message Signs to Assist Elder Drivers' Message Comprehension, <i>J. H. Wang, University of Rhode Island</i>	\$59,991.00	\$14,697.60	\$45,293.40
05-7	Warrants for Exclusive Left Turn Lanes at Unsignalized Intersections and Driveways, <i>J. Ivan, University of Connecticut, A. Sadek, University of Vermont</i>	\$100,000.00	\$0.00	\$100,000.00
05-8	Evaluation and Implementation of Traffic Simulation Models for Work Zones, <i>J. Collura, University of Massachusetts</i>	\$100,000.00	\$0.00	\$100,000.00

**Note: Retainage is not included in "INVOICES APPROVED FOR PAYMENT"**

<b>D. 2 FUND BALANCE:</b>				
<b>Table 2: NETC Fund Balance (as of December 20, 2006)</b>				
<b>ITEM</b>	<b>ALLOCATION</b>	<b>ENCUMB/ EXPEND.</b>	<b>INVOICE</b>	<b>CUM. BALANCE</b>
<b>Unexpended Balance of NETC funds from AASHTO as of 6/5/95 (Per AASHTO memo 12/4/95)</b>				132,777.07
<b>Member Allocations 1994 = 6 X \$75,000</b>	450,000.00			582,777.07
<b>Coord./Admin. of NETC: Calendar Year 1995 Bdgt. = \$73,042</b>		58,761.32	FINAL	524,015.75
<b>Continued Projects:</b>				
- Construction Costs of New England Bridges-Phase II		39,500.00	FINAL/CLOSED	484,515.75
- Tire Chips as Lightweight Backfill-Phase II: Full-Scale Testing (Supplemental Funding)		16,000.00	FINAL/CLOSED	468,515.75
- Bridge Rail Crash Test - Phase II: Sidewalk-Mounted Rail		134,127.00	FINAL/CLOSED	334,388.75
- New England Vehicle Classification and Truck Weight Program		6,752.57	FINAL/CLOSED	327,636.18
<b>Member Allocations 1995 = 7 X \$75,000</b>	525,000.00			852,636.18
<b>"95" Project Series:</b>				
95-1: Use of Tire Chips/Soil Mixtures to Limit Pavement Damage of Paved Roads		75,000.00	FINAL/CLOSED	777,636.18
95-2: Suitability of Non-Hydric Soils for Wetland Mitigation		39,867.70	FINAL/CLOSED	737,768.48
95-3: Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes		120,812.12	FINAL/CLOSED	616,956.36
95-5: Buried Joints in Short Span Bridges		61,705.61	FINAL/TERM.	555,250.75
95-6: Guidelines for Ride Quality Acceptance of Pavements		106,124.00	FINAL/CLOSED	449,126.75
<b>"94" Project Series:</b>				
94-1: Structural Analysis of New England Subbase Materials and Structures		110,057.38	FINAL/CLOSED	339,069.37
94-2: Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques		224,901.80	FINAL/CLOSED	114,167.57
<b>Member Allocations 1996 = 6 X \$75,000</b>	450,000.00			564,167.57
<b>Coord./Admin. of NETC: Calendar Year 1996; Bdgt. = \$75,000</b>		69,123.85	FINAL	495,043.72
<b>Member Allocations 1997 = 6 X \$75,000</b>	450,000.00			945,043.72
<b>Coord./Admin. of NETC: Calendar Year 1997; Bdgt. = \$82,494</b>		77,244.35	FINAL	867,799.37
<b>"94" Project Series:</b>				
94-3: Procedures for The Evaluation of Sheet Membrane Waterproofing <i>Note: Project administered by VAOT under TPF Project No. SPR-3</i>		67,002.00	FINAL/CLOSED	800,797.37
94-4: Durability of Concrete Crack Repair Systems		72,036.04	FINAL/TERM.	728,761.33
<b>"96" Project Series:</b>				
96-1: SUPERPAVE Implementation		60,139.25	FINAL/CLOSED	668,622.08
96-2: Optimizing GPS Use in Transportation Projects		27,008.81	FINAL/TERM.	641,613.27
96-3: Effectiveness of Fiber Reinforced Composites as Protective Coverings for Bridge Elements, etc.		135,000.00	FINAL/CLOSED	506,613.27
<b>T2 (per 12/2/97 Adv. Committee Mtg.) for 1998 = \$10,000</b>		9,551.06	FINAL	497,062.21
<b>Coord./Admin. of NETC: Calendar Year 1998; Bdgt = \$73,021</b>		80,422.65	FINAL	416,639.56
Refund Check (No. 15-663337), for CY '98 Management of NETC, from UConn OSP; Ref. 7/19/00 letter to J. Sime from J. Devereux, UConn OSP	336.00			416,975.56



<b>D. 2 FUND BALANCE:</b>				
<b>Table 2: NETC Fund Balance (as of December 20, 2006)</b>				
<b>ITEM</b>	<b>ALLOCATION</b>	<b>ENCUMB/ EXPEND.</b>	<b>INVOICE</b>	<b>CUM. BALANCE</b>
<b>Member Allocations 1998 = 6 X \$75,000</b>	450,000.00			866,975.56
<b>"97" Project Series:</b>				
97-1: A Portable Method for Determining Chloride Concentration on Roadway Pavements	Phase 1	96,669.50	FINAL/CLOSED	770,306.06
	Phase 2	90,667.79	FINAL/CLOSED	679,638.27
97-2: Performance Evaluation & Economic Analysis of Durability Enhancing Admixtures, etc.		108,318.73	FINAL/CLOSED	571,319.54
97-3: Determining Properties, Standards & Performance of Wood Waste Compost, etc.:	Phase 1	27,779.64	FINAL/CLOSED	543,539.90
	Phase 2	16,074.30	FINAL/CLOSED	527,465.60
Alloc. to ConnDOT for Constr. Costs of Test Site (Approved 1/21/99 Ballot)		10,700.00		516,765.60
97-4: Early Distress of Open-Graded Friction Course		57,495.71	FINAL/CLOSED	459,269.89
<b>Travel Tech. Comm. ( Aug. 98 tel. poll) for 1998 = \$5,000</b>		0.00		459,269.89
<b>Member Allocations 1999 = 6 X \$75,000</b>	450,000.00			909,269.89
<b>Coord./Admin. of NETC: Calendar Year 1999:</b>				909,269.89
- Administration = \$77,666				
- Technology Transfer & Technical Committee				
Travel = \$20,400				
- Total = \$98,066		79,101.20	FINAL	830,168.69
<b>"99" Project Series:</b>				
99-1: Bridge Rail Transitions		240,000.00	FINAL/CLOSED	590,168.69
99-2: Evaluation of Asphaltic Expansion Joints		62,234.76	FINAL/CLOSED	527,933.93
99-3: Bridge Scour Monitoring Systems		78,523.32	FINAL/CLOSED	449,410.61
99-4: Quantifying Roadside Rest Area Usage		44,857.00	FINAL/CLOSED	404,553.61
99-6: The Effects of Concrete Removal Operations on Adjacent That Is to Remain		96,008.36	FINAL/CLOSED	308,545.25
<b>Member Allocations 2000 = 6 X \$100,000</b>	600,000.00			908,545.25
<b>Coord./Admin. of NETC: Calendar Year 2000:</b>		91,899.37	FINAL	816,645.88
- Administration = \$ 85,788				
- Technology Transfer & Technical Committee				
Travel = \$ 16,800				
- Total = \$102,588				
<b>"00" Project Series:</b>				816,645.88
00-1: Ground-Based Imaging and Data Acquisition Systems for Roadway Inventories in New England - A Synthesis of Practice		31,251.92	FINAL/CLOSED	785,393.96
00-2: Evaluation of Permeability of Superpave Mixes		95,499.16	FINAL/CLOSED	689,894.80
00-3: Composite Reinforced Timber Guard Rail - Phase I: Design, Fabrication and Testing		81,989.38	FINAL/CLOSED	607,905.42
00-4: Falling Weight Deflectometer Study		100,000.00	FINAL/CLOSED	507,905.42
00-5: Guard Rail Testing - Modified eccentric Loading Terminal at NCHRP 350 TL2		61,287.00	FINAL/CLOSED	446,618.42
00-6: Implementation of Visualization Technologies to Create Simplified Presentations Within Highway agencies to be Used at Public Hearings		74,914.49	FINAL/CLOSED	371,703.93
00-7: A Complete Review of Incident Detection Algorithms and Their Deployment: What Works and What Doesn't		45,369.45	FINAL/CLOSED	326,334.48
00-8: Performance and Effectiveness of A Thin Pavement Section Using Geogrids and Drainage geocomposites in A Cold Region		150,000.00		176,334.48

