ANNUAL REPORT

For Calendar Year 2003

NEW ENGLAND TRANSPORTATION CONSORTIUM

NETCR 55 **September 2005**

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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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. 2003 HIGHLIGHTS

1. **FUNDING APPROVED FOR NEW RESEARCH TO ADDRESS SIX HIGH PRIORITY REGIONAL TRANSPORTATION RESEARCH NEEDS:** The NETC Policy Committee, upon recommendation of the Advisory Committee, approved six research project, totaling $589,000, to be initiated in FY 2004 to address the following high priority regional transportation research needs:
   - Recycling Asphalt Pavements Containing Modified Binders
   - Driver-Eye Movement-Based Investigation for Improving Work-Zone Safety
   - Estimating the Magnitude of Peak Flows for Steep Gradient Streams in New England
   - Determining the Effective PG Grade of Binder in RAP Mixes
   - Network-Based Highway Crash Prediction Using Geographic Information Systems
   - Development of Truck Lane Design Software That Uses A Current Model of Truck Performance

2. **FINDINGS FROM SEVEN RESEARCH PROJECTS PUBLISHED AND DISTRIBUTED:** Final reports for the following projects were published and distributed to New England's State transportation agencies and universities, the Federal Highway Administration, the AASHTO Region 1 Research Advisory Committee, and the National Transportation Library:
   - NETC 94-2: "Non Destructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques"
   - NETC 97-1: "A Portable Method for Determining Chloride Concentration on Roadway Pavements"
   - NETC 97-2: "Performance Evaluation and Economic Analysis of Combinations of Durability Enhancing Admixtures in Structural Concrete for the Northeast U.S.A."
   - NETC 00-5: "Guardrail Testing – Modified Eccentric Loader Terminal (MELT) at NCHRP 350 TL-2"
   - NETC 01-2: "Development of A Testing Protocol for Quality Control/Quality Assurance of Hot Mix Asphalt"
   - NETC 01-6: "Field Evaluation of a New Compaction Device"
   - NETC 02-5: "Determination of Moisture Content of De-icing Salt at Point of Delivery

3. TECHNOLOGY TRANSFER:

- **19 Requests for Information and/or NETC Research Project Reports Were Processed:** The requests were received from a variety of sources including: the Connecticut, Maryland, New Mexico, Oregon, and Ohio Departments of Transportation; the Universities of Alabama, Massachusetts Dartmouth, and Rhode Island; the New Jersey Port Authority; Consultants, and Road Builders.
- **Research Newsletter Published:** Volume 2 of the NETC newsletter, 'Research News', was published and distributed.
- **5 Ready-To-Use Technologies Developer Through NETC Research Submitted to the AASHTO Technology Implementation Group for Consideration for National Promotion for Implementation:** The following ready-to-use technologies, which were developed through NETC sponsored research, were submitted to the AASHTO Technology Implementation Group
  - **a. Design Recommendations for the Use of Tire Shreds/Soil Mixtures to Limit Frost Heave and Damage of Secondary Paved Roads**
  - **b. Performance Specifications for Wood Waste Materials As An Erosion Control Mulch and As A Filter Berm**
  - **c. Design Criteria for Using Tire Shreds as Lightweight Backfill for Retaining Walls**
  - **d. The New England Transportation Consortium 2-Bar, Curb-Mounted Bridge Rail**
  - **e. The New England Transportation Consortium 4-Bar, Sidewalk-Mounted Bridge Rail**
- **Meetings/Conferences:**
  - **a. NASTO Annual Meeting:** The Chairman of the NETC Advisory Committee and the NETC Coordinator attended the NASTO meeting held in Saratoga, NY in April 2003.
  - **b. AASHTO Region 1 Research Advisory Council Meeting:** Members of the NETC Advisory Committee attended the AASHTO Region 1 RAC meeting held in Boston, MA in June 2003.
  - **c. AASHTO Annual Meeting:** The NETC Coordinator presented an exhibit of NETC research projects at the AASHTO Annual Meeting held in Minneapolis, MN in September 2003.
- **Connecticut Transportation Institute Peer Exchange:** The NETC Coordinator participated in the peer exchange held for the Connecticut Transportation Institute in July 2003.
- **Papers Presented at Technical Conferences or Published in Technical Journals by NETC Researchers:**
  - **a.** " Development of Mix Design Criteria for Low Traffic Volume Hot Mix Asphalt Roads", Yamini V. Nanagiri, Rajib Mallick and Walaa S. Mogawer. Selected for publication in the Proceedings of the Annual Meeting of the Canadian Technical Asphalt Association, November 2003.
  - **b.** "Inclement Weather and Traffic Flow at Signalized Intersections: A Case Study from Northern New England", Agbolosu-Amison, S. J., A.W. Sadek, and W. El-Dessouki, 2003. Tentatively accepted for publication in the *Journal of the Transportation Research Board.*
  - **c.** "Impact of Inclement Weather on Traffic Signal Operations in New

England", Agbolosu-Amison, S. J., A.W. Sadek, and W. El-Dessouki, 2003. A presentation made to the *Vermont Chapter of the Institute of Transportation Engineers*, Montpelier, Vermont.

d. " Addressing Ski Resort Transportation Problems with Intelligent Transportation Systems Applications", Knapick, R.J. and A.W. sadek, 2003. Abstract submitted to the *Institute of Transportation Engineers District One Meeting*, Burlington, Vermont.

C. PROGRESS OF ACTIVE PROJECTS

PROJECT NUMBER: 97-2

PROJECT TITLE: Performance Evaluation and Economic Analysis of Combination of Durability Enhancing Admixtures (Mineral and Chemical) in Structural Concrete for the Northeast U.S.A.

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

STATUS: Completed

INITIAL AGREEMENT DATE: 8/30/98

END DATE: 8/30/02

PROJECT OBJECTIVES: To evaluate the performance of chemical and mineral durability enhancing admixtures in structural reinforced concrete mixes typical of those specified by State Highway Departments in New England. Combinations of silica fume, fly ash, ground granulated blast furnace slag, disodium salts, and chemical corrosion inhibitors are being considered. The final report will contain guidelines for the New England State Highway Departments on the specification and use of mineral and chemical admixtures in structural reinforced concrete, including both expected long-term durability enhancement and overall life cycle economic impacts.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003: The final report was published

REPORTS, PAPERS, AND PRESENTATIONS:

1. "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., NETCR36, February 2003.
2. "Performance Evaluation of Combinations of Durability Enhancing Admixtures in Concrete – Review and Experimental Program," Lovett, D., Report in Partial Fulfillment of a Master of Science in Civil Engineering Degree, Department of Civil and Environmental Engineering, University of Massachusetts, Amherst. February, 2001.
3. "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.
4. "Performance Evaluation of Durability Enhancing Admixtures (Mineral and Chemical) in Structural Concrete," Sund, D., Report in Partial Fulfillment of a Master of Science in Civil Engineering Degree, Department of Civil and Environmental Engineering, University of Massachusetts, Amherst, September, 1999.

PROJECT NUMBER: 99-1

PROJECT TITLE: NETC Bridge Rail Transitions - Development and Crash Testing

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S): Technical Committee Chairman, David R. Hall, Federal Highway Administration, New Hampshire Division

STATUS: Continuing

INITIAL AGREEMENT DATE: 6/5/98

END DATE: To be determined

PROJECT OBJECTIVES: (1) To design bridge rail transitions for use with the NETC 2-bar curb-mounted bridge rail; the 4-bar sidewalk-mounted steel bridge rail; the Mass Highway concrete end wall with approach curb; and the Mass Highway concrete end wall mounted behind a sidewalk and (2) to crash test these transitions to meet NCHRP 350 TL-3 criteria.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003: Bridge rail transition designs were designed for the NETC 2-Bar Curb-Mounted and 4-Bar Sidewalk Mounted Bridge Rails and for a concrete end wall. These designs will be constructed and crash tested.

A Request for Proposals (Scope of Work) for crash testing the aforementioned transitions was completed and sent to the Texas Transportation Institute, the Southwest Research Institute, and the Midwest Roadside Safety Facility. The Texas Transportation Institute (TTI) responded with a proposal to perform the required crash tests plus an optional test to qualify the Mass Highway transition mounted behind a sidewalk to TL-4. No other proposals were received. The Texas Transportation Institute (TTI) was awarded funding to conduct the crash tests.

REPORTS, PAPERS, AND PRESENTATIONS: Design documents for the NETC 2-Bar Curb-Mounted and 4-Bar Sidewalk-Mounted Bridge Rail Transitions and the Concrete End Wall Transition are available from the NETC Coordinator.

