ANNUAL REPORT
For Calendar Year 1999

NEW ENGLAND TRANSPORTATION CONSORTIUM

NETCR21 **January, 2000**

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. .epartment of Transportation's Federal Highway Administration.

NEW ENGLAND TRANSPORTATION CONSORTIUM

POLICY COMMITTEE

James F. Sullivan, Commissioner, CT Department of Transportation
Matthew J. Amorello, Commissioner, MA Highway Department
John Melrose, Commissioner, ME Department of Transportation
Leon S. Kenison, Commissioner, NH Department of Transportation
William Ankner, Director of Transportation, RI Department of Transportation
Brian Searles, Secretary, VT Agency of Transportation
Donald West , CT Division Administrator, FHWA

ADVISORY COMMITTEE

James M. Sime, Manager for Research, ConnDOT
Dale Peabody, Transportation Research Engineer, Maine DOT
Deborah Tucker, Director of Research, Massachusetts Highway Department
Gilbert S. Rogers, Assistant Director of Project Development, NHDOT
Colin A. Franco, Managing Engineer, Research and Technology Development, RIDOT
Robert F. Cauley, Materials & Research Engineer, VAOT
Amy Jackson-Grove, Planning, Environment and Research Manager, FHWA CT Division

Norman W. Garrick, Associate Professor, University of Connecticut
Per Garder, Associate Professor of Civil Engineering, University of Maine
David Gress, Professor, University of New Hampshire
Walaa Mogawer, Professor, University of Massachusetts
Wayne Lee, Professor, University of Rhode Island
James Olson, Professor, University of Vermont

LEAD STATE

James M. Sime, Manager for Research
CT Department of Transportation

COORDINATOR

Gerald M. McCarthy
CT Transportation Institute, University of Connecticut

TABLE OF CONTENTS

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.

The Consortium operates through a) a committee structure consisting of: a Policy Committee, an Advisory Committee and Project Technical Committees and b) a Coordinator and Lead State.

B. 1999 ACCOMPLISHMENTS

1. **Four research projects completed.** Final reports for the following projects were published and distributed to New England's State transportation agencies and universities, the Federal Highway Administration, and the AASHTO Region 1 Research Advisory Committee:
   -Full Scale Crash Evaluation of The NETC 4-Bar, Sidewalk-Mounted Steel Bridge Railing
   -Early Distress in Open-Graded Friction Course
   -Procedures for The Evaluation of Sheet Membrane Waterproofing
   -SUPERPAVE Implementation

2. **Nineteen student research positions were funded at participating universities through NETC-funded research projects.** During 1999, NETC-funded research projects supported nineteen student research positions at participating universities, fifteen of which were graduate students and four of which were undergraduate students.

3. **Two bridge rail systems developed by NETC for use in New England approved by FHWA for use on the federally funded national highway system.** The 2-Bar Curb-Mounted and 4-Bar Sidewalk-Mounted Bridge Rail Systems developed by NETC for use by the New England States were approved by FHWA for use on the federally funded National Highway System.

4. **Funding approved for new research in eight high priority areas.** The NETC Policy Committee, upon recommendation of the Advisory Committee, approved funding for new research in the following areas:
   -Ground-Based Imaging and Data Acquisition Systems for Roadway Inventories in New England
   -Evaluation of Permeability of SUPERPAVE Mixes
   -Composite Reinforced Timber Guard Rails
   -Use of The Portable Falling Weight Deflectometer As A Compaction Quality Control Tool for Road Construction, and A Low Cost Method for Quantitatively Determining When to Post and Remove Seasonal Load Restrictions on Low Volume Roads
   -Testing Capability of The Modified Eccentric Loading Terminal (Guard Rail), Developed for Use in New England, to Meet the Federal Highway Administration Standards (NCHRP 350 TL2)
   -Visualization Technologies to Create Simplified Presentations Within Highway Agencies to be Used at Public Hearings
   -Incident Detection Algorithms and Their Deployment: What Works and What Doesn't
   -Performance and Effectiveness of Thin Pavement Sections Using Geogrids and Drainage Geocomposites in a Cold Region

5. **NETC Advisory Committee tests video-conferencing technology.** Advisory Committee members held their December 1, 1999 meeting through the technology of video-conferencing. FHWA Division Offices assisted by making their video-conferencing facilities available to the committee.