<b>D. 2 FUND BALANCE:</b>				
<b>Table 2: NETC Fund Balance (as of December 20, 2006)</b>				
<b>ITEM</b>	<b>ALLOCATION</b>	<b>ENCUMB/ EXPEND.</b>	<b>INVOICE</b>	<b>CUM. BALANCE</b>
<b>Member Allocations 2001 = 6 X \$100,000</b>	600,000.00			776,334.48
<b>Coord./Admin. of NETC: Calendar Year 2001 = \$108,376</b>		104,385.35	FINAL	671,949.13
<b>"01" Project Series:</b>				
01-1: Advanced Composite Materials for New England's Transportation Infrastructure		47,559.27	FINAL/CLOSED	624,389.86
01-1: Advanced Composite Materials for New England's Transportation Infrastructure - Technology Transfer Phase		25,000.00		599,389.86
01-2: Development of A Testing Protocol for Quality Control/Quality Assurance of Hot Mix Asphalt		80,000.00	FINAL/CLOSED	519,389.86
01-3: Design of Superpave HMA for Low Volume Roads		120,324.15	FINAL/CLOSED	399,065.71
01-6: Field Evaluation of A New Compaction Device		49,944.50	FINAL/CLOSED	349,121.21
<b>Member Allocations 2002 = 6 X \$100,000</b>	600,000.00			949,121.21
<b>NY DOT Allocation = \$52,500</b>	52,500.00			1,001,621.21
<b>Coord./Admin. Of NETC: Calendar Year 2002 = \$123,967</b>		109,207.12	FINAL	892,414.09
<b>"02" Project Series:</b>				
02-1: Relating Hot Mix Asphalt Pavement Density to Performance		103,524.00		788,890.09
02-2: Formulate Approach for 511 Implementation in New England Phase 1		48,158.19	FINAL/CLOSED	740,731.90
02-2: Formulate Approach for 511 Implementation in New England Phase 2		32,813.16	FINAL/CLOSED	707,918.74
02-3: Establish Subgrade Support Values ( $M_r$ ) for Typical Soils in New England		79,936.86	FINAL/CLOSED	627,981.88
02-5: Determination of Moisture Content of De-Icing Salt at Point of Delivery		19,679.99	FINAL <sup>2</sup> /CLOSED	608,301.89
02-6 : Sealing of Expansion Joints - Phase 1		74,982.81	FINAL/CLOSED	533,319.08
02-7: Calibrating Traffic Simulation Models to Inclement Weather Conditions with Applications to Arterial Coordinated Signal Systems		74,037.57	FINAL/CLOSED	459,281.51
02-8: Intelligent Transportation Systems Applications to Ski Resorts in New England		54,724.71	FINAL/CLOSED	404,556.80
<b>Member Allocations 2003 = 6 X \$100,000</b>	600,000.00			1,004,556.80
<b>NY DOT Allocation = \$40,000</b>	40,000.00			1,044,556.80
<b>Coord./Admin. Of NETC Calendar Year 2003 = \$124,258</b>		118,855.19	FINAL	925,701.61
<b>"03" Project Series:</b>				
03-1: Ability of Wood Fiber Materials to Attenuate Heavy Metals Associated with Highway Runoff		72,000.00		853,701.61
03-2: Field Studies of Concrete Containing Salts of An Alkenyl-Substituted Succinic Acid		140,000.00		713,701.61
03-3: Feasibility Study and Design of An Erosion Control Laboratory in New England		20,682.70	FINAL/CLOSED	693,018.91
03-3: Feasibility Study and Design of An Erosion Control Laboratory in New England Phase 2		13,135.80	FINAL/CLOSED	679,883.11
03-4: Measuring Pollutant Removal Efficiencies of Storm Water Treatment Units		80,000.00	FINAL/CLOSED	599,883.11
03-5: Evaluation of Field Permeameter As A Longitudinal Joint Quality Control Indicator		77,646.00		522,237.11
03-6: New England Land Grant University Consortium Members Research Challenge		99,927.00		422,310.11
03-7 (Alt.): Basalt Fiber Reinforced Polymer Composites		65,791.00		356,519.11

<b>D. 2 FUND BALANCE:</b>				
<b>Table 2: NETC Fund Balance (as of December 20, 2006)</b>				
<b>ITEM</b>	<b>ALLOCATION</b>	<b>ENCUMB/ EXPEND.</b>	<b>INVOICE</b>	<b>CUM. BALANCE</b>
<b>Member Allocations 2004 = 6 X \$100,000</b>	600,000.00			956,519.11
<b>NY DOT Allocation = \$52,000</b>	52,000.00			1,008,519.11
<b>Coord./Admin. Of NETC Calendar Year 2004 = \$126,559</b>		113,012.87	FINAL	895,506.24
<b>"04" Project Series:</b>				
04-1: Recycling Asphalt Pavements Containing Modified Binders		109,918.00		785,588.24
04-2: Dryver-Eye-Movement-Based Investigation for Improving Work Zone Safety		74,491.00		711,097.24
04-3: Estimating the Magnitude of Peak Flows For Steep Gradient Streams in New England		120,000.00		591,097.24
04-4: Determining the Effective PG Grade of Binder in RAP Mixes		130,876.00		460,221.24
04-5: Network-Based Highway Crash Prediction Using Geographic Information Systems		130,000.00		330,221.24
<b>Member Allocations 2005 = 6 x \$100,000</b>	600,000.00			930,221.24
<b>NY DOT Allocation = \$50,000</b>	50,000.00			980,221.24
<b>Coord./Admin. Of NETC Calendar Year 2005 = \$130,528</b>		128,934.25		851,286.99
<b>"05" Project Series:</b>				
05-1: Develop Base Resistance Load-Displacement Curves for The Design of Drilled Shaft Rock Sockets		100,000.00		751,286.99
05-2 Safety of Reflective Median Barriers Phase 1		48,000.00		703,286.99
05-2: Safety of Reflective Median Barriers Phase 2		72,000.00		631,286.99
05-3: Analysis of Roundabout Operational Characteristics Utilizing Microscopic Simulation Modeling		75,000.00		556,286.99
05-5: Measurement of Work of Adhesion Between Paint and Metalized/Galvanized Steel		125,000.00		431,286.99
05-6: Employing Graphic-Aided Dynamic Message Signs to Assist Elder Drivers' Message Comprehension		60,000.00		371,286.99
05-7: Warrants for Exclusive Left Turn Lanes at Unsignalized Intersections and Driveways		70,000.00		301,286.99
05-8: Evaluation of Alternative Traffic Simulation Models, Including CA4PRS for Analysis of Traffic Impacts of Highway Construction, Reconstruction and Rehabilitation		100,000.00		201,286.99
<b>Member Allocations 2006 = 6 x \$100,000</b>	600,000.00			801,286.99
<b>Coord./Admin. Of NETC Calendar Year 2006 = \$131,814</b>		131,814.00		669,472.99
<b>"06" Project Series:</b>				
06-1: New England Verification of NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide With Level 2 & 3 Input		150,295.00		519,177.99
06-2: Infrastructure Management Systems Enhancement and Integration to Support True Integrated Management Decision-Making		100,000.00		419,177.99
06-3 Establish Default Dynamic Modulus Values for New England		110,000.00		309,177.99
06-4 Preventative Maintenance and Timing of Applications		200,000.00		109,177.99
06-5 Winter Severity Indices for New England		100,000.00		9,177.99
<b>Member Allocations 2007 = 6 x \$100,000</b>	600,000.00			609,177.99
<b>Coord./Admin. Of NETC Calendar Year 2007 = \$136,061</b>		136,061.00		473,116.99
<b>"07" Project Series:</b>				
07-1 In-Place Response Mechanisms of Recycled Layers Due to Temperature and Moisture Variataions		150,000.00		323,116.99
07-2 Exploring the Potential of Intelligent Intersections Deployment in New England		100,000.00		223,116.99