PROJECT NUMBER: NETC 99-2

PROJECT TITLE: Evaluation of Asphaltic Expansion Joints

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):
Prof. Walaa S. Mogawer, P.E.
University of Massachusetts Dartmouth

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/01

END DATE: 12/31/03

PROJECT OBJECTIVES:

1. To evaluate the overall costs of the asphaltic expansion joints including periodic maintenance
2. To identify its average useful lifespan
3. To identify flaws in installation and maintenance methods which could hinder maximum performance
4. To establish recommendations and limitations regarding expansion, skew, thermal limits, etc.
5. To identify possible reasons for failure, and
6. To develop a specification and design-repair guidelines as well as methods for quality control for use by State Highway Departments

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:

1. Completed the field inspections of asphaltic expansion joints in all the New England States
2. Witnessed asphaltic expansion joints installations in Connecticut and Vermont
3. Received virgin aggregate and binder material from two manufacturers. Commenced lab testing on these materials
4. Completed nationwide survey of asphaltic expansion joints usage and specifications. Final results were tabulated and put in geographical form.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: 00-3

PROJECT TITLE: Design, Fabrication and Preliminary Testing of a Composite Reinforced Timber Guardrail

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S): W. Davids, H. Dagher, University of Maine

STATUS: Continuing

INITIAL AGREEMENT DATE: 5/1/01

END DATE: 5/31/03

PROJECT OBJECTIVES: The primary objective of the proposed research is to develop a timber guardrail reinforced with fiber-reinforced polymers (FRP) and having the potential to meet TL-3 crash test performance criteria. This timber guardrail will take advantage of glued-laminated timber technology, allowing the use of more readily available smaller sections of dimensioned lumber. The FRP reinforcement will permit the use of lower grade lumber, making native New England species (such as red maple and Eastern hemlock) competitive with non-native timber.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:

A. The guardrail design cross-section was finalized to a 10-1/4" wide by 3" deep glulam consisting of a brickwork layup of mixed hardwoods (primarily red maple). Two 5" wide by 1/8" thick pieces of E-glass/epoxy FRP produced by Gordon Composites were selected for tension reinforcement.
B. We purchased 560 board-feet of soft maple from O&R lumber in Milo, Maine and fourteen 5" wide pieces of e-glass/epoxy FRP from Gordon Composites for use in guardrail fabrication. The random-width lumber was ripped into consistent widths suitable for use in a 10-1/4" wide guardrail layup, and was also planed and graded into three grades (#6, #3, and #2) according to the AITC 119-96 Standard Specifications For Structural Glued Laminated Timber of Hardwood Species for red maple.
C. Josh Botting (project graduate student) and Chad Gibson (undergraduate student funded by the NSF REU program) completed finger jointing and planning the mixed hardwoods to be used for rail specimen. 12'-long rail specimens were fabricated for the testing program at the AEWC Center Laboratory (see Figure 1).
D. An effective field splice design was finalized for connecting individual 12' rail sections at alternate post locations. The unique splice relies on a steel-to-steel single shear connection utilizing ¾"-diameter, field-installed bolts. One steel plate is pre-bonded to the rail section with an inexpensive off-the-shelf epoxy, which eliminates the need for the use of any adhesive in the field. This splice is critical to guardrail performance, as it must transfer the entire tensile force developed during impact between each 12' section of guardrail. We note that other timber guardrail systems rely on a continuous steel backing plate or rolled section to

carry tension in the guardrail system.

E. Six tension-shear tests of the bolted splice connections were completed that mimicked actual eccentricities of the actual splice (see Figure 2). To determine the effect of bolt pretension on connection performance, tests were performed with bolt torques of 100 ft-lbs, 40 ft-lbs, and 20 ft-lbs. (two nominally identical specimens at each torque level). As expected, the 100 ft-lb. specimens performed best, with a splice capacity near 100 kips. However, even when the torque was reduced to 20 ft-lbs., the connection still sustained approximately 80 kips of tension. We note that the expected tension during a TL-3 rail impact was estimated at 40 kips using the Barrier VII computer program. These test results indicate that the bolted splice connection will continue to perform well in the field after initially high bolt pretension load is lost due to creep and rail dimensional changes under moisture cycling. In all cases, the steel-FRP epoxy bond performed very well.
F. ASTM D1101 moisture cycling tests were conducted to evaluate the efficacy of the steel-FRP-wood bond lines at the splice connection. It is critical to qualify these bonds for an exterior application: the steel undergoes essentially no dimensional changes with moisture cycling, while the wood swells significantly, inducing large tensile and peeling stresses at the wood-FRP and FRP-steel interface. The specimens performed very well, with no delamination noted at the wood-FRP or FRP-steel interface.
G. A test rig was set up for flexural testing, and three dummy specimens were tested to verify its adequacy and our instrumentation scheme. The 3-point bending tests of two reinforced rail specimens were completed, achieving excellent results. The measured strengths of the two specimens were nearly equal, and about 20% higher than expected based on our models.
H. A novel test rig was designed to allow the testing of reinforced guardrail specimens under simultaneous tension and bending. While the design of the test rig was fairly complex, the importance of producing simultaneous bending and tension warrants attempting to design and fabricate such an innovative test rig. The combined bending and tension tests of the rail section were successfully completed (See Figure 3). The performance of all three specimens was consistently good, and they all exhibited a capacity significantly larger than expected. The average peak transverse load carried by each specimen was 187 kN, and the average peak induced tension was 439 kN.
I. The project graduate student, Joshua Botting, successfully defended his M.S. thesis and graduated in December 2003. The project draft final report was distilled from this thesis, and is under review by the project technical committee.

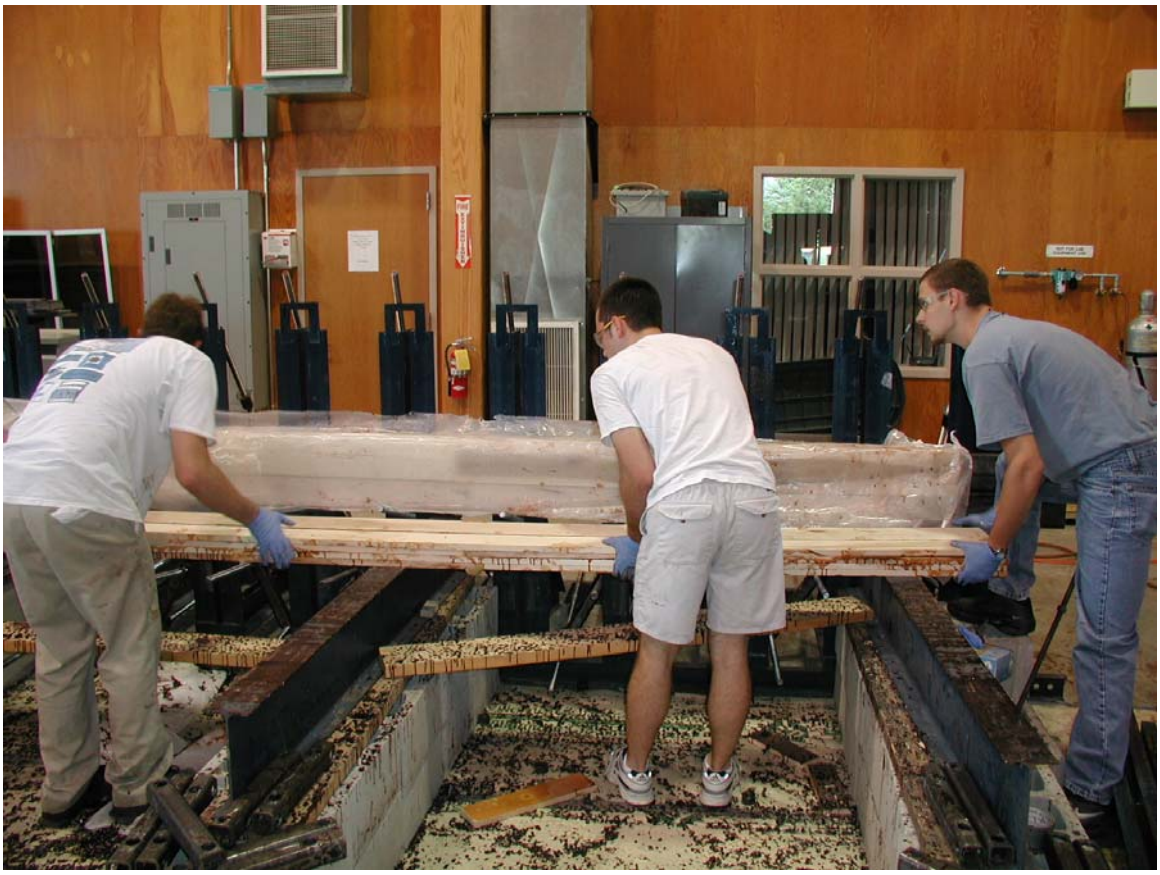

Figure 1: Guardrail Layup in Progress

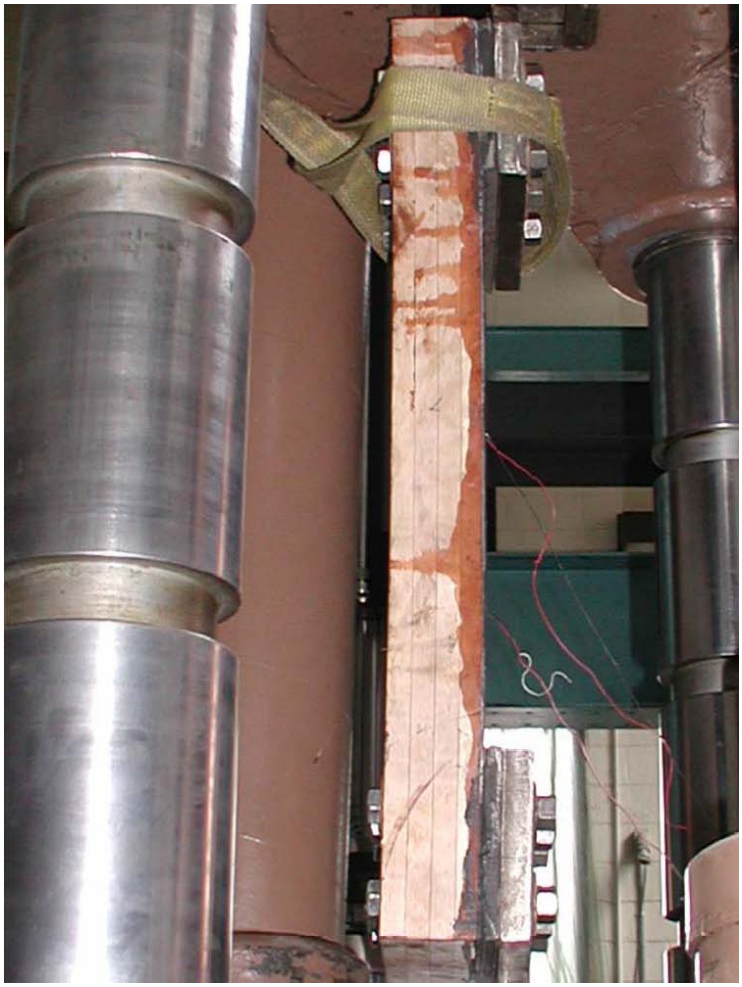

Figure 2: Rail Tension Splice Test

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THOUGH DECEMBER 31, 2003: None