6. **NETC Advisory Committee approves publication of research reports in electronic format.** Starting with the year 2000 projects, NETC will require final reports for its research projects to be produced in electronic as well as hard copy format. The electronic format will improve access to NETC research findings thereby improving technology transfer.

7. **NETC advisory committee approves funding for biannual newsletter.** The NETC Advisory Committee approved funding for a newsletter to be published twice a year starting in 2000. One of the prinicipal objectives of the newsletter is to improve the timeliness and comprehensiveness of the distribution of research findings, from NETC sponsored research, to transportation practitioners in order to more effectively encourage the application of the findings in practice.

8. **Technology Transfer:**

   a. Workshop seminars:

   -"Highway Applications of Tire Shreds": A 7-hour, one day workshop, sponsored by NETC, was presented by Dr. Dana Humphrey of the University of Maine for

personnel from the Rhode Island Department of Transportation. The workshop was presented at the Alton Jones Campus of the University of Rhode Island, West Greenwich, Rhode Island in April 1999.

-"New Developments in Bridge Maintenance." Planning was initiated for the presentation of six seminars on "New Developments in Bridge Maintenance." The seminars, to be presented in the year 2000 in each of the six New England States, will present the findings of recent NETC funded research on buried joints in short span bridges, non-destructive testing of reinforced concrete bridges using radar imaging, sheet membrane bridge deck waterproofing, fiber reinforced composites, and concrete crack repair systems.

b. Presentations at conferences.

-**New England Materials and Research Engineers' Annual Meeting.** A report on active and recently completed research projects was presented, by the NETC Coordinator, to the Materials and Research Engineers from the six New England States and Federal Highway Administration representatives from the New England state division offices at the New England Materials and Research Engineers' Annual Meeting held in Concord, New Hampshire in May 1999.

-**Connecticut Transportation Research Showcase.** The NETC exhibit of current and recently completed research projects was presented by staff from the Connecticut Department of Transportation, the NETC Lead Agency, at the Connecticut Transportation Research Showcase held in Newington, Connecticut in May 1999.

-**Region 1 Local Technical Assistance Program (LTAP) Annual Meeting.** A presentation, entitled "The New England Transportation Consortium and The Region One LTAP Centers: Opportunities for Partnering," was made by the NETC Coordinator to the directors and staff of the Region 1 LTAP/T2 Centers at the Annual Meeting of the Centers held in Mystic, Connecticut in July 1999.

-**AASHTO Annual Meeting.** The NETC exhibit of current and recently completed research projects was presented by the NETC Coordinator at the Technology Transfer Fair session of the AASHTO Annual Meeting held in Tulsa, Oklahoma in October 1999.

c. Reports/presentations on NETC funded research projects.

-Four final reports on NETC funded research projects (see B.1) were published and distributed to state and federal transportation practitioners and research administrators.

-Presentations on research findings from NETC funded projects were presented, by NETC researchers, at fourteen international, national and local professional conferences.

C. PROGRESS OF ACTIVE PROJECTS

PROJECT NUMBER: None.

PROJECT TITLE: Bridge Rail Crash Testing-Phase II: Sidewalk-Mounted Rail System

PRINCIPAL INVESTIGATOR (S):
Eric C. Lohrey, Connecticut Department of Transportation
Charles F. McDevitt, Federal Highway Administration
Joseph B. Mayer, Southwest Research Institute

STATUS: Completed

INITIAL AGREEMENT DATE: 10/1/96

END DATE: 8/04/99

PROJECT OBJECTIVES:
To conduct three (3) full-scale crash tests on the NETC 4-Bar Sidewalk-Mounted Tubular Steel Bridge Railing in accordance with the recommended procedures in National Cooperative Highway Research Program (NCHRP) Report 350 for a Test Level 4 Longitudinal Barrier.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
The Phase II bridge rail test section was constructed during 1997, and all three (3) specified crash tests were conducted in November and December 1997 in accordance with NCHRP Report 350 for a Test Level 4 (TL-4) Longitudinal Barrier. According to the test reports, the railing was judged to have met all required performance criteria.

Test results were forwarded to the Federal Highway Administration's Office of Engineering in Washington, D.C. Subsequently the Federal Highway Administration approved the bridge rail design for use on the National Highway System.