**D. 2 FUND BALANCE:**

**Table 2: NETC Fund Balance  
(as of December 20, 2006)**

ITEM	ALLOCATION	ENCUMB/ EXPEND.	INVOICE	CUM. BALANCE
07-3 Determining Optimum Distance for a Lane Drop Downstream from a Signalized Intersection		100,000.00		123,116.99
07-4 Estimating and Predicting Traffic Conditions for Traveler Information and Emergency Response		100,000.00		23,116.99
<b>Notes:</b>				

1 = Member FFY allocations are obligated between October 1 and December 31

2 = A credit of \$6,599.70 for NETC's overpayment to UConn for CY 2004 NETC Management was applied, by UConn, to the 'Indirect Cost' for project 02-5. Therefore although the total expenditures of the project were \$26,279.69 the amount paid by NETC was \$19,679.99

## **E. REPORTS, PAPERS AND PRESENTATIONS**

### **E.1 POLICIES AND PROCEDURES:**

- “Policies and Procedures, New England Transportation Consortium,” July 1995.
- “Policies and Procedures, New England Transportation Consortium,” April 2002.

### **E.2 ANNUAL REPORTS:**

- “Annual Report For Calendar Year 1995,” March 1996, NETCR3
- “Annual Report For Calendar Year 1996,” January 1997, NETCR4
- “Annual Report For Calendar Year 1997,” January 1998, NETCR9
- “Annual Report For Calendar Year 1998,” January 1999, NETCR10
- “Annual Report For Calendar Year 1999,” January 2000, NETCR21
- “Annual Report For Calendar Year 2000,” August 2001, NETCR27
- “Annual Report For Calendar Year 2001,” December 2002, NETCR40
- “Annual Report For Calendar Year 2002,” November 2003, NETCR41
- “Annual Report For Calendar Year 2003,” September 2005, NETCR55
- “Annual Report For Calendar Year 2004,” December 2005, NETCR59
- “Annual Report For Calendar Year 2005,” August 2006, NETCR61

### **E.3 REPORTS, PAPERS, AND PRESENTATIONS 1988-1994:**

- “The Development of a Common Regional System for Issuing Permits for Oversize and Overweight Trucks Engaged in Interstate Travel,” Humphrey, T.F., May 1986.
- “Agreement to Implement a Common Set of Procedures for Issuing Permits for Nondivisible Oversize and Overweight Trucks Engaged in Interstate Travel,” The New England Transportation Consortium, October 1988.
- “The New England Transportation Consortium, Round One Activities,” Humphrey, T.F., and Maser, K.R., MIT, December 1988.
- “New Technology for Bridge Deck Assessment - Phase I Final Report,” Vols. I and II, Maser, Kenneth R., MIT Center for Transportation Studies, October 1989.
- “Handbook for Use by the Trucking Industry to Implement The NETC Common Truck Permit Procedures for Certain Nondivisible Oversize/Overweight Vehicles Traveling on State Highways,” MIT Center for Transportation Studies, January 1989.
- “Bridge Rail Design and Crash Worthiness - Final Report,” Elgaaly, M., Dagher, H., and Kulendran, S., University of Maine, May 1989.
- “New England Transportation Consortium, Operational Procedures,” Humphrey, T.F., November 1991.

**E.3 NETC REPORTS, PAPERS, AND PRESENTATIONS 1988-1994 (cont'd):**

“Wetlands: Problem & Issues,” Shuldiner, P.W., University of Massachusetts, August 1990.

“Development of a Uniform Truck Management System,” Vols. I and II, Lee, K.W., and McEwen, E.E., University of Rhode Island. July 1990.

“A Study of STAA Truck Safety In New England - Phases I & II,” MIT, November 1991.

“New Technology for Bridge Deck Assessment - Phase II Final Report,” MIT, May 1990.

“Rail Service In New England,” Martland, C.P. Little, and Alvaro, A.E., MIT Center for Transportation Studies, April 1992.

“CMA Degradation and Trace Metals in Roadside Soil,” Ostendorf, D.W., Palaia, T.A., and Zutell, C.A., University of Massachusetts, March 1993.

“Tire Chips as Lightweight Backfill for Retaining Walls - Phase I,” Humphrey, D., Sandford, T.C., Cribbs, M.M., Gharegrat, H.G., and Manion, W.P., University of Maine, August 1992.

“Cooperative Regional Transportation Research Programs Underway in New England,” Humphrey, T.F., and Sussman, J.M., International Congress on Technology and Technology Exchange, June 1989.

“Uniformity Efforts in Oversize/Overweight Permits,” Humphrey, T.F., NCHRP Synthesis, No. 143, Transportation Research Board, 1988.

“Implementation of a Uniform Truck Permit System by the New England Transportation Consortium,” Humphrey, T.F., AASHTO 1987 Annual Meeting Proceedings, pp. 84-90, 1987.

“Advantages of Oversize/Overweight Truck Permit Uniformity,” AASHTO 1990 Annual Meeting Proceedings, pp. 83-85, 1990.

“Crash Worthiness of Bridge Rails,” Dagher, H., Elgaaly, M., and Kulendran, S., Proceedings, Fourth Rail Bridge Centenary Conference, Heriot-Watt University, Edinburgh, Scotland, August 1990.

“Principles of Radar and Thermography for Bridge Deck Assessment,” Maser, R., and Roddis, W.M.K., ASCE Journal of Transportation Engineering, Vol. 116, No. 5, Sept./Oct. 1990.

**E.3 NETC REPORTS, PAPERS, AND PRESENTATIONS 1988-1994 (cont'd):**

“Regional Rail Planning In New England,” Martland, C.P. Little, and Alvaro, A.E., MIT, August 1993. (Accepted for publication 1994)

“CMA Degradation in Roadside Soil: Acetate Microcosms,” Ostendorf, D.W., Pollock, S.J., De Cheke, M.E., and Palaia, T.A., Transportation Research Record, No. 1366, pp. 41-43, 1992.

“Aerobic Degradation of CMA in Roadside Soils: Field Simulations from Soil Microcosms,” Ostendorf, D.W., Pollock, S.J., De Cheke, M.E., and Palaia, T.A., Journal of Environmental Quality, Vol. 22, pp. 229-304, 1993.

“Shear Strength and Compressibility of Tire Chips for Use as Retaining Wall Backfill,” Humphrey, D.N., Sandford, T.C., Cribbs, M.M., and Manion, W.P., Transportation Research Record No. 1422, pp. 29-35, Transportation Research Board, National Research Council Washington, D.C., 1993.

“Tire Chips as Lightweight Subgrade Fill and Retaining Wall Backfill,” Humphrey, D.N., and Sandford, T.C., Proceedings of the Symposium on Recovery and Effective Reuse of Discarded Materials and By-Products for Construction of Highway Facilities, pp. 5-87 to 5-99, Federal Highway Administration, Washington, D.C., 1993.

**E.4                    REPORTS, PAPERS AND PRESENTATIONS 1995-2006:**

**Project No.    Title**

**N/A                    Construction Costs Of New England Bridges**

Reports:

“Construction Costs of New England Bridges,” Alexander, J.A., Dagher, H. and James, S., November 1996, NETCR1.

Papers and Presentations:

“Construction Costs of New England Bridges,” Alexander, J., Dagher, H. and James, S. Presented at the Annual Maine Transportation Conference, December 7, 1995.

**N/A                    Tire Chips As Lightweight Backfill For Retaining Walls, Phase II: Full-Scale Testing**

Reports:

“Tire Chips As Lightweight Backfill For Retaining Walls - Phase II,” Tweedie, Jeffrey J., Humphrey, Dana N., and Sandford, T.C., March 11, 1998, NETCR8.