PROJECT NUMBER: 00-4

PROJECT TITLE: Portable Falling Weight Deflectometer Study

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S): Dana N. Humphrey, Department of Civil and Environmental Engineering, University of Maine, Orono, Maine; Maureen A. Kestler, Geotechnical/Pavements Engineer, USDA Forest Service

STATUS: Continuing

INITIAL AGREEMENT DATE: 7/1/02

END DATE: 6/30/04

PROJECT OBJECTIVES:
The objective of this project is to evaluate the effectiveness of portable falling weight deflectometers (PFWD) as a means of monitoring compaction, density, or bearing capacity at construction sites. This will include developing correlations between PFWD results and percent compaction for a range of soils. Guidelines for use of PFWDs will be developed. The guidelines will include acceptance and testing protocols. In addition, the PFWD will be evaluated as a means of optimizing timing for load restriction placement and removal on secondary roads in New England. A comparison will be made of the results from different PFWDs and several alternate devices for measuring the degree of compaction of highway subgrade soils and base/subbase aggregates.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:

The fully executed contract from the Connecticut Department of Transportation was mailed to the University of Maine on October 3, 2002. This allowed work on the project to begin.

The Literature Review Task (Task 1) was prepared. In general terms, useful information was found on use of the PFWD to evaluate the modulus of paved and unpaved roads. However, very limited information was found on use of the PFWD as a tool to evaluate thaw weakening for roads. As part of the literature review, a questionnaire aimed at determining current usage of the PFWD was sent to each of the 50 state departments of transportation. The responses indicated that very few DOT's currently use PFWD's. A Test Plan (Task 2) was also prepared. The literature review and test plan were reviewed and approved at a meeting of the project technical committee on July 25, 2003.

In preparation for performing field and laboratory testing (Tasks 4 and 5), several makes and models of PFWD's were investigated. Based on this review a PFWD manufactured by Keros (model Prima 100) was purchased. This unit had the capabilities needed for this project including variable drop weights, drop heights, and plate diameters along with up to three deflection sensors. In addition, this unit complemented PFWDs from other manufacturers that are already owned by the U.S. Forest Service, our partners on this research project. Proper operation of the Prima

100 was confirmed in late March during the spring thaw.

A major objective of this project is to investigate using PFWD's to monitor seasonally posted roads (Task 4). Preliminary PFWD measurements were made in conjunction with FWD measurements at two sites located in northern Maine. These sites are being monitored as part of a Maine DOT research project. The measurements were taken during the spring thaw. Good correlation was obtained between back calculated moduli from the PFWD and FWD. In addition, a US Forest Service field site located near Rumney, NH was intensively monitored during the spring 2003 thaw. This included matched measurements with FWD, Prima 100 PFWD, Loadman PFWD, and Clegg Hammer. Measurements were also made with a Humboldt soil stiffness gage on some days, however, the unit experienced a mechanical problem. In total, these sets of measurements were taken on six days spaced out during the spring thaw. Field sites for the monitoring that is planned for Spring 2004 were located. Instrumentation (thermocouples and piezometers) for installation at these sites was fabricated. Additional instrumentation was installed at a US Forest Service field site located new Rumney, NH. Instrumentation (thermocouples and piezometers) were installed at two field sites in Maine. All instrumentation is now in place to monitor the selected field sites during the spring 2004 thaw.

Work on Task 5 (Perform testing on subgrades and construction materials) was initiated. This included testing of base aggregate and subgrade soils at construction sites in Maine, New Hampshire, and Connecticut. PFWD and nuclear density measurements were taken at east test location. Sources of aggregate for large-scale laboratory tests to be conducted during the winter and spring of 2004 were located. Approximately 3 tons of each of crushed base was obtained from a site in Connecticut, and gravel base and sand base from a site in New Hampshire. An additional 3 ton sample meeting the requirements of MDOT Type D subbase was obtained from a pit in Maine. There are now four samples stored in our laboratory for the large scale PFWD tests. The final sample will be obtained spring, 2004.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: 00-6

PROJECT TITLE: Effective Visualization Techniques for the Public Presentation of Transportation Projects

PRINCIPAL INVESTIGATORS: Norman W. Garrick, Peter Miniutti and Mark Westa, University of Connecticut

STATUS: Continuing

INITIAL AGREEMENT DATE: 6/01/01

END DATE: June 31, 2003

PROJECT OBJECTIVES:
The objective of this work is to develop an effective approach that area DOT's can use for presenting transportation projects to the public.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:
The state transportation agencies were surveyed to gain an understanding of how and where visualization is used by DOT personnel. This survey showed that all the DOTs are using visualization for public presentation but few are using these techniques as an integral part of the design. The survey found that the level of training and support for visualization varied significantly from state to state.

A separate survey of private sector firms (in transportation and allied design fields) was also conducted. This survey was useful in illustrating the full range of visualization tools that are being employed in design and the level to which these tools have been integrated into the design process by these firms. Based on these surveys, a workshop and manual for guiding the use of visualization tools in the DOTs is being developed.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: "EffectiveVisualization Techniques for the Public Presentation of Transportation Projects," Luo, J., MS Thesis, University of Connecticut, August 2002.

PROJECT NUMBER: 00-7

PROJECT TITLE: A Complete Review of Incident Detection Algorithms and their Deployment: What Works and What Doesn't

PRINCIPAL INVESTIGATOR(s) & UNIVERSITY(s): Dr. Emily Parkany, Assistant Professor, University of Massachusetts, Amherst

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/00

END DATE: 6/30/02

PROJECT OBJECTIVES: This study focuses on a comprehensive evaluation and comparison on all available sensor technologies and processing algorithms for incident detection. There is an emphasis on implemented algorithms, arterial algorithms and algorithms that utilize section data other than point data.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:

1. All academically recognized incident detection algorithms were reviewed and compared and the algorithms used for arterials and based on probe-based and drive based data were emphasized. Previous literature reviews were also investigated, but the focus of this review is distinguished from previous reviews.
2. A new classification system for current incident detection approaches was defined and identified.
3. A review on procedures for calibration of incident detection algorithms was conducted.
4. The first draft of the final report has been finished. However, newly available findings and progress will further be incorporated into this study. Hence the report draft is being revised and improved.
5. A set of recommendations of incident detection implementation approaches based on the previous evaluations and comparisons were made.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: "Use of Driver-Based Data for Incident Detection," Parkany, E. Submitted to the 7th International Conference on Applications of Advanced Technologies in Transportation Engineering (AATT) to be held in Boston in August 2002.

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, Maine.

STATUS: Continuing

INITIAL AGREEMENT DATE: 7/1/01

END DATE: 6/30/05

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, 2003: 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 and then removed prior to the winter freeze-up in November, 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. As of December 31, 2002, 103 out of 120 strain gages are operating, which demonstrates the effectiveness of the protective system. The piezometers have a measurement range of 0 to 34 kPa (0 to 5

psi) and an accuracy of ±0.17 kPa (±0.025 psi). This allows heads as low as 1.5 mm (0.06 in.) to be measured. Most of the pore pressure readings have been negative suggesting that the subbase has remained partially saturated throughout the monitoring period both in sections with and without drainage geocomposite.

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 data logger. 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 data loggers. 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 are read manually every two weeks and converted to an average flow rate for the period. These have proved to be very reliable and simple to use. 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 data logger that takes and stores hourly readings. The readings are downloaded by-weekly via modem. To analyze the data, the 23 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 data logger, bi-weekly manual readings were generally taken.

A performance evaluation was made based on data gathered through June, 2003. 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 data loggers analyzed. This included preparation of plots of geogrid strain, subgrade and subbase pore pressures, and front penetration versus time.

A draft interim project report was prepared. The report details construction of the project, and findings and conclusions based on data gathered through June 2003. this report includes the literature review for the project and data fathered from Maine DOT files that are related to this project.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

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): Sergio F. Breña, Scott A. Civjan, University of Massachusetts Amherst.

STATUS: New

INITIAL AGREEMENT DATE: 8/1/03

END DATE: 12/31/04

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, 2003:

The following points list the major accomplishments of the project thought 31 December 2003:

1. Conducting an initial literature review has allowed us to identify application projects of FRP products in the transportation infrastructure throughout the U.S. This information will be used to compare current practice in the Nation with application projects in New England.

2. A database of groups involved with the use of FRP products in transportation applications within New England was created. Three major groups were identified: FRP product fabricators, universities and research institutions involved with FRP product testing, and transportation agencies. These groups encompass the major players for the successful implementation of FRP products for transportation infrastructures uses. This database will serve to foster information exchange between participants of an FRP network in New England.

3. Surveys on the use of FRP products for transportation applications were prepared and sent to the key participants of the FRP network. Different surveys were sent to the FRP fabricators group and the Transportation Agencies group. Additionally, university and research institutions have been contacted to provide technical information on current research being conducted at their respective institutions.