REPORTS, PAPERS, AND PRESENTATIONS:

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

2. NETC 4-Bar Sidewalk-Mounted Bridge Rail - Design Plans and Specifications, Revised January 1997.

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

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

PROJECT NUMBER: 94 - 1

PROJECT TITLE: Structural Analysis of New England Subbase Materials and Structures

PRINCIPAL INVESTIGATOR (S):
K. Wayne Lee, Milton T. Huston, Jeffrey S. Davis, and Sekhar Vajjhala.
University of Rhode Island, Department of Civil Engineering

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/10/95

END DATE: 3/31/99

PROJECT OBJECTIVES:
The objectives of this research are: (1) to compile a database of subbase aggregate properties by aggregate types common to New England, (2) collect data from existing analysis of natural aggregates and recycled material/aggregates blends, (3) develop recycled material blends, and (4) recommend appropriate testing for State agencies to develop optimum properties for specific sources and various combinations of blended materials projects.

The objectives were amended to modify the existing Instron testing system for the AASHTO TP46, and to characterize the subbase materials with and without reclaimed asphalt pavement (RAP).

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:

1. The resilient modulus testing had been performed for all the acquired New England subbase materials in accordance with the AASHTO TP-46 procedure.

2. The statistical analysis of the structural property data was performed, and the results were interpreted realistically.

3. After a series of testing with different amount of RAP, optimum performance characteristics for aggregate type and recycled material blends have been developed.

4. The effectiveness of the developed parameter values through a design example of the typical pavement structures in New England using the 1993 AASHTO Guide and/or DARWinTM2.01 has been demonstrated.

5. A draft final report had been prepared, and submitted to the Technical Committee for their review on 4/30/99.

6. The comments on the draft report by the Technical Committee were received on 9/15/99. The draft is being revised and submitted for the approval of printing the final report.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "Structural Analysis of New England Subbase Materials and Structures," Davis, J.S., Huston, M.I., and Lee, K.W. Presented at the 1998 TRB Annual Meeting.

2. "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.

3. "Characterization of Subbase Materials of Flexible Pavements With and Without Reclaimed Asphalt Pavement," K. Wayne Lee, Jeffrey Davis and Sekhar Vajhalla. Presented at the 1999 World Congress for Korean Scientists and Engineers, July 7, 1999.

4. "Characterization of Subbase Materials of Flexible Pavements With and Without Reclaimed Asphalt Pavement," K. Wayne Lee, Jeffrey Davis and Sekhar Vajhalla. Presented at the 12th Rhode Island Transportation Forum, University of Rhode Island, October 15, 1999.

PROJECT NUMBER: 94-2

PROJECT TITLE: Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques

PRINCIPAL INVESTIGATOR:
Dryver R. Huston, University of Vermont

STATUS: Continuing

INITIAL AGREEMENT DATE: 10/16/95

END DATE: 9/30/99

PROJECT OBJECTIVES:
The overall goal of this project is to advance the state-of-the-art in ground-penetrating-radar (GPR) imaging techniques so that it will become an even more practical and precise tool for assessing the integrity of reinforced concrete bridge decks, with particular attention directed towards the specific problems of New England bridges. The plan is to conduct numerical, laboratory and field studies with the ultimate goal of developing a reliable and easy-to-use field technique. **Phase I** involves the numerical modeling of the interactions of defects in concrete bridge decks and GPR through the adaptation of available algorithms, software and dielectric parameter data. **Phase II** involves the laboratory verification of the numerical models through the testing of specimens with known defects. **Phase III** involves the development of radar waveform image processing techniques so that defect conditions can be identified readily. **Phase IV** involves the field testing of the methods on selected bridge structures in New England. **Phase V** involves the development of the appropriate documentation so the technology developed in this project is capable of being used by the state transportation agencies. This is an interdisciplinary project that has a team of investigators from Vermont and Massachusetts: Prof. Dryver R. Huston and Prof. Peter L. Fuhr from the University of Vermont; Dr. Kenneth Maser of Infrasense, Inc; and Dr. William Weedon of Applied Radar Analysis, Inc. The project will take three years to complete.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:

Phase 1 - Numerical Modeling: The primary goal of this task is to develop numerical models of the interaction of GPR with concrete pavements so that field conditions can be simulated and investigated. This task was largely completed in the previous year's work. This task is 100% complete.

Phase 2 - Design and Conduct of Laboratory Evaluations: The goal of the laboratory studies is to fabricate concrete slabs with various defects and features that can be identified with a radar system. A series of concrete slabs, with embedded defects, including delamination produced by accelerated corrosion, have been fabricated. These

slabs were tested with a system that underwent several phases of development and improvement. The final version of the system was fairly capable at identifying features that lie underneath the bridge deck. Of particular note is that the system is able to detect delaminations with a width of 1 mm. or less. This task is 100% complete.