Papers and Presentations:

“Tire Shreds as Lightweight Retaining Wall Backfill-Active Conditions,” Humphrey, D. Submitted for publication in the ASCE Journal of Geotechnical and Geoenvironmental Engineering.

“Civil Engineering Uses for Tire Chips,” Humphrey D.N. A six-hour short course presented to the Nebraska Department of Environmental Quality, the Maine Dept. of Transportation, the Texas Engineering Extension Service, the Manitoba Tire Stewardship Board, the Alberta Tire Recycling Management Board, and the Arkansas Department of Pollution Control and Ecology.

“Tire Chips as Lightweight Subgrade and Retaining Wall Backfill,” by Humphrey, D.N. and Sandford, T.C. Symposium on Recovery and Effective Reuse of Discarded Materials and By-Products for Construction of Highway Facilities, FHWA, Denver, Colorado, October 19-22, 1993.

“Use of Tire Chips as Subgrade Insulation and as Lightweight Fill for Highway Construction,” Humphrey, D.N. Presented at the 18<sup>th</sup> Annual Meeting of the Asphalt Recycling and Reclaiming Association, Pompano Beach, Florida, February 23-26, 1994.

“Use of Tire Chips in Highway Construction,” Humphrey, D.N. Presented to the New England Environmental Expo, Boston, Massachusetts, May 9, 1995.



N/A

**Tire Chips As Lightweight Backfill For Retaining Walls, Phase II:  
Full-Scale Testing (cont'd):**

Papers and Presentations (cont'd):

“Use of Tire Chips in Highway Construction,” Humphrey, D.N. Presented to the AASHTO Region 1 RAC Meeting, Portland, Maine, May 23, 1995.

“Tire Chips for Highway Construction,” Humphrey, D.N. Presented to the Northeast Recycling Council in Sturbridge, Massachusetts on December 8, 1995.

“Tire Chips: A New Road Building Geomaterial,” Humphrey, D. Presented at the Conference on Waste and Recycled Materials in the Transportation Infrastructure, held in conjunction with the 75th Annual Meeting of the Transportation Research Board, January 7, 1996.

“Use of Tire Chips in Civil Engineering.” Presented at the 76th Annual Meeting of the Rubber Association of Canada, March 7, 1996.

“Civil Engineering Uses for Scrap Tires,” Humphrey, D. Presented at Scrap Tire '96 held in Chicago, Illinois on August 16, 1996.

“Full Scale Field Trials of Tire Chips as Lightweight Retaining Wall Backfill-At Rest Conditions,” Tweedie, J.J., Humphrey, D.N., and Sandford, T.C., Transportation Research Board No. 1619, Transportation Research Board, Washington, D.C., p. 64-71, 1998.

“Tire Shreds as Retaining Wall Backfill, Active Conditions,” Tweedie, J.J., Humphrey, D.N., and Sandford, T.C, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 124, No. 11, Nov., pp.1061-1070, 1998.

“Highway Applications of Tire Shreds,” Humphrey, D. A 7-hour short course presented in each of the six New England States, 1998.

“Highway Applications of Tire Shreds,” Humphrey, D. A 7-hour short course presented to the RI DOT, April 1999.

N/A

**New England Vehicle Classification And Truck Weight Program,  
Phase I**

Reports:

“New England Vehicle Classification and Truck Weight Program, Technical Report No. 1: Toward the Development of a Vehicle Classification Program for New England,” Collura, J., Chan, D., Evans, E., Kelly, S., Hosmer, T., and Shuldiner, P., April 1996.

N/A

**New England Vehicle Classification And Truck Weight Program, Phase I (cont'd):**

Reports (cont'd):

“New England Vehicle Classification and Truck Weight Program, Technical Report No. 2: Toward the Development of a Truck Weight Program for New England,” Collura, J., Chan, D., Evans, E., Kelly, S., Hosmer, T., and Shuldiner, P., April 1996.

“New England Vehicle Classification and Truck Weight Program, Technical Report No. 3: Supplemental Analysis of Truck Weight Data Collection at SHRP Continuous Count Stations,” Collura, J., Chan, D., Evans, E., Kelly, S., Hosmer, T., and Shuldiner, P., April 1996.

“New England Vehicle Classification and Truck Weight Program, Phase I,” Collura, J., Chan, D., Evans, E., Kelly, S., Hosmer, T. and Shuldiner, P., April 1996, NETCR2.

“An Analysis of Vehicle Class and Truck Weight Patterns in New England,” Collura, J. and Orloski, F. Presented at the 1994 National Traffic Data Acquisition Conference, Rocky Hill, Connecticut, September 18-22, 1994.

“New England Vehicle Classification and Truck Weight Program,” Collura, J. and Orloski, F. Presented to the Transportation Research Board's Highway Traffic Monitoring Committee, Annual Meeting of the Transportation Research Board, Washington, D.C., January 1995.

Papers and Presentations: None

N/A

**Bridge Rail Crash Test, Phase II: Sidewalk-Mounted Rail**

Reports:

“NETC 2-Bar Curb-Mounted Bridge Rail Design - Plans and Specifications.” Revised January 1997.

“NETC 4-Bar Sidewalk-Mounted Bridge Rail Design - Plans and Specifications.” January 1997.

“Crash Testing and Evaluation of the NETC 2-Bar Curb-Mounted Bridge Rail,” Mak, K.K., and Menges, W.L., February 1998, NETCR10.

“Full-Scale Crash Evaluation of the NETC 4-Bar Sidewalk Steel Bridge Railing,” Kimball, C.E., and Mayer, J.B., March 1999, NETCR14.

Papers and Presentations: None

94-1

**Structural Analysis Of New England Subbase Materials And Structure**

Reports:

“Structural Analysis of New England Subbase Materials and Structures,” Lee, K.W., Huston, M.T., Davis, J., Vajjhalla, S., June 30, 2001, NETCR26.

Papers and Presentations:

“Structural Analysis of New England Subbase Materials and Structures,” Davis, J. Presented at the Rhode Island Transportation and Civil Engineering Forum, Kingston, Rhode Island, October 23, 1996.

“Structural Analysis of New England Subbase Materials and Structures.” Presented at the Northeast Graduate Student Symposium on Applied Mechanics, University of Rhode Island, April 26, 1997.

“Structural Analysis of New England Subbase Materials and Structures.” Presented at the Rhode Island Transportation and Civil Engineering Forum, University of Rhode Island, October 15, 1997.

“Structural Analysis of New England Subbase Materials and Structures,” Davis, J., Huston, M., and Lee, K.W. Presented at the 1998 Annual Transportation Research Board Meeting.

“Structural Properties of New England Subbase Materials of Flexible Pavements.” Presented at the 5<sup>th</sup> International Conference on the Bearing Capacity of Roads and Airfields, July 8, 1998.

“Structural Properties of New England Subbase Materials of Flexible Pavements.” Presented at the 5<sup>th</sup> International Conference on the Bearing Capacity of Roads and Airfields on July 8, 1998.

“Characterization of Subbase Materials of Flexible Pavements With and Without Reclaimed Asphalt Pavement,” Lee, K.W., Davis, J., and Vajjhalla, S. Presented at the 1999 World Congress for Korean Scientists and Engineers, July 7, 1999.

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## 94-2 **Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques**

### Reports:

“Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques,” Huston, D., Fuhr, P., Maser, K. and Weedon, W., July 1, 2002, NETCR 19.

### Papers and Presentations:

“Bridge Deck Structural Monitoring Techniques,” Huston, D. Presented at the New England State Materials Engineer Association Conference, Burlington, Vermont, October 9, 1996.

“Bridge Deck Evaluation with Ground Penetrating Radar,” Huston, D., Maser, K., Weedon, W., Fuhr, P.L., and Adam, C., Structural Health Monitoring, Chang F., Editor, Technomic Publishing, pp. 91-109, Proceedings of the International Workshop on Structural Health Monitoring, Stanford, California, September 1997.

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“Bridge Deck Evaluation with Ground Penetrating Radar,” Huston, D., Master, K., Hu, J.Q., Weedon, W., and Adam, C., Proceedings of the GPR '98 7th International Conference on Ground-Penetrating Radar, The University of Kansas, Lawrence, KS, May 27-30, 1998.