4. The information compiled so far is being incorporated into a Web Site being created for this project (http://www.ecs.umass.edu/cee/NETC_01-1). The site will be posted during the first quarter of 2004 and will promote the exchange

of information among different groups. The purpose of having a project site if also to provide contact information and summarize different FRP products that are available for potential use in transportation infrastructure applications.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THE PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: 01-2

PROJECT TITLE: Development of a Testing Protocol for QC/QA of Hot Mix Asphalt (HMA)

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S): Walaa S. Mogawer, P.E., UMass Dartmouth; Rajib Mallick, Worcester Polytechnic Institute

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/02

END DATE: 12/31/02

PROJECT OBJECTIVES:

1. Evaluate the sensitivity, accuracy and repeatability of the rapid triaxial testing equipment.
2. Develop criteria for using the results from these tests for identifying poor and good performing mixes during production and construction.
3. Develop quality control and quality assurance specification limits based on the results from the triaxial testing equipment.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:

All tasks related to this project were completed. The final report is being reviewed.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: "An Evaluation of Use of Rapid Triaxial Test In Quality Control of Hot Mix Asphalt (HMA)," Mogawer, W. S., Presented at the 82nd Annual Meeting of the Transportation Research Board, January 12-16, 2003, Washington DC.

PROJECT NUMBER: 01-3

PROJECT TITLE: Design of Superpave HMA for Low Volume Roads

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S): Walaa S. Mogawer, P.E., UMass Dartmouth, and Rajib Mallick, P.E., Worcester Polytechnic Institute

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/01

END DATE: 2/29/04

PROJECT OBJECTIVES:
1. Develop compaction and volumetric (mix design) criteria for designing asphalt mixes for low volume roads.
2. Evaluate the performance of mixes designed according to these criteria.
3. Provide recommendations for proper implementation of the new mix design system by the state DOTs.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:

All work related to design and testing of sex mixes has been completed. Testing of field cores from two sites was completed. The results were used to correlate stiffness (of asphalt binder and mix) with volumetric properties such as VMA, VFA, and film thickness.

Work is being conducted to analyze the data and make conclusions and recommendations.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: Yamini V. Nanagiri, Rajib Mallick and Walaa S, Mogawer, "Development of Mix Design Criteria for Low Traffic Volume Hot Mix Asphalt Roads". Selected for publication in the Proceedings of the Annual Meeting of the Canadian Technical Asphalt Association, November 2003.

PROJECT NUMBER: 01-6

PROJECT TITLE: Field Evaluation of a New Compaction Monitoring Device

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S): Heather J. Miller, PI, University of Massachusetts Dartmouth (UMD); Rajib Mallick, Co-PI, Worcester Polytechnic Institute (WPI)

STATUS: Completed

INITIAL AGREEMENT DATE: 8/1/01

END DATE: 7/31/03

PROJECT OBJECTIVES:
The primary objective of this study is to verify the effectiveness of the "Soil Compaction Meter" (SCM) as a tool for determining optimum compaction for highway construction applications. The scope of this project will initially involve performing a literature review of previous research performed on the Compaction Meter in order to identify the operational parameters, current capabilities and limitations of the device. Subsequently, testing will be performed to evaluate the effective uses of the device in a variety of applications and for a variety of materials. Based upon statistical analysis of the data obtained, conclusions and recommendations for use of the device in highway applications will be provided.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003: The final report was published.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: "Field Evaluation of a New Compaction Monitoring Device", Miller, H.J., June 2003, NETCR42.

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: New

INITIAL AGREEMENT DATE: 9/1/03

END DATE: 8/31/06

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 stimulation. Another objective is to use the obtained relationship to determine pay adjustments for different densities.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003: One 9.5mm Nominal Maximum Aggregate Size mix was selected. Two sets of slabs (A and B) have been compacted, with different densities. Two slabs have been tested for rutting at 60˚C. The rut data obtained from profilometer is being analyzed. One slab is being instrumented with strain gauges for fatigue testing.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: 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: Continuing

INITIAL AGREEMENT DATE: 8 /1/02

END DATE: 5/31/05

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, 2003:
The work in the project during 2003 completed the initial objective of developing guidelines for the minimum requirements that a deployment or system should meet in order to be suitable for inclusion in the New England regional 511 initiative. The guidelines define the information to be provided, the geographic resolution and presentation of that information and a number of other attributes that will be important to provide travelers with a consistent and useful information service.

This work included review of the National Guidelines for 511 developed by the National 511 Development Coalition; review of early adopter solutions; and a stakeholder survey. The review of early adopter solutions includes documentation of lessons learned.

The survey compilation was overseen by the NETC project committee. The purpose of the survey was to gather information about existing systems and perceived needs according to the types of agencies that may be involved with 511 systems as they

developed. The survey was mailed to contacts recommended by members of the committee as well as to regional transit agencies within our area of interest registered with NEPTA (Northeast Passenger Transportation Association).

The results of the survey of government agencies showed that their interests are virtually the same as the national 511 guidelines. The only area where little interest was expressed was in providing highways travel times.

There was very strong agreement between the surveys and the national guidelines regarding the provision of observed weather and road surface conditions particularly from the agencies associated with highways. The responses of the transit agencies also had a strong correlation with the national guidelines.

Based on the results of these surveys and on the rapidly changing level of deployment of 511 throughout the region, the project team performed a detailed analysis of the remainder of the scope of the project. Based on this review, the project team recommended changing the scope of the project from designing a 511 system and business model for the region to investigating and developing an approach to addressing the cross border issues associated with the various 511 deployments that are underway or planned.

REPORTS, PAPERS AND PRESENTATIONS: None

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: Continuing

INITIAL AGREEMENT DATE: 8/1/02

END DATE: 7/31/05

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, 2003:
1. Website Created:
We have designed and created a website for this project. The website URL address is: http://www.engr.uconn.edu/~mallar/netc02-3/
It consists of the brief outline of the project, material presented to the NETC Technical Committee and the Quarterly Reports to date. Any relevant information will be posted via this website.

2. Collection of Literature on Resilient Modulus and Falling Weight Deflectometer:
An extensive literature search and review of the resilient modulus and previous Falling Weight Deflectometer (FWD) studies was completed. The literatures reviewed are as follows:

a. **From Various State Departments of Transportation (DOT's):** Reports of the research studies done on Resilient Modulus and FWD in New England States, Florida, Louisiana, Tennessee, Texas. The existing correlations of resilient modulus with various subgrade properties were identified from these reports.

b. **New England States Studies**

- Reports on resilient modulus and FWD tests conducted in New England states, including Long and Crandlemire 1992, Janoo 1994, Lee et al. 1994, Janoo and Berg 1996, Berg et al. 1996, Kestler 1997, Smart and Humphrey 1999, Janoo et al. 1999, Janoo and Bayer 2001.
- Journal Papers on the testing procedures and factors influencing resilient modulus and FWD, including (Sebaaly et al. 1985, Pezo and Hudson 1994, Jin et al. 1994, Drumm et al. 1996, Livneh et al. 1997, Hjelmstad and Taciroglu 2000, Ping et al. 2002)

c. **Search using Transportation Research Information Services (TRIS),**

Research In Progress (RIP) and other database

- Several recent publications on Resilient Modulus and FWD from TRIS and RIP.
- Manual for FWD testing published by Strategic Highway Research Program (SHRP)
- Reports of studies on Backcalculation of Moduli from FWD data done by SHRP and Federal Highway Administration (FHWA)
- Nondestructive Testing of Pavements and Backcalculation of Moduli (Bush and Baladi, 1989, Von Quintas et al. 1994 etc.)
- Users manual of widely used Back calculating Moduli Software packages, MODULUS 4.0 and MODULUS 5.0. Software package MODULUS 6.0 has been obtained and will be used for the back calculation process in this project.

3. Collection of existing subgrade data in New England States:

a. Soil Survey Reports

The soil survey reports published by U.S. Department of Agriculture were collected and the existing soil types in New England States were identified. We have prepared a consolidated summary sheet indicating the soil types state-wise of all the six New England States.

b. STATSGO Data

State Soil Geographic Database (STATSGO) consists soil data of all states and has been designed for use in Geographic Information Systems (GIS). The data can be accessed through GIS software packages (PCARC and ArcView). We have retrieved relevant data available in STATSGO database (ftp://ftp.ftw.nrcs.usda.gov/pub/statsgo/dos/arc/data/).

c. Data collected and analyzed from LTPP database:

The Long Term Pavement Performance (LTPP) Customer Service Support Center, Oak Ridge, TN. The database is available in the form of compact disc. It consists of several parameters relevant to this project including FWD data, subgrade resilient modulus data and the profile data of selected in-service pavement test sections in North America. The data that we have extracted from the database are as follows:

(i) Index Properties: A comprehensive list of the Index properties of the subgrades of New England States were collected from LTPP Information Management System (IMS). The index properties include liquid limit, plasticity index, particle shape, relative density, resilient modulus, material type, maximum lab dry density, optimum and natural moisture contents. The subgrades were also classified as per AASHTO classification system.

(ii) Resilient Modulus Data: Data relating to Resilient Modulus studies conducted in New England States for different stress states was also collected from LTPP IMS. It includes average resilient modulus values for various cycic, confining and maximum axial stress states.

(iii) FWD Data: FWD Data for New England states available in LTPP IMS was collected. It consists of average drop load, number of drops and average

deflection at sensor locations.

(iv) Resilient Modulus and FWD Studies: Towards the effort to correlate subgrade modulus from lab testing (resilient modulus) and from field tests using FWD (Back calculated modulus), we have identified sites in U.S. and few other countries where both FWD and resilient modulus tests have been carried out. Out of these test sites, those specific sites where the subgrade modulus has been back calculated from FWD were also identified. These data are being analyzed to compare the values of resilient modulus obtained from laboratory testing and back calculation process.

REPORTSPAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: 02-5

PROJECT TITLE: Determination of Moisture Content of Deicing Salt at Point of Delivery

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY:
Richard P. Long and Kenneth R. Demars, University of Connecticut

STATUS: Continuing

INITIAL AGREEMENT DATE: 7/1/02

END DATE: 12/31/03

PROJECT OBJECTIVES:
The object of this research is to find or develop a simple affordable method of device for quickly measuring the moisture content of road salt in the field. The test will be carried out in about five minutes and be capable of measuring moisture contents in the range of 3% to 5% to an accuracy equal to +/- 0.5%.