Phase 3 - Development of Radar Data Processing Software: A set of software tools for acquiring, processing and displaying the radar signals has been developed. The software is able to display the data in a format that can indicate the presence and location of underlying features. Efforts were undertaken to acquire and develop synthetic aperture radar signal processing software. This software is capable of the distortion caused by off-axis reflections.

Phase 4 - Correlation of Software with Laboratory and Field Data: Three field tests with the radar system were completed. The purpose of the tests was primarily for the development and debugging of the radar system. The results of the tests were somewhat sporadic. The system was able to detect gross features, such as potholes that are visible to the eye, but could not clearly identify underlying features. The third tests were where the FHWA Demonstration Radar System operated by Concorr was tested on a variety of bridge decks. The fourth and fifth tests were conducted on an old and damaged bridge and on a new bridge with an improved radar system. The system was able to detect features underlying the roadway. This task is 100% complete.

Phase 5 - Implementation of Research Results: A specification for a new radar system has been developed. The final project report is mostly complete.

REPORTS, PAPERS, AND PRESENTATIONS:

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

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

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

4. "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, July 1999.

5. "Electromagnetic Interrogation of Structures," Huston, D. 4th Army Research Office on Smart Structures, State College, PA, August 1999.

6. "Good Impedance Match Antenna (GIMA) Design and Its Applications for Ground Penetrating Radar in Concrete Structures NDE Applications," Hu, J.Q. Masters Thesis Mechanical Engineering, University of Vermont, August 1999.

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

PROJECT NUMBER: 94-3

PROJECT TITLE: Procedures for the Evaluation of Sheet Membrane Waterproofing

PRINCIPAL INVESTIGATOR (S):
Charles J. Korhonen, Jim Buska, and Edel Cortez, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL).

STATUS: Completed

INITIAL AGREEMENT DATE: 12/31/97

END DATE: 12/01/99

PROJECT OBJECTIVES: Waterproofing membranes have been used by transportation agencies in New England for more than two decades to prevent water and deicing salts from penetrating concrete bridge decks and corroding the embedded reinforcing steel. Although field performance studies have proven the efficacy of waterproofing membranes at extending bridge life, there are problem areas where improvements in test procedures or materials are needed. For example, if a membrane cannot be fully adhered to the deck, or somehow becomes damaged during construction, or is unable to resist splitting when cracks develop in the deck or bituminous overlay, moisture and chlorides can leak through the system and accelerate bridge deterioration. The objective of this project is to develop new or modify existing laboratory tests for evaluating sheet membrane waterproofing for their ability to resist cracking, blistering and puncturing.

This project consists of four tasks. **Task 1** will develop a test to evaluate adhesion between the membrane and a concrete substrate. Membranes that exhibit good bond should be better able to resist the development of blisters caused by the vaporization of moisture or other gases at the concrete surface and to remain intact during the life of the bridge. **Task 2** will analyze the tensile strength and elongation of a membrane as a function of temperature because membranes are most likely to split at low temperature, when cracks widen in concrete. **Task 3** will develop a test to measure the resistance of a membrane to rock puncture as membranes are most susceptible to this type of puncture during construction. **Task 4** will examine the water vapor permeability of a membrane with the idea that more breathable membranes should be better able to resist blistering.

It was acknowledged at the outset of this project that the findings from these four tasks, by themselves, might not necessarily provide sufficient insight into how well a given membrane may perform on a bridge. However, these results can be used to rank one membrane against another and, if combined with field performance studies, should lead to a much better understanding of membrane performance.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
The final report was completed and distributed.

REPORTS, PAPERS AND PRESENTATIONS:

1. "Procedures for the Evaluation of Sheet Membrane Waterproofing," Korhonen, Charles J., Buska, James S., Cortez, Edel R., and Greatorex, Alan R., August 1999, NETCR13.