“Bridge Deck Evaluation with Ground Penetrating Radar,” Huston, D., Hu, J.Q, Pelczarski, N, and Esser, B., Proceedings Second International Conference on Structural Health Monitoring, Stanford University, September 1999.

“GIMA Antenna Design for Ground Penetrating Radar in Concrete NDE Application,” Hu J.Q., Huston, D. and Fuhr, P. SPIE paper 3670-63, SPIE Conference On Sensory Phenomena and Measurement Instrumentation for Smart Structures and Materials, Newport Beach, CA, March 1999.

“Ground Penetrating Radar for Concrete Bridge Health Monitoring Applications,” Huston, D, Hu, J.Q., Maser, K., Weedon, W., and Adam, C. SPIE 3587-23, Proceedings SPIE NDE Techniques for Aging Infrastructure and Manufacturing, Newport Beach, CA, March 1999.

“Electromagnetic Interrogation of Structures,” Huston, D. Fourth Army Research Office on Smart Structures, State College, PA, August 1999.

**Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques (cont'd):**Papers and Presentations (cont'd):

“GIMA Ground Penetrating Radar System For Infrastructure Health Monitoring,” Huston, D.R., Hu, J.Q, Maser, K., Weedon, W., and Adam, C. Journal of Applied Geophysics 43, 2000, pp. 39-146.

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“Inspection of Bridge Columns and Retaining Walls with Electromagnetic Waves,” Huston D.R., Pelczarski N., and Key C. SPIE Symposium on Smart Systems for Bridges, Structures, and Highways, 4330-09, Newport Beach, CA, March 2001.

“Wireless Electromagnetic Interrogation of Structures,” Huston D., Pelczarski N., Fuhr P., Arms S., and Esser B. (Tentatively accepted) Smart Materials and Structures, April 2001.

“Adaptive Sensors and Sensor Networks for Structural Health Monitoring,” Huston D. SPIE 4512-24, Symposium on Complex Adaptive Structures, Hutchinson Island, FL, June 2001.

“Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques,” Huston, D., Fuhr, P., Maser, K. and Weedon, W., July 1, 2002, NETCR19.

- 94-3**            **Procedures For The Evaluation Of Sheet Membrane Waterproofing:**  
Reports:  
“Procedures for the Evaluation Sheet Membrane Waterproofing,”  
Korhonen, C.J., Buska, J.S., Cortez, Edel R., and Greatorex, Alan R.,  
August 1999, NETCR13.
- Papers and Presentations: None
- 94-4**            **Durability Of Concrete Crack Repair Systems:**  
Reports: None
- Papers and Presentations:  
“Durability of Concrete Crack Repair, Projects,” Robinson, J. Presented at  
the University of Rhode Island Graduate Seminar Series, Kingston, RI,  
November 19, 1997.
- “Durability of Concrete Crack Repair System,” Tsiatas, G. and Robinson,  
J. Presentation to representatives of the Chemical Grouting Division of  
Kajima Corporation (Japan), University of Rhode Island, College of  
Engineering, October 26, 1999.
- 95-1**            **Use Of Tire Chip/Soil Mixtures To Limit Frost Heave And Pavement  
Damage Of Paved Road**  
Reports:  
“Use of Tire Chip/Soil Mixtures to Limit Frost Heave and Pavement  
Damage of Paved Roads,” Brian, K.L., and Humphrey, D. N., June 2000,  
NETCR12.
- Papers and Presentations:  
“Laboratory and Field Measurement of the Thermal Conductivity of Tire  
Chips for Use as Subgrade Insulation,” Humphrey, D., Chen, L.H. and  
Eaton, R. A paper submitted to the Transportation Research Board for  
presentation at the session on “Properties of Unconventional Aggregates”  
at the Annual Meeting of the Transportation Research Board, Washington,  
D.C., January 1997.
- “Highway Applications of Tire Shreds,” Humphrey, D. A 7-hour short  
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course presented to the RI DOT, April 1999.
- “Field Trial of Tire Shreds as Insulation for Paved Roads,” Humphrey, D.,  
Chen, L.H., Lawrence, B. A paper presented at the 10th International  
Conference on Cold Regions Engineering: Putting Research into Practice,  
held in Hanover, NH, August 16-19, 1999.

- 95-2 Suitability Of Non-Hydric Soils For Wetland Mitigation**  
Reports:  
“Suitability of Non-Hydric Soils for Wetland Mitigation,” Brannaka, L.K. and Evans, C.V., February 28, 1997, NETCR5.
- Papers and Presentations: None
- 95-3 Implementation And Evaluation Of Traffic Marking Recesses For Application of Thermo-Plastic Markings On Modified Open Graded Mixes**  
Reports:  
“Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Friction Course,” Lee, K.W., Cardi, S.A., and Corrigan, S., July 2000, NETCR23.
- Papers and Presentations:  
“Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes,” Lee, K.W. Presented at the Rhode Island Transportation and Civil Engineering Forum, Kingston, Rhode Island, October 23, 1996.
- “Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open-Graded Mixes,” Lee, K.W. Presented at the Rhode Island Transportation and Civil Engineering Forum, University of Rhode Island, October 15, 1997.
- 95-5 Buried Joints In Short Span Bridges**  
Reports: None
- Papers and Presentations:  
“State of the Art Study of Bridge Joint Systems in New England,” Tsiatas, and Chandrasekaran, S. Submitted for presentation at the Annual Meeting of the Transportation Research Board, Washington, D.C., January 1997.
- 95-6 Guidelines For Ride Quality Acceptance Of Pavements**  
Reports:  
“Guidelines for Ride Quality Acceptance of Pavements,” Collura, J., El-Korchi, T., Black K., Chase, M. and Li, J., April 1997, NETCR 6.
- Papers and Presentations: None

96-1

**Implementation of Superpave**

Reports:

“Superpave Implementation,” Mahoney, James, Stephens, Jack E., September 1999, NETCR18.

96-3

**Effectiveness Of Fiber Reinforced Composite As Structural And Protective Coverings For Bridge Elements Exposed To Deicing Salt Chlorides**

Reports:

“Effectiveness of High Strength Composites as Structural and Protective Coatings for Structural Elements,” Balaguru, P., and Lee, K.W., May 2001, NETCR28

Papers and Presentations:

“Inorganic Matrices for Composites,” NSF Workshop on Composites, Hanover, NH, March 15, 1998.

“Behavior of Geopolymer Reinforced with Various Types of Fabrics,” SAMPE 1998, Anaheim, CA, May 1998.

“Use of Ferrocement Theory for Analysis of High Strength Composites,” Ferrocement VI, Ann Arbor, MI, June 1998.

“Advances in Composites,” National University of Singapore, July 19, 1998.

“Effectiveness of Fiber Reinforced Composites as Structural and Protective Covering Bridge Elements Exposed to Deicing-Salt Chlorides,” Visiting Scholar Lecture, Transportation Forum, University of Rhode Island, October 15, 1999.

“Advanced High Strength Fiber Composites,” U.S.-Germany Workshop, Maiz, Germany, May 16-19, 1999.

“Recent Advances in Fiber Composites,” Seminar Series, University Cataleuna, Spain, June 28, 1999.

“Inorganic Coatings for Transportation Infrastructures,” Geopolymer Conference, St. Quentin, France, July 2, 1999.

“State-of-the-Art: Fiber Reinforced Concrete,” NSF Faculty Workshop, Northwestern University, Evanston, IL, July 21, 1999.

“Recent Advances in High Strength Composites and Applications for Repair and Rehabilitation,” 6th International Conference on Structural Failure, Durability, and Retrofitting, Singapore, September 15, 2000.