There are several methods of measuring moisture in a material. The analytical and gravimetric methods require substantial time to complete. In the infrared method the material's particle size, particle shape, particle surface characteristics and color can cause moisture measurement errors. The microwave methods require a large space and tend to be expensive. We are investigating the capacitive, neutron and gamma ray, and conductive methods of measuring moisture content.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:
A graduate student performed moisture measurements using a conductivity bridge and the testing methods developed by the principal investigators. These measurements focused on repeatability within the stated range of accuracy (+ - 0.5%), corroboration of existing calibration curves and examined operator effects. Calibration curves were repeated for Salt Sample 3 at different temperatures. These calibrations compared favorably to the calibrations prepared by the principal investigators for that material suggesting that results are not operator specific.

The student also tested the three salt samples acquired from Connecticut DOT salt suppliers including a solar salt from Morton and rock salts from International Rock Salt and American Rock Salt. The calibration curves for electrical conductivity with varying moisture content and temperature were developed similar to the other salt samples. All of the test data from the various samples at constant test temperature were combined and confidence limits established for the 95% level. These confidence results show that the project accuracy limits on moisture contents up to about 5% of +- 0.5% cannot be obtained using electrical conductivity calibration to moisture content.

Following our meeting with the NETC technical advisory committee on Sept. 23, 2003 in Brattleboro, VT, we performed additional moisture measurements using a conductivity

bridge. These tests were performed on three different salts: reagent grade NaCl, as recommended by one of the advisory committee, and also table salt (food quality) from Morton and Diamond Crystal. The objective was to compare the calibration curves for these high quality salts. The reagent grade NaCl and Diamond Crystal salts had essentially the same calibration curves while the Morton Salt is significantly different, which suggests that salt chemistry is a factor, as had been observed for the road salts tested by the conductivity method.

A draft report which contains all of the results and progress to date has been prepared and was mailed to the NETC technical advisory committee members for their review and comments. All comments are due presently and will be considered in preparation of the Final Report.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS: None

PROJECT NUMBER: NETC 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: New

INITIAL AGREEMENT DATE: 8/1/03

END DATE: 7/31/05

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, 2003:

1. A thorough literature search was conducted to identify and evaluate the existing types of expansion joints in New England and other states. Asphaltic plug joints and strip seal joints were found to be the predominantly used joints in New England region for sealing of small joints. The asphaltic plug joint is used for movements of up to about 50 mm and the strip seal joint is being used for accommodating motion ranges between 45 mm and about 100mm.

2. The critical factors influencing the successful performance of the above mentioned joint, as well as other various joint sealing systems in use were found to depend chiefly on followings: a) Poor design, b) Improper installation technique, and c) Lack of proper attention to manufacturer's recommendation.

3. The summary of the literature review was presented to the NETC project Technical Committee at the December 10, 2003 meeting. The meeting with the Technical Committee members was held using Federal highway Administration's video conferencing facility.

4. Based on the literature search, it was concluded that none of the existing joints can be assumed to last indefinitely. All of them start leaking at the interface between joint seal and joint face.

5. As a solution to the problem, development of a low modulus silicone foam as the potential joint sealant is in progress. The new sealant material is expected to exhibit the following characteristics: a) low modulus, b) reduced interfacial

stresses during joint movement, c) damage confinement to local area, and d) increase in the volume of the material after reaction.
Samples of the low modulus silicone foam sealant have been prepared in the laboratory (Figure 1) using the chemicals Platinum-carbonyl cyclovinmethylsiloxane, Vinyl terminated PDMS and etc. (supplier Gelest Inc., PA). The chemical catalysts were used to facilitate the rapid curing and growth in the volume of the material. The volume change factor in the cured sample was nearly 2, which is desirable, as it would save the cost of the sealant material. The tack free time of the sealant was found to be lass than an hour.

6. Commercial solid silicone joint sealants such as Wabo Seal (manufacture: Watson Bowman Acme) and Dow Corning 902 RCS (manufacturer: Dow Corning Corporation) were obtained and test samples were prepared of these materials to use them as the control during laboratory validation testing of the foam sealant. Series of laboratory tests including tensile adhesion, puncture ability, shear strength, cyclic loading, aging, etc. are planned to be conducted. We have initiated some preliminary tests on both foam silicone and solid silicone. A preliminary test data from tensile test (Figure 2-4) of the sample made from Wabo Seal material has been presented in the graph below (Figure 5).

7. The website for the NETC 02-6 research project work was designed and created (http://www.engr.uconn.edu/~mallar/netc02-6). The website is intended to keep the NETC technical committee up-to-date on the project's status.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: 02-7

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

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):
Adel W. Sadek, University of Vermont

Wael El-Dessouki, University of Connecticut

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/02

END DATE: 11/30/04

PROJECT OBJECTIVES:
The objective of the proposed study is twofold. The first objective is to explore how to best calibrate simulation models to inclement weather conditions in New England. With the simulation models calibrated, the second objective of the study will be to use the calibrated model to investigate the feasibility and benefits of tailoring signal timing to adverse weather conditions along New England arterials. Specifically, the proposed project has the following objectives:

(1) To determine the impacts of inclement weather (i.e. snow and ice) on traffic flow parameters such as discharge headway, startup lost times, speeds and speed-density relationships as documented in the literature;
(2) To check whether these values apply to New England conditions;
(3) To calibrate various traffic simulation models to inclement weather travel conditions;
(4) To use the calibrated simulation model to assess whether timing plans could be developed to accommodate inclement weather travel conditions; and to assess the benefits of implementing such tailored plans

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:

During the calendar year 2003, significant progress has been made on the project during the calendar year 2003, and a number of important findings have been made. During the winter months (i.e. January, February, March), the study continued to collect data for assessing the impact of adverse weather on the different traffic flow parameters. Specifically, the study collected data on startup lost time and discharge headways for seven different weather conditions, namely: (1) Dry, (2) Wet, (3) Wet and Snowy, (4) Wet and Slushy, (5) Slushy in wheel paths, and (6) Snowy and packed.

The data collected was then reduced, and a comprehensive statistical analysis was performed. The analysis indicates that there is enough evidence to suggest that inclement weather does have a significant impact on the values of saturation headways, and hence saturation flow rates at signalized intersections. Out of the six different weather/road surface conditions considered in this study, conditions four through six (i.e. wet and slushy, slushy in wheel paths, and snowy and sticky) appear to have the most significant impact on saturation flow rate. Values for startup lost time do not appear to be significantly impacted by inclement weather.

Table 1 summarizes the values the current study obtained for the saturation headways and the startup for lost times for the six different weather conditions. The table also computes the corresponding saturation flow rates, and the reduction in the saturation flow rate, compared to the dry condition, for each road condition. Given the different slope for the EB and WB directions, the results are recorded separately for each approach. As can be seen, the percentage reductions in the saturation flow rate are in the range of 3% to 16% for the EB direction, and in the range of 2% to 21% for the WB direction.

TABLE 1. Summary of Values Obtained for Startup Lost Times and Saturation Headways

Road Condition	Startup Lost Time		Saturation Headway (Saturation Flow Rate)[1]		% Reduction in Saturation Flow Rate	
	EB	WB	EB	WB	EB	WB
1. Dry	2.20	1.84	2.24 (1607)	2.04 (1766)	0%	0%
2. Wet	2.42	1.98	2.31 (1558)	2.08 (1734)	3%	2%
3. Wet and Snowy	2.18	2.28	2.42 (1490)	2.13 (1691)	7%	4%
4. Wet and Slushy	1.29	2.00	2.41 (1491)	2.39 (1505)	7%	15%
5. Slushy	---[2]	1.90	---[2]	2.58 (1396)	---[2]	21%
6. Snowy and Stick	3.04	2.20	2.67 (1348)	2.44 (1475)	16%	16%

[1] Units: Saturation Headway (seconds per vehicle), Start lost time (seconds)
[2] Values not available

With the impact of inclement weather on traffic flow parameters quantified, the study proceeded to assess the feasibility and likely the benefits of implementing special timing plans for inclement weather. To do this, the study developed two models, one using TRANSYT-7F and the other using CORSIM, for a segment of Dorset Street in South Burlington, Vermont. The TRANSYT-7F model was used to develop optimal plans for the six different weather conditions. The likely benefits of designing and implementing "special" plans for inclement weather were then determined by comparing travel conditions under the optimal inclement weather timing plans to conditions assuming the optimal "dry" condition plan would remain unchanged. This comparison was performed utilizing the TRANSYT-7F model first, and then using the more detailed microscopic simulation environment of the CORSIM model.

The results indicate that operational benefits, in terms of reductions in average delay and number of stops as well as improvement in average speeds and move time, are to be expected from implementing "special" signal plans for inclement weather, especially

once slushy conditions start developing or once snow starts sticking to the ground. However, for the case study considered, these benefits appear to be somewhat on the modest side, especially when evaluated in the CORSIM model. The results also indicate that the magnitude of the benefits appear to increase with increases in the traffic volumes along the study corridor.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003:

1) Agbolosu-Amison, S.J., A. W. Sadek, and W. El-Dessouki. (2004). Inclement Weather and Traffic Flor at Signalized Intersections: A Case Study from Northern New England. A paper presented at the *83rd Annual Transportation Research Board Meeting*, Washington, D.C.

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

3) Agbolosu-Amison, S.J., A. W. Sadek, and W. El-Dessouki. (2003). Inclement Weather and Traffic Flor at Signalized Intersections: A Case Study from Northern New England. A presentation made to the Vermont Chapter of the Institute of Transportation Engineers, Montpelier, Vermont.

PROJECT NUMBER: 02-8

PROJECT TITLE:
Intelligent Transportation Systems Applications to Ski Resorts in New England

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S):
Adel W. Sadek, University of Vermont

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/02

END DATE: 3/31/04

PROJECT OBJECTIVES:
The main objective of the proposed research is to conduct a comprehensive study aimed at understanding ski resort travel problems in New England, and the applicability of ITS to address these problems. Specifically, the proposed study has the following objectives:

(1) To define and quantify the transportation problems and challenges associated with ski resorts travel in New England, and to study the implications of such problems with respect to traffic management;
(2) To define and understand the needs of travelers to ski resort areas in New England;
(3) To identify ITS strategies and applications that have the potential to address the problems and needs identified in (1) and (2) above;
(4) To assess the costs and benefits of the ITS strategies identified in (3); and
(5) To explore the opportunity for public-private partnerships to fund the strategies identified in (4)

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:
The progress started on September 1, 2003. During the calendar year 2003, a number of accomplishments were made, and the project is currently nearing completion. The first task in the project involved reviewing the literature to identify pertinent information that would be helpful for the purposes of the current study. The review focused on identifying the challenges associated with rural travel (since a number of ski resorts are located in rural areas) as well as the information needs of travelers. A review of successful ITS applications in National parks and rural tourism areas was also conducted to help identify promising ITS strategies for ski resorts applications.

Different stakeholders were then surveyed in order to identify the major transportation challenges that are specific to ski resorts in New England and Northeastern New York State. The groups surveyed included ski associations, ski resort managers, state departments of transportation, state and local police, tourism agencies, transit/shuttle operators and ski resort travelers. With the transportation needs and challenges defined, the study proceeded to identify appropriate ITS strategies that have the potential to

address the identified problems. To help identify those strategies, the research team divided a typical ski traveler home-to-resort journey into six "Ski Travel Zones", each having unique functional and/or geographic characteristics. The six ski travel zones are as follows: (1) pre-trip planning; (2) principal highways; and (3) secondary highways; (4) gateway community; (5) resort property; and (6) slopeside. ITS strategies were then identified for each zone.

To facilitate the identification of appropriate ITS strategies for ski resorts, the study then developed an "ITS Ski Resort Toolkit". The toolkit lists several examples for ITS systems that have the potential to address a number of the transportation challenges associated with travel to and from ski resorts. For each ITS system, the toolkit gives a brief description of the system, lists the travel zones to which the system might be applicable, identifies the lead and key stakeholders, lists the transportation needs addressed by the system, and discusses any deployment issues that are specific to ski resorts.

The study team, in collaboration with the project's technical committee, then selected the Vermont Route 103/100 Corridor, which includes a number of ski resorts to serve as a case study for the feasibility of using ITS to address ski resorts transportation problems. The corridor includes a number of ski resorts, to serve as the subject of detailed analysis during the upcoming stages of the study. Background information regarding the corridor was compiled from existing reports as well as from Geographic Information Systems (GIS) coverages. A meeting was also held at the Okemo Ski resort to solicit information from the major stakeholders in the region regarding the different transportation problems and challenges that they face. The information gathered was then used to develop a high-level ITS project architecture for the region.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMEBER 31, 2003:

An abstract describing the major activities and findings of this research was submitted for presentation at the upcoming Institute of Transportation Engineers (ITS) District One Meeting in May, 2004. The citation information for the abstract is as follows:

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

PROJECT NUMBER: NETC 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: New

INITIAL AGREEMENT DATE: 8/23/03

END DATE: 5/31/06

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 slop 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, 2003:

1. The design of the laboratory column testing apparatus was completed. Each column will be constructed from clean PVC with dimensions of 6-inch diameter and 12-inch length. The top and base of each column will consist of a re-sealable flanged cap so that columns can be repacked for each experiment. A total of 5 columns will be used in each experiment to yield one control and four columns with varied test parameter – wood type, particle size, flow rate, wet-dry cycle frequency, salt concentration or wood age. Simulated stormwater will be delivered to all columns from a single reservoir using a computer-controlled variable speed pump.

2. Glastonbury Mulch was identified as the standard woody material for comparison of test parameter effects. This material was used previously by Demars and Long for storm water erosion control (NETC Project 97-3 "*Use of Wood Waste Materials for Erosion Control"*) and hence has current field application and aged samples of this material are readily available.

3. Appropriate flow rates for column tests were identified. Calculations assumed typical conditions for New England of sheet flow from a two-lane road with the average 1-year hydrograph of Connecticut.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: NETC 03-3

PROJECT TITLE: Feasibility Study of an Erosion Control Laboratory in New England – Phase 1

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S): Richard P. Long and Kenneth R. Demars, University of Connecticut

STATUS: New

INITIAL AGREEMENT DATE: 9/1/03

END DATE: 8/31/04

PROJECT OBJECTIVES:

a) Survey, obtain and summarize the needs of the New England Departments of Transportation concerning information about erosion protection products and techniques. This will include erosion control goals, objectives and best management practices (BMPs), including state and federal guidance, standards and regulations, from each of the New England states.

b) Determine the need for an erosion control facility in New England and the operational feasibility of a testing facility, including criteria for location, general facility requirements (including ability to test for New England climates and soils), anticipated capital and operational costs, and potential funding sources (e.g., state participation or testing for fees); and

c) If the findings indicate that a New England erosion-control testing laboratory is required and feasible, prepare a final project report with specific recommendations for objectives and work tasks of a second phase NETC project.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:

The planned survey of "Erosion Control Practice and Needs" to be evaluated by northeastern DOTs was finalized and copies were mailed to members of the NETC technical advisory committee for distribution. Eight of the survey forms were completed and returned for analysis.

Several existing erosion-testing laboratories and erosion control product manufacturers have been contacted by phone, letter or email to obtain background information on testing facilities, operational requirements, cost and typical test results. Both large- and small-scale testing facilities are being considered. This information is being analyzed for inclusion in a summary draft report for the technical advisory committee.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: NETC 03-4

PROJECT TITLE: Measuring Pollutant Removal Efficiencies of Stormwater Treatment Units

PRINCIPAL INVESTIGATOR(S) & UNIVERSITY(S): Xiaoqi (Jackie) Zhang, University of Massachusetts Lowell

STATUS: New

INITIAL AGREEMENT DATE: 9/1/03

END DATE: 8/31/05

PROJECT OBJECTIVES:
The goal of this project is to establish preliminary guidelines for best management practices for stormwater. The objectives of this project are to:

(1) develop a "bacteria budget" to track influent and effluent bacteria concentrations as well as measuring the growth or reduction of bacteria within the separator units;
(2) determine the extent of bacteria survivability in hydrodynamic separator units.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 2003:
During year 2003 (the project was started in Sept. 2003), moderate progress was made. Much time was spent on recruiting a graduate student, student training, equipment purchase and project planning. The following accomplishments were made during year 2003:

- A graduate student was identified to work on the project. He officially starter in January 2004.
- The same graduate student performed literature search on particle counting and read many articles on stormwater.
- Two sampling sites in Rhode Island were selected for future sampling.
- A major instrument "laser particle counter" out of PI's startup account was purchased to track the size and quantity of the particles in suspension and sediments.
- A portable pH/DO/TDS/conductivity meter out of PI's startup account was purchased for on-site measurements.
- A laminar hood for maintaining sterilized working environment which is critical for bacteria work was purchased.
- Several pairs of cartridges for producing de-ionized water were purchased.
- Procedures including fecal coliform, E. *coli*, *enterococci*, spread plate count, and particle size analysis were established. Laboratory supplies were identified and would be ordered.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THIS PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: NETC 03-5

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

STATUS: New

INITIAL AGREEMENT DATE: 9/1/03

END DATE: 2/28/06

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, 2003:
Work on this project did not begin until the end of January 2004.

REPORTS/PAPERS PUBLISHED, PRESENTATIONS MADE RELATING TO THE PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

PROJECT NUMBER: NETC 03-7

PROJECT TITLE: Basalt Fiber Reinforced Polymer Composites

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

STAUTS: New

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, 2003:
A mold was built to produce the composite samples (Figure 1). Several composite plaques of basalt fiber in epoxy polymer have been produced by compression molding in a 25 ton press (Figure 2). The composites were produced by first cutting the woven fabric to size, cleaning the fabric in a vacuum oven at 300 C, and then compression molding in the press.

More recently, glass reinforced epoxy composites and basalt reinforced vinyl ester composites have also been produced. Details on these composites and data from initial tests will be reported next time.

PAPERS/REPORTS PUBLISHED, PRESENTATIONS MADE RELATING TO THE PROJECT FROM THE START OF THE PROJECT THROUGH DECEMBER 31, 2003: None

D.1 FINANCIAL STATUS OF ACTIVE PROJECTS

Table 1: Financial Status of Projects Active During 2003
(As of 11/13/2003)