- 96-3 Effectiveness Of Fiber Reinforced Composite As Structural And Protective Coverings For Bridge Elements Exposed To Deicing Salt Chlorides (cont'd):**  
Papers and Presentations (cont'd):  
 “Durability of Carbon Composites Made With Inorganic Matrix,” Garon, R., and Balaguru, P., "SAMPE", November 2000, pp. 34-43.  
 “Inorganic Matrix - High Strength Fiber Composites,” University of Missouri, Rolla, July 27, 2000.  
 “Comparison of Inorganic and Organic Matrices for Strengthening of Reinforced Concrete Beams,” Kurtz, S., and Balaguru, P., Journal of Structural Engineering ASCE, V 127, January 2001, pp. 35-42.  
 “Durability of High Strength Composite Repairs under Scaling Conditions,” Garon, R., and Balaguru, P., Proceedings of Third International Conference on Concrete Under Severe Conditions, Vancouver, Canada, June 2001 (in print).
- 97-1 A Portable Method To Determine Chloride Concentration On Roadway Pavements**  
Reports:  
 “A Portable Method to Determine Chloride Concentration on Roadway Pavements,” Garrick, N., Nikolaidis, N., P. and Luo, J, September 2002, NETCR17.  
Papers and Presentations: None
- 97-2 Performance Evaluation And Economic Analysis Of Combinations Of Durability Enhancing Admixtures (Mineral And Chemical) In Structural Concrete For The Northeast U.S.A**  
Reports:  
 “Performance Evaluation of Durability Enhancing Admixtures (Mineral and Chemical) in Structural Concrete,” Sund, D., Report in Partial Fulfillment of Master of Science in Civil Engineering Degree, Department of Civil and Environmental Engineering, University of Massachusetts, Amherst, September, 1999.  
 “Performance Evaluation of Combinations of Durability Enhancing Admixtures in Concrete - Review and Experimental Program,” Report in Partial Fulfillment of Master of Science in Civil Engineering Degree, Lovette, D., Department of Civil and Environmental Engineering, University of Massachusetts, Amherst, February, 2001.

**97-2 Performance Evaluation And Economic Analysis Of Combinations Of Durability Enhancing Admixtures (Mineral And Chemical) In Structural Concrete For The Northeast U.S.A (cont'd):**

Papers and Presentations:

“On the Use of Combinations of Durability Enhancing Admixtures (Mineral and Chemical) in Structural Concrete,” Lafave, J.M., Lovett, D., and Civjan, S.A., ACI Fall Convention, Toronto, Ontario, Canada, October 15-21, 2000.

“Performance Evaluation and Economic Analysis of Combinations of Durability Enhancing Admixtures (Mineral and Chemical) in Structural Concrete for the Northeast U.S.A.,” Civjan, S.A., LaFave, J.M., Lovett, D., Sund, D.J., Trybulski, J., February 2003, NETCR 36.

**97-3 Determining Properties, Standards And Performance Of Wood Material As An Erosion Control Mulch And As A Filter Berm**

Reports:

“Performance Specifications for Wood Waste Materials as an Erosion Control Mulch and as a Filter Berm,” Demars, K.R., Long, R.P., Ives, J.R. April 2000, NETCR20.

Papers and Presentations:

“Compost Applications for Erosion Control: New and Improved Methods,” K. Demars. Presented at the Conference on ‘Putting Compost in the Specs: Practical Applications for Erosion Control’, Wrentham Development Center, Wrentham, MA, October 8, 2002.

**97-4 Early Distress Of Open-Graded Friction Course (OGFC)**

Reports:

“Early Distress in Open-Graded Friction Course,” Stephens, J.E., Mahoney, J., Dougan, C.E., July 1999, NETCR16.

Papers and Presentations: None

**99-1 Bridge Rail Transitions – Development and Crash Testing**

Reports:

Design documents for the NETC 2-Bar Curb-Mounted and 4-Bar Sidewalk-Mounted Bridge Rail Transitions are available from the NETC Coordinator.

“NCHRP Report 350 Testing and Evaluation of NETC Bridge Rail Transitions,” Dean C. Alberson, C. Eugene Buth, Wanda L. Menges, and Rebecca R. Haug, Texas Transportation Institute, Texas A&M University, December 2005, NETCR 53.

- 99-1 Bridge Rail Transitions – Development and Crash Testing (cont’d):**  
Papers and Presentations:  
“NETC Bridge Rail Transitions,” by Dean C. Alberson and Wanda L. Menges, Concord, New Hampshire, December 13, 2005.  
  
“Summary of NCHRP Report 350,” by Dean C. Alberson, Concord, New Hampshire, December 13, 2005.
- 99-2 Evaluation of Asphaltic Expansion Joints**  
Reports:  
“Evaluation of Asphaltic Expansion Joints,” Mogawer, W.S., November 2004, NETCR 50.  
  
Papers and Presentations: None
- 99-3 Development Of Priority Based Statewide Scour Monitoring Systems In New England**  
Reports:  
“Development of Priority Based Statewide Scour Monitoring Systems in New England,” Ho, C.T., Di Stasi, J.M., August 2, 2001  
  
“Real-Time Bridge Scour Assessment and Warning,” Di Stasi, J.M. and Ho, C.L., Proceedings of International Symposium: Technical Committee No. 33 on Scour of Foundations. Melbourne, Australia, pp. 337-352.  
  
Papers and Presentations: None
- 99-4 Quantifying Roadside Rest Area Usage**  
Reports:  
“Quantifying Roadside Rest Area Usage,” Garder, P. and Bosonetto, N., November 27, 2002, NETCR 38.  
  
Papers and Presentations:  
Results from the rest-area research were included in a presentation by the PI: “The Efficacy and Use of Continuous Shoulder Rumble Strips: Engineering a Solution,” presented at the November 20-21, 2002 National Summit to Prevent Drowsy Driving, National Academy of Sciences, Washington, DC, November 21, 2002 (taped by C-SPAN. Summit also covered by CNN Live Today, CNN Live on Location, CBS Early Show, National Public Radio’s Market Place, and national radio network coverage by ABC, CBS, and AP as well as two stories by nationally syndicated health columnist Jane Brody of The New York Times).

**99-6 Analytical and Experimental Investigation Of The Effects Of Concrete Removal Operations On Adjacent Concrete That Is To Remain**

Reports:

“Analytical and Experimental Investigation of the Effects of Concrete Removal Operations on Adjacent Concrete That is to Remain,” Masih, R., Wang, T. and Forbes, A., January 15, 2002, NETCR 29.

Papers and Presentations:

“Enhancing the Students' Learning Process Through Interaction Project Between Academia and Industry.” Presented and published in the Abstract of ASEE 2000 at the University of Massachusetts, Lowell, April 2000.

“The Effect of Powerful Demolition Equipment on the Remaining Part of the Concrete Bridge,” Masih, R. Presented and published in the proceedings of the Second International Conference on Computational Methods for Smart Structures and Material. Madrid, June 2000.

“Effect of Demolition on Remaining Part of Concrete Bridge, Numerical Analysis Vs. Experimental Results.” Presented and published in the proceedings of Internationales Kolloquium uber die Anwendungen der Informatik in Architectur und Bauwesen, Germany, June 2000

“The Effect of Bridge Rehabilitation on the Remaining Structural Parts.” Presented and published in the proceedings of the ASCE conference at Stanford University, August 2000.

**00-1 Ground-Based Imaging And Data Acquisition Systems For Roadway Inventories In New England - A Synthesis Of Practice**

Reports:

“Ground-Based Image and Data Acquisition Systems for Roadway Inventories in New England – A Synthesis of Highway Practice,” Hancock, K. and Degray, J., August 2002, NETCR 30.

Papers and Presentations: None

- 00-2 Evaluation Of Permeability Of Superpave Mixes**  
Reports:  
“Evaluation of Permeability of Superpave Mixes,” Mogawer, W., Mallick, R., Teto, M. and Crockford, C., July 3, 2002, NETCR34.
- Papers and Presentations:  
“An Alternative Approach to Determination of Bulk Specific Gravity and Permeability of Hot Mix Asphalt (HMA),” Bhattacharjee, S., Mallick, R. and Mogawer, W. Submitted to International Journal of Pavement Engineering.
- A Presentation, by W. Mogawer, to the Northeast Asphalt User Producer Group Meeting, October 18, 2001, Albany, New York.
- 00-3 Design, Fabrication and Preliminary Testing of a Composite Reinforced Timber Guardrail**  
Reports:  
“Design, Fabrication and Preliminary Testing of a Composite Reinforced Timber Guardrail,” Davids, W., Botting, J., March 31, 2004, NETCR 39.
- Papers and Presentations: None
- 00-4 Portable Falling Weight Deflectometer Study**  
Reports:  
“Portable Falling Weight Deflectometer Study,” Steinert, B., Humphrey, D., Kestler, M., March 11, 2005, NETCR52.
- Papers and Presentations: None
- 00-5 Guardrail Testing Modified Eccentric Loader Terminal (MELT) at NCHRP 350 TL-2**  
Reports:  
“Guardrail Testing Modified Eccentric Loader Terminal (MELT) at NCHRP 350 TL-2,” Alberson, D., Menges, W. and Haug, R., July 2002, NETCR35.
- Papers and Presentations:  
Dean Alberson, Texas Transportation Institute, Principal Investigator presented the results of the crash tests conducted on the MELT guardrail terminal to the Association of General Contractors/American Road Transportation Builders Association/American Association of State Highway Transportation Officials Task Force 13 meeting in Seattle, Washington, April 2002.

- 00-6 Effective Visualization Techniques for the Public Presentation of Transportation**  
Reports:  
“Effective Visualization Techniques for the Public Presentation of Transportation Projects,” Luo, J., MS Thesis, University of Connecticut, August 2002.  
  
“Effective Visualization Techniques for the Public Presentation of Transportation Projects,” Garrick, N.W., Minutti, P., Westa, M., Luo, J., Bishop, M., July 2005, NETCR 48.  
  
Papers and Presentations: None
- 00-7 A Complete Review of Incident Detection Algorithms and Their Deployment: What Works and What Doesn’t**  
Reports:  
“A Complete Review of Incident Detection Algorithms & Their Deployment: What Works and What Doesn’t,” Parkany, E., Xie C., February 7, 2005, NETCR 37.  
  
Papers and Presentations:  
“Use of Driver-Based Data for Incident Detection,” Parkany, Emily, Submitted to the 7<sup>th</sup> International Conference on Applications of Advanced Technologies in Transportation Engineering (AATT), Boston, August 2002.
- 00-8 Performance and Effectiveness of a Thin Pavement Section Using Geogrids and Drainage Geocomposites in a Cold Region**  
Reports: None  
  
Papers and Presentations:  
“Geogrid Reinforced Pavement Structure in a Cold Region,” Helstrom, C.L., Humphrey, D.N., and Hayden, S.A., Proceedings of the 13th International Conference on Cold Regions Engineering, ASCE, Orono, Maine, 12 pp., 2006

- 01-1           Advanced Composite Materials for New England’s Transportation Infrastructure: A Study for Implementation and Synthesis of Technology and Practice**  
Reports:  
“Advanced Composite Materials for New England’s Transportation Infrastructure: A Study for Implementation and Synthesis of Technology and Practice,” Breña, S.F., Civjan, S.A., and Goodchild, M., May 2006, NETCR62.
- Papers and Presentations: None
- 01-2           Development of a Testing Protocol for QC/QA of Hot Mix Asphalt**  
Reports:  
“Development of a Testing Protocol for QC/QA of Hot Mix Asphalt (HMA),” Mogawer, W.S., Mallick, R., February 2004, NETCR 43.
- Papers and Presentations:  
“An Evaluation of Use of Rapid Triaxial Test In Quality Control of Hot Mix Asphalt (HMA),” Mogawer, W. S., Presented at the 82<sup>nd</sup> Annual Meeting of the Transportation Research Board, January 12-16, 2003, Washington DC.
- 01-3           Design of Superpave HMA for Low Volume Roads**  
Reports:  
“Design of Superpave HMA for Low Volume Roads,” Mogawer, W.S., Mallick, R., December 2004, NETCR 51.
- Papers and Presentations:  
“Development of Mix Design Criteria for Low Traffic Volume Hot Mix Asphalt Roads,” Nanagiri, Y.V., Mallick, R., Mogawer, W.S. Proceedings of the Annual Meeting of the Canadian Technical Asphalt Association, November 2003.
- 01-6           Field Evaluation of a New Compaction Monitoring Device**  
Reports:  
“Field Evaluations of A New Compaction Monitoring Device,” Miller, H.J., June 2003, NETCR 42.
- Papers and Presentations: None

- 02-2 Formulate Approach for 511 Implementation in New England**  
Reports:  
“Formulate Approach for 511 Implementation in New England,”  
Shuldiner, P., Loane, G., and Knapick, R., October 2005, NETCR44.
- Papers and Presentations: None
- 02-3 Establish Subgrade Support Values for Typical Soils in New England**  
Reports:  
“Establish Subgrade Support Values for Typical Subs in New England,”  
Malla, R. B., and Joshi, S., April 2006, NETCR57.
- Papers and Presentations:  
“Resilient Modulus Prediction Models for Some New England Subgrade  
Soils,” Malla, R. and Joshi, S., *Electronic Proceedings* of the 2005 Joint  
ASCE/ASME/SES Conference on Mechanics and Materials (McMat  
2005), Baton Rouge, LA, June 1-3, 2005.
- “Resilient Modulus of Subgrade Soils A-1-b, A-3, an A-7-6 using LTPP  
Data: Prediction Models with Experimental Verification,” Joshi,  
Shraddha, and Malla, R., *Proceedings, ASCE GeoCongress 2006*,  
(Atlanta, GA, Feb. 26-March 01, 2006), ASCE, Reston, VA; Feb. 2006,  
6p (CD ROM).
- 02-5 Determiration of Moisture Content of Deicing Salt at Point of  
Delivery**  
Reports:  
“Determiration of Moisture Content of Deicing Salt at Point of Delivery,”  
Long, R., Demars, K., March 2004, NETCR 45.
- Papers and Presentations: None



02-6

### **Sealing of Small Movement Bridge Expansion Joints**

#### Reports:

“Sealing of Small Movement Bridge Expansion Joints,” Malla, R.B., Shaw, M.T., Shrestha, M.R. and Boob, S., June 2006, NETCR58.

#### Papers and Presentations:

“Silicone Foam Sealant for Bridge Expansion Joints,” Malla R. B., Shaw M. T., Shrestha M. R., Boob S., McMat 2005 Mechanics and Materials Conference Baton Rouge, Louisiana, June 1-3, 2005.

“Experimental Evaluation of Mechanical characteristics of Silicone Foam Sealant for Bridge Expansion Joints,” Malla R. B., Shaw M. T., Shrestha M. R., Boob S., 2005 Society for Experimental Mechanics Annual Conference Portland, Oregon, June 7-9, 2005.

“Development and Experimental Evaluation of Silicone Foam Sealant For Small Bridge Expansion Joints,” Matu Shrestha, M.S. Thesis, Dept. of Civil & Environmental Engineering, University of Connecticut, Storrs, CT, September 2005.

“Laboratory Evaluation of Weathering and Freeze-Thaw Effects on Silicone Foam Bridge Joint Sealant,” Shrestha, M.R., Malla, R.B., Boob, S. and Shaw, M.T., Paper #369, *Proceedings, SEM 2006 Annual Conference and Exposition* ( St. Louis, MO, June 04-07, 2006), SEM, Bethel, CT, June 2006, 8p (CD ROM).

“Development and Laboratory Analysis of Silicone Foam Sealant for Bridge Expansion Joints,” Malla, R., Shaw, M., Shrestha, M., and Brijmohan, S., *Journal of Bridge Engineering*, ASCE, Reston, VA, July 2006.

02-7

**Validating Traffic Simulation Models to Inclement Weather Travel Conditions with Applications to Arterial Coordinated Signal Systems**  
Reports:

“Validating Traffic Simulation Models to Inclement Weather Travel Conditions with Applications to Arterial Coordinated Signal Systems,” Sadek, A., El-Dessouki, W., November 2004, NETCR 47.

Papers and Presentations:

“Inclement Weather and Traffic Flow at Signalized Intersections: A Case Study from Northern New England,” Agbolosu-Amison, S.J., Sadek, A.W., and El-Dessouki, W., (2003). Tentatively accepted for publication in the *Journal of the Transportation Research Board*.