NO.	PROJECT TITLE, PI, UNIVERSITY	APPROVED BUDGET	INVOICES APPROVED FOR PAYMENT	PROJECT BALANCE
97-2	Performance Evaluation and Economic Analysis of Combinations of Durability Enhancing Admixtures (Chemical and Mineral) in Structural Concrete for the Northeast U.S.A., *S. Civjan, University of Massachusetts, Amherst*	$118,473.00	$108,318.73	$10,154.27
99-1	NETC Bridge Rail Transitions – Development and Crash Testing, *J. Zoller, New Hampshire Department of Transportation*	$240,000.00	$0.00	$240,000
00-3	Design, Fabrication and Preliminary Testing of a Composite Reinforced Timber Guardrail, *W. Davids, University of Maine, Orono*	$83,469.00	$54,302.02	$29,166.98
00-4	Portable Falling Weight Deflectometer Study, *D. Humphrey, University of Maine, Orono*	$100,000.00	$20,435.68	$79,564.32
00-6	Effective Visualization Techniques for the Public Presentation of Transportation Projects, *N. Garrick, University of Connecticut*	$74,929	$69,150.24	$5,778.76
00-7	A Complete Review of Incident Detection Algorithms and Their Deployment: What Works and What Doesn't, *E. Parkany, University of Massachusetts, Amherst*	$45,384.00	$40,558.26	$4,825.74
00-8	Performance and Effectiveness of a Thin Pavement Section Using Geogrids and Drainage Geocomposites in a Cold Region, *D. Humphrey, University of Maine, Orono*	$150,000.00	$135,478.25	$14,521.757
01-1	Advanced Composite Materials For New England Highway Infrastructure, *S. Brena, University of Massachusetts Amherst*	$53,339.00	$0.00	$53,339.00
01-2	Development of a Testing Protocol for QC/QA of Hot Mix Asphalt (HMA), *W. Mogawer, University of Massachusetts, Dartmouth*	$80,000.00	$65,670.63	$14,329.37
01-3	Design of Superpave HMA for Low Volume Roads, *W. Mogawer, University of Massachusetts, Dartmouth*	$126,657.00	$100,758.39	$25,898.61
01-6	Field Evaluation of a New Compaction Monitoring Device, *H. Miller, University of Massachusetts, Dartmouth*	$50,000.00	$43,294.34	$6,705.66
02-1	Relating Hot Mix Asphalt Pavement Density to Performance, *W. Mogawer, University of Massachusetts, Dartmouth*	$103,524.00	$0.00	$103,524.00
02-2	Formulate Approach for 511 Implementation in New England, *P. Shuldiner, University of Massachusetts, Amherst*	$84,013.00	$23,517.32	$51,224.40
02-3	Establish Subgrade Support Values for Typical Soils in New England, *R. Malla, University of Connecticut*	$80,000.00	$25,958.70	$54,041.30

D.1 FINANCIAL STATUS OF ACTIVE PROJECTS

Table 1: Financial Status of Projects Active During 2003 (As of 11/13/2003)

NO.	PROJECT TITLE, PI, UNIVERSITY	APPROVED BUDGET	INVOICES APPROVED FOR PAYMENT	PROJECT BALANCE
02-5	Determination of Moisture Contecnt of Deicing Salt Point of Delivery, *K. Demars, University of Connecticut*	$59,236.00	$24,425.29	$34,810.71
02-6	Sealing of Small Movement Bridge Expansion Joints, *R. Malla, University of Connecticut*	$74,996.00	$5,764.28	$69,231.72
02-7	Validating Traffic Simulation Models to Inclement Weather Conditions with Applications to Arterial Conditions with Applications to Arterial Coordinated Signal Systems, *A. Sadek, University of Vermont*	$74, 731.00	$21,898.80	$52,832.20
02-8	Intelligent Transportation Systems Applications to Ski Resorts in New England, *A. Sadek, University of Vermont*	$60,000.00	$27,962.76	$32,037.24
03-1	Ability of Wood Fiber Materials to Attenuate Heavy Metals Associated with Highway Runoff, *A. MacKay, University of Connecticut*	$72,000.00	$0.00	$72,000.00
03-3	Feasibility Study of an Erosion Control Laboratory in New England, *K. Demars, University of Connecticut*	$31,938.00	$0.00	$31,938.00
03-4	Measuring Pollutant Removal Efficiencies of Stormwater Treatment Units, *X. Zhang, University of Massachusetts, Lowell*	$80,000.00	$0.00	$80,000.00
03-5	Evaluation of a Field Permeameter as a Longitudinal Joint Quality Control Indicator, *J. Daniel, University of New Hampshire*	$77,646.00	$0.00	$77,646.00
03-7	Basalt Fiber Reinforced Composites, *R. Parnas, University of Connecticut*	$65,791.00	$0.00	$65,791.00

Notes: 1. Retainage is not included in "INVOICES PAID TO DATE"

D.2 FUND BALANCE:

Table 2: NETC Fund Balance

(As of December 31, 2003)

ITEM	ALLOCATION	ENCUMB/ EXPEND.	INVOICE	CUM. BALANCE
Unexpended Balance of NETC funds from AASHTO as of 6/5/95 (Per AASHTO memo 12/4/95)				132,777.07
Member Allocations 1994 = 6 X $75,000	450,000.00			582,777.07
Coord./Admin. of NETC: Calendar Year 1995 Bdgt. = $73042		58,761.32	FINAL	524,015.75
Continued Projects:				
- 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
Member Allocations 1995 = 7 X $75,000	525,000.00			852,636.18
"95" Project Series:				
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
"94" Project Series:				
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	114,167.57
Member Allocations 1996 = 6 X $75,000	450,000.00			564,167.57
Coord./Admin.of NETC: Calendar Year 1996; Bdgt. = $75,000		69,123.85	FINAL	495,043.72
Member Allocations 1997 = 6 X $75,000	450,000.00			945,043.72
Coord./Admin. of NETC: Calendar Year 1997; Bdgt. = $82,494		77,244.35	FINAL	867,799.37
"94" Project Series:				
94-3: Procedures for The Evaluation of Sheet Membrane Waterproofing		67,000.00	FINAL/CLOSED	800,799.37
94-4: Durability of Concrete Crack Repair Systems		72,036.04	FINAL/TERM.	728,763.33
"96" Project Series:				
96-1: SUPERPAVE Implementation		60,139.25	FINAL/CLOSED	668,624.08
96-2: Optimizing GPS Use in Transportation Projects		120,000.00		548,624.08
96-3: Effectiveness of Fiber Reinforced Composites as Protective Coverings for Bridge Elements, etc.		135,000.00	FINAL/CLOSED	413,624.08
T2 (per 12/2/97 Adv. Committee Mtg.) for 1998 = $10,000		9,551.06	FINAL	404,073.02
Coord./Admin. of NETC: Calendar Year 1998; Bdgt = $73,021		80,422.65	FINAL	323,650.37
Member Allocations 1998 = 6 X $75,000	450,000.00			773,650.37
"97" Project Series:				
97-1: A Portable Method for Determining Chloride Concentration on Roadway Pavements		96,669.50	Phase 1/FINAL	676,980.87
		90,667.79	Phase 2/FINAL	586,313.08
97-2: Performance Evaluation & Economic Analysis of Durability Enhancing Admixtures, etc.		118,473.00	FINAL	467,840.08
97-3: Determining Properties, Standards & Performance of Wood Waste Compost, etc.		43,853.94	FINAL/CLOSED	423,986.14
Alloc. to ConnDOT for Constr. Costs of Test Site (Approved 1/21/99 Ballot)		11,000.00		412,986.14

D.2 FUND BALANCE (Cont'd):

Table 2: NETC Fund Balance

(As of December 31, 2003)

ITEM	ALLOCATION	ENCUMB/ EXPEND.	INVOICE	CUM. BALANCE
97-4: Early Distress of Open-Graded Friction Course		57,495.71	FINAL/CLOSED	355,490.43
Travel Tech. Comm. (Aug. 98 tel. poll) for 1998 = $5,000		0.00		355,490.43
Member Allocations 1999 = 6 X $75,000	450,000.00			805,490.43
Coord./Admin. of NETC: Calendar Year 1999:				805,490.43
- Administration = $77,666				
-Technology Transfer & Technical Committee Travel = $20,400				
-Total =$98,066		79,101.20	FINAL	726,389.23
"99" Project Series:				
99-1: Bridge Rail Transitions		240,000.00		486,389.23
99-2: Evaluation of Asphaltic Expansion Joints		62,236.00		424,153.23
99-3: Bridge Scour Monitoring Systems		78,523.32	FINAL/CLOSED	345,629.91
99-4: Quantifying Roadside Rest Area Usage		44,857.00	FINAL/CLOSED	300,772.91
99-6: The Effects of Concrete Removal Operations on Adjacent That Is to Remain		96,008.36	FINAL/CLOSED	204,764.55
Member Allocations 2000 = 6 X $100,000	600,000.00			804,764.55
Coord./Admin. of NETC: Calendar Year 2000:		91,899.37	FINAL	712,865.18
- Administration = $ 85,788				
- Technology Transfer & Technical Committee Travel =$ 16,800				
- Total =$102,588				
"00" Project Series:				712,865.18
00-1: Ground-Based Imaging and Data Acquisition Systems for Roadway Inventories in New England - A Synthesis of Practice		31,251.92	FINAL/CLOSED	681,613.26
00-2: Evaluation of Permeability of Superpave Mixes		95,499.16	FINAL/CLOSED	586,114.10
00-3: Composite Reinforced Timber Guard Rail - Phase I: Design, Fabrication and Testing		83,469.00		502,645.10
00-4: Falling Weight Deflectometer Study		100,000.00		402,645.10
00-5: Guard Rail Testing - Modified eccentric Loading Terminal at NCHRP 350 TL2		61,287.00	FINAL/CLOSED	341,358.10
00-6: Implementation of Visualization Technologies to Create Simplified Presentations Within Highway agencies to be Used at Public Hearings		74,929.00		266,429.10
00-7: A Complete Review of Incident Detection Algorithms and Their Deployment: What Works and What Doesn't		45,384.00		221,045.10
00-8: Performance and Effectiveness of A Thin Pavement Section Using Geogrids and Drainage geocomposites in A Cold Region		150,000.00		71,045.10
Member Allocations 2001 = 6 X $100,000	600,000.00			671,045.10
Coord./Admin. of NETC: Calendar Year 2001:		104,385.35	FINAL	566,659.75
- Administration = $89,448				
- Technology Transfer & Technical Committee Travel = $16,800				
- Total = $106,248				

D.2 FUND BALANCE (Cont'd):

Table 2: NETC Fund Balance
(As of December 31, 2003)