“Impact of Inclement Weather on Traffic Signal Operations in New England,” Agbolosu-Amison, S.J., Sadek, A.W., (2003). Presented to the Vermont Chapter of the Institute of Transportation Engineers, Montpelier, Vermont.

“Inclement Weather and Traffic Flow at Signalized Intersections: A Case Study from Northern New England,” Agbolosu-Amison, S.J., Sadek, A.W., and El-Dessouki, W., (2003). Presented at the *83rd Annual Transportation Research Board Meeting*, Washington, D.C.

02-8

**Intelligent Transportation Systems Applications to Ski Resorts in New England**

Reports:

“Intelligent Transportation Systems Applications to Ski Resorts in New England,” Sadek, A., March 2004, NETCR 46.

Papers and Presentations:

“Addressing Ski Resort Transportation Problems with Intelligent Transportation Systems Applications,” Knapick, R.J., and Sadek, A.W., (2003). Abstract submitted to the Institute of Transportation Engineers District One Meeting, Burlington, VT.

**03-2 Field Studies of Concrete Containing Salts of an Alkenyl-Substituted Succinic Acid**

Reports: None.

Papers and Presentations:

“Hycrete – DSS An Innovative Admixture for Concrete: An Update on NETC 03-2,” Civjan, Scott A., and Crellin, Benjamin, 16th Annual NE Materials and Research Meeting Concord, NH. June 7, 2005.

“Hycrete Concretes: An Update on NETC 03-2,” Civjan, Scott A., and Crellin, Benjamin, Connecticut DOT, November 2, 2005.

“A New Admixture to Mitigate Corrosion Problems,” Civjan, S.A., and Crellin, B.J., *Concrete International*, Volume 28, No. 8, Pp. 78-82.

**03-3 Phase 1 Feasibility Study of an Erosion Control Laboratory in New England**

Reports:

“Feasibility Study of an Erosion Control Laboratory in New England,” Long, R.P., and Demars, K.R., December 2004, NETCR 49.

Papers and Presentations: None

**03-3 Phase 2 Design Considerations for a Prototype Erosion Control Laboratory in New England**

Reports:

“Design Considerations for a Prototype Erosion Control Testing Plot,” Long, R.P., and Demars, K.R., December 2005, NETCR 56.

Papers and Presentations: None

**03-4 Measuring Pollutant Removal Efficiencies of Stormwater Treatment Units**

Reports:

“Measuring Pollutant Removal Efficiencies of Stormwater Treatment Units,” Zhang, X., September 27, 2005, NETCR54.

Papers and Presentations:

“Evaluation of Pathogenic Indicator Bacteria in Structural BMPs,” Zhang, X. and Lulla, M., to be published in the *Journal of Environmental Science and Health, Volume A41* (November 2006).

“Distribution of Pathogenic Indicator Bacteria in Structural BMPs,” Zhang, X. and Lulla, M. to be published in the *Journal of Environmental Science and Health, Volume A41* (August 2006).

**03-5 Evaluation of a Field Permeameter as a Longitudinal Joint Quality Indicator**

Reports: None

Papers and Presentations:

“Development of a Longitudinal Joint Permeameter as a QC/QA Tool for HMA Pavements,” Daniel, J.S., a Presentation to the Petersen Asphalt Research Conference, Cheyenne, WY, June 2005.

“Longitudinal Joint Permeameter: New Non-Destructive Pavement Joint Test,” Daniel, J.S., a Presentation to the North East Asphalt User/Producer Group Meeting, Burlington, VT, October 2005.

“Longitudinal Joint Permeameter: Non-Destructive Test for QC,” Daniel, J.S., a presentation to PennDOT Bituminous Technician Certification Program, March 14, 2006.

“Development and Evaluation of a Field Permeameter as a Longitudinal Joint Quality Indicator,” Mallick, R.B., and Daniel, J.S., *International Journal of Pavement Engineering*, Vol. 7, No. 1, March 2006. pp. 11-21.

03-7

**Basalt Fiber Reinforced Polymer Composites**

Reports: None

Papers and Presentations:

“Preliminary Investigation of Basalt Fiber Composite Properties for Applications in Transportation,” Liu, Q., Shaw, M.T., Parnas, R.S., McDonnell, A., Transportation Research Board Annual Meeting, January 2005, Washington, D.C., Paper 05-1117, Session 487.

“Investigation of Basalt Fiber Composite Mechanical Properties for Applications in Transportation,” Q. Liu, M.T. Shaw, R.S. Parnas and A.M. McDonnell, *Polymer Composites*, 27(1), 41-48, 2006.

“New Set-Up For In-Plane Permeability Measurement,” Q. Liu, R. S. Parnas and H. S. Giffard, *Composites Part A*, submitted.

“Investigation of Basalt Fiber Composite Aging Behavior for Applications in Transportation,” Q. Liu, M. T. Shaw, R. S. Parnas, A.M. McDonnell, *Polymer Composites* (*in press*).

“Basalt Fiber Reinforced Polymer Composites,” Q. Liu, R.S. Parnas, M.T. Shaw, A.M. McDonnell, SAMPE, Seattle, WA, November 2005.

“New Set-up for Permeability Measurement,” Q. Liu, R.S. Parnas, SAMPE, Seattle, WA, November 2005.

04-2

**Driver-Eye-Movement-Based Investigation for Improving Work-Zone Safety**

Reports: None

Papers and Presentations:

“Human Factors: Understanding & Evaluating Driver Response,” Muttart, J.W., Anne Arundel County Police Special Operations Building, Sponsored by the Maryland Association of Traffic Accident Investigators, Hanover, MD. March 20 - 23, 2006.

“Understanding and Quantifying Driver Response,” Muttart, J.W., Texas Association of Accident Reconstructionist Specials, Houston, TX, February 17 & 18, 2006.

“Using Event Data Recorder Information for Driver Response Research and Intelligent Transportation Systems in Rear End Collision,” Muttart, J.W., CDR Users Conference, Dallas, TX. February 13, 2006.

**04-2 Driver-Eye-Movement-Based Investigation for Improving Work-Zone Safety (cont'd):**

Papers and Presentations (cont'd):

“Human Factors: Understanding & Evaluating Driver Response,” Muttart, J.W., Canadian Association of Traffic Accident Investigators & Reconstructionists, Fredericton, NB, Canada. July 10 - 13, 2006.

“Driving Simulator Evaluation of Situational Awareness during Hands-Free Communication,” Muttart, J.W., New England Institute of Transportation Engineers Technology Day, Amherst, MA. July 20, 2006.

“Accounting for Moderate Driver Distractions in Work Zones,” Muttart, J.W., Factors, Formulae, Forensic, Technology, & Training Conference, Houston, TX. September 17, 2006.

“Driving Simulator Evaluation of Situational Awareness during Hands-Free Communication Tasks,” Muttart, J.W., Research paper submitted to the Transportation Research Board and accepted as a presentation to be given 1/21/07 in Washington, DC.

**04-5 Network-Based Highway Crash Prediction Using Geographic Information Systems**

Reports: None

Papers and Presentations:

“A Procedure for Allocating Zonal Attributes to a Link Network in a GIS Environment,” Jonsson, T., Deng, Z., Ivan, J.N., presented at 85th TRB Annual meeting, Jan. 2006, Paper No.: 06-2561.

“Using Land Use Data to Estimate Exposure for Improving Road Accident Prediction,” Jonsson, T., Ivan, J.N., Zhang, C., presented at 32<sup>nd</sup> Annual Traffic Records Forum, Palm Desert CA, Aug. 3, 2006.

**05-3 Practicable Calibration Procedures to Enhance the Accuracy of Analytical and Microsimulation Software for Modern Four-Legged Single-Lane Roundabouts**

Reports: None

Papers and Presentations:

“Assessing the Accuracy of Roundabouts Analysis Procedures against Field Observations: Preliminary Results from a Case Study in Northern New England,” Smith, M.C., Sadek, A.W., Johnson I., Aultman-Hall L., and Garder P., 2007, Proceedings of the *Annual Transportation Research Board Meeting*, TRB, National Research Council, Washington, D.C.