ITEM	ALLOCATION	ENCUMB/ EXPEND.	INVOICE	CUM. BALANCE
"01" Project Series:				
01-1: Advanced Composite Materials for New England's Transportation Infrastructure		53,339.00		513,320.75
01-2: Development of A Testing Protocol for Quality Control/Quality Assurance of Hot Mix Asphalt		80,000.00		433,320.75
01-3: Design of Superpave HMA for Low Volume Roads		126,657.00		306,663.75
Note: Additional funding ($26,902) approved 11/19/02				
01-5: Procedures for the Evaluation of Liquid-Applied Membrane	Phase 1	50,000.00		256,663.75
Note: Proposals due12/31/03	Phase 2	25,000.00		231,663.75
01-6: Field Evaluation of A New Compaction Device		49,944.50	FINAL	181,719.25
Member Allocations 2002 = 6 X $100,000	600,000.00			781,719.25
NY DOT Allocation = $52,500	52,500.00			834,219.25
Coord./Admin. Of NETC: Calendar Year 2002		123,967.00		710,252.25
- Administration				
- Technology Transfer & Technical Committee Travel				
-Total				
"02" Project Series:				
02-1: Relating Hot Mix Asphalt Pavement Density to Performance		103,524.00		606,728.25
02-2: Formulate Approach for 511 Implementation in New England		84,013.00		522,715.25
02-3: Establish Subgrade Support Values ($M_{r)}$ for Typical Soils in New England		80,000.00		442,715.25
02-5: Determination of Moisture Content of De-Icing Salt at Point of Delivery		59,236.00		383,479.25
02-6: Sealing of Expansion Joints		74,996.00		308,483.25
02-7: Calibrating Traffic Simulation Models to Inclement Weather Conditions with Applications to Arterial Coordinated Signal Systems		74,731.00		233,752.25
02-8: Intelligent Transportation Systems Applications to Ski Resorts in New England		60,000.00		173,752.25
Member Allocations 2003 = 6 X $100,000	600,000.00			773,752.25
NY DOT Allocation 2003 = $40,000	40,000.00			813,752.25
Coord./Admin. Of NETC Calendar Year 2003 = $124,258		124,258.00		689,494.25
"03" Project Series:				
03-1: Ability of Wood Fiber Materials to Attenuate Heavy Metals Associated with Highway Runoff		72,000.00		617,494.25
03-2: Field Studies of Concrete Containing Salts of An Alkenyl-Substituted Succinic Acid *Note: Proposals due 12/15/03*		140,000.00		477,494.25
03-3: Feasibility Study and Design of An Erosion Control Laboratory in New England		31,938.00		445,556.25
03-4: Measuring Pollutant Removal Efficiencies of Storm Water Treatment Units		80,000.00		365,556.25
03-5: Evaluation of Field Permeameter As A Longitudinal Joint Quality Control Indicator		77,646.00		287,910.25
03-6: New England Land Grant University Consortium Members Research Challenge *Note: Scope of Work being developed*		103,000.00		184,910.25
03-7 (Alt.): Basalt Fiber Reinforced Polymer Composites		65,791.00		119,119.25
Member Allocations 2004 = 6 X $100,000	600,000.00			719,119.25
NY DOT Allocation 2004 = $52,000,000	52,000.00			771,119.25
Coord./Admin. Of NETC Calendar Year 2004		126,559.00		644,560.25
"04" Project Series:		589,000.00		55,560.25

Note: Member FFY allocations are obligated between October 1 and December 31

E. NETC 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 2003," November 2003 NETCR41

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.

"Wetlands: Problem & Issues," Shuldiner, P.W., University of Massachussetts, August 1990.

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

"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.

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

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

"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 1995-2003:

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.

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

"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 18th 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.

"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.

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

"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.

"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.

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

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 Structures**

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.

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

"Structural Properties of New England Subbase Materials of Flexible Pavements." Presented at the 5th 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 5th 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.

"Characterization of Subbase Materials of Flexible Pavements With and

Without Reclaimed Asphalt Pavement," Lee, K.W., Davis, J. and Vajjhalla, S. Presented at the 12th Rhode Island Transportation Forum, University of Rhode Island, October 15, 1999.

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., NETCR19, July 1, 2002.

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, Stamford, California, September 1997.

"Ground Penetrating Radar for Nondestructive Evaluation of Concrete Bridge Decks," Adam, C., M.S. Thesis Department of Mechanical Engineering University of Vermont, September 1997.

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

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

"Bridge Deck Evaluation with Ground Penetrating Radar," Huston, D., Hu, J.Q, Pelczarski, N, and Esser, B. Proc. 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 Conf. On Sensory Phenomena and Measurement Instrumentation for Smart Structures and Materials, Newport Beach, CA, March 1999.

Papers and Presentations (cont'd):

"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.

"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.

"Good Impedance Match Antenna (GIMA) Design and Its Applications for Ground Penetrating Radar In Concrete Structures NDE Applications," Hu, J. M.S. Thesis, Department of Mechanical Engineering, University of Vermont, March, 2000.

"Damage Assessment in Roadways with Ground Penetrating Radar," Huston, D., Pelczarski, N., Esser, B., Maser, K., and Weedon, W. SPIE Conference on Nondestructive Evaluation and Health Monitoring of Aging Infrastructure, 3995A-55, Newport Beach CA, March 2000.

"Damage Detection in Roadways with Ground Penetrating Radar," Huston, D.R., Pelczarski, N., Esser, B., and Master, K. GPR 2000, 8th International Conference on Ground Penetrating Radar," Gold Coast, Australia, May 2000.

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

"Wireless Inspection of Structures Aided by Robots," Huston D.R., Pelczarski N., Esser B., Gaida G., Arms S. and Townsend C. SPIE Symposium on NDE for Health Monitoring and Diagnostics, 4337-24, Newport Beach CA, March 2001.

"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., NETCR19, July 1, 2002.

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.

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

95-1 Use Of Tire Chip/Soil Mixtures To Limit Frost Heave And Pavement Damage Of Paved Roads

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 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.

"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.

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

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.

96-1 Implementation of Superpave

Papers and Presentations: None

96-2 Optimizing GPS Use in Transportation Projects

Reports: None

Papers and Presentations: None

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

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

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.

"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.

E.4 REPORTS, PAPERS AND PRESENTATIONS 1995-2003 (cont'd):

"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 Concenteration on Roadway Pavements," Garrick, N., Nikolaidis, N., P. and Luo, J, NETCR17, September 2002.

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.

"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., NETCR36, February 2003.

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.

E.4 NETC Reports, Papers And Presentations 1995-2003 (cont'd):

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

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

Papers and Presentations: None

99-2 Evaluation of Asphaltic Expansion Joints

Reports: None

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.

99-4 Quantifying Roadside Rest Area Usage

Reports:
"Quantifying Roadside Rest Area Usage," Garder, P. and Bosonetto, N., NETCR 38, November 27, 2002.

E.4 NETC Reports, Papers And Presentations 1995-2003 (cont'd):

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., NETCR29, January 15, 2002.

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 Anwedungen 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., NETCR30, August 2002.

Papers and Presentations: None

E.4 NETC Reports, Papers And Presentations 1995-2003 (cont'd):

00-2 Evaluation Of Permeability Of Superpave Mixes

Reports:

"Evaluation of Permeability of Superpave Mixes," Mogawer, W., Mallick, R., Teto, M. and Crockford, C., NETCR34, July 3, 2002.

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: None

Papers and Presentations: None

00-4 Portable Falling Weight Deflectometer Study

Reports: None

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., NETCR35, July 2002.

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 in April 2002.

E.4 NETC Reports, Papers And Presentations 1995-2003 (cont'd):

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.

Papers and Presentations: None

00-7 **A Complete Review of Incident Detection Algorithms and Their Deployment: What Works and What Doesn't**

Reports: None

Papers and Presentations:
"Use of Driver-Based Data for Incident Detection," Parkany, Emily, Submitted to the 7th International Conference on Applications of Advanced Technologies in Transportation Engineering (AATT) held in Boston in 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: None

01-1 **Advanced Composite Materials for New England's Transportation Infrastructure: A Study for Implementation and Synthesis of Technology and Practice**

Reports: None

Presentations: None

01-2 **Development of a Testing Protocol for QC/QA of Hot Mix Asphalt**

Reports: None

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 82nd Annual Meeting of the Transportation Research Board, January 12-16, 2003, Washington DC.

01-3 **Design of Superpave HMA for Low Volume Roads**

Reports: None

E.4 NETC Reports, Papers And Presentations 1995-2003 (cont'd):

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

02-1 Relating Hot Mix Asphalt Pavement Density to Performance

Reports: None

Papers and Presentations: None

02-2 Formulate Approach for 511 Implementation in New England

Reports: None

Papers and Presentations: None

02-3 Establish Subgrade Support Values for Typical Soils in New England

Reports: None

Papers and Presentations: None

2-5 Determination of Moisture Content of Deicing Salt at Point of Delivery

Reports: None

Papers and Presentations: None

02-7 Validating Traffic Simulation Models to Inclement Weather Travel Conditions with Applications to Arterial Coordinated Signal Systems

Reports: None

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

E.4 NETC Reports, Papers And Presentations 1995-2003 (cont'd):

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

Agbolosu-Amison, S.J., A.W. Sadek, and W. El-Dessouki. (2003). Inclement Weather and Traffic Flow at Signalized Intersections: A Case Study from Northern New England. 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: None

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

03-1 Ability of Wood Fiber Materials to Attenuate Heavy Metals Associated with Highway Runoff
Reports: None

Papers and Presentations: None

03-3 Feasibility Study of an Erosion Control Laboratory in New England
Reports: None

Papers and Presentations: None

03-4 Measuring Pollutant Removal Efficiencies of Stormwater Treatment Units
Reports: None

Papers and Presentations: None

03-5 Evaluation of a Field Permeameter as a Longitudinal Joint Quality Indicator
Reports: None

Papers and Presentations: None

03-7 Basalt Fiber Reinforced Polymer Composites
Reports: None

Papers and Presentations: None