PROJECT NUMBER: 94-4

PROJECT TITLE: Durability of Concrete Crack Repair Systems

PRINCIPAL INVESTIGATOR:
George Tsiatas, University of Rhode Island

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/97

END DATE: 12/31/99

PROJECT OBJECTIVES:
The objective of this research project is to determine the fatigue life durability of structural concrete crack repair systems when subjected to dynamic flexural and compressive stresses and freeze-thaw testing. This is be accomplished by performing flexural strength testing and freeze-thaw testing on concrete beams that have been repaired with various crack repair systems. These systems are selected from a generic classification of systems in order to determine the fatigue life durability of generic types of repair systems rather than that of specific repair products. The testing program follows modified procedures of ASTM C78 and ASTM C666 for the fatigue and freeze-thaw specimens, respectively.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
Literature Search. A literature search of all the research recently or currently performed with respect to durability and crack repair systems has been conducted. The most relevant articles have been organized and abstracted. These abstracts include publication information as well as a summary of the content with respect to this research project.

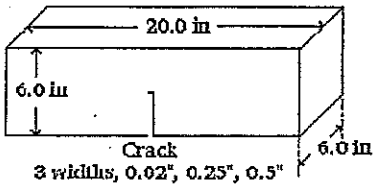
Methods. A generic classification of concrete crack repair systems has been developed. This classification is a result of the literature search, a nationwide survey, extensive review of manufacturers' product guides, and meetings with RIDOT personnel. The classification separates crack repair systems into 3 categories namely, Resin Based repair materials, Modified Cementitious repair materials, and Cementitious repair materials.

In developing this classification, a survey was sent to the state Departments of Transportation throughout the United States. In addition, the six New England states were solicited, including a request for the concrete crack repair approved materials lists. The survey objective was to evaluate the applicability and performance of various crack repair systems, as well as to determine which repair systems are currently being utilized. In response, 19 states (38%) have either replied or completed the survey, and 4 New England states have supplied the approved materials list.

Specimen Preparation.

The specimens for the fatigue testing measure 6" x 6" x 20". The specimens for the freeze-thaw testing measure 3" x 4" x 16". The mix design for all the beams is RIDOT Class X 3/4" AE concrete. Excluding the control units, all the beams are cast with metal inserts placed in the middle third of the beams. These inserts vary in thickness to form cracks in the beams of varying widths. The crack widths are 0.02", 0.25", and 0.50". The crack depths extend from the tensile face to the neutral axis of the beams. The crack lengths are the width of the beams; 6" for the fatigue specimens and 4" for the freeze-thaw specimens. The geometry for the fatigue beams is illustrated in Figure 1, Fatigue Beam Geometry.

Figure 1: Fatigue Beam Geometry



The beams were cast in batches of approximately 30 fatigue and 17 freeze-thaw specimens each. During 1999 the final two batches were cast on 3/19/99, and 5/28/99. With these two castings the total number of specimens include 135 fatigue specimens and 49 freeze-thaw specimens. The average 28 day compressive strength of all batches is 4450 psi with a standard deviation of 820 psi.

Repair Systems. After the concrete beam specimens have been cured, appropriate crack repair systems are applied to the cast in place cracks. These cracks are cleaned by means of a high-pressure water jet and compressed air. In addition the cracks receive additional preparation as specified by the manufacturer's guidelines. After the beams are repaired, they are allowed to cure, and then tested.

Currently, repair systems have been investigated from five manufacturers as well as one method recommended by ACI. The specific systems are shown in Table 1, Repair Systems Investigated. The systems have been applied in accordance with manufacturer's specifications. The ChemMaster product, Duraguard 401, was applied in Buffalo, NY, using a patented vacuum assisted injection process. In addition, one system will be selected from Master Builder's product list.

Table 1: Repair Systems Investigated

Manufacturer	Product	Classification
ACL	Drypack Method	Cementitious
ChemMaster	Duraguard 401	Methylmethacrylate
Fosroc	ULV 140	Epoxy
Silpro	VO Patch	Mod. Cementitious
Sika	SikaPronto 19	Methylmethacrylate
Sto	CR 641	Epoxy

Testing Program:
The testing for the fatigue specimens follows a modified ASTM C78 'Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)' procedure. The repaired beams are loaded at third points and are simply supported. The loading will be a dynamic load. The frequency, intensity, and duration of loading are based on several trial tests. The frequency of the cyclic loading is 10 Hz. The intensity of the loading is incrementally increasing, starting with an amplitude of 30% of the static flexural strength. The duration of this initial amplitude is 100, 000 cycles, which cycles between 10 and 40 % of the static flexural strength. After 100, 000 cycles, the maximum stress (and amplitude) increases incrementally every 10, 000 cycles. The incremental increase is 10%, and continues until the specimen fails or withstands 10, 000 cycles with maximum stress
EMBED Excel.Sheet.8
equal to 100 % of static flexural strength. The fatigue loading program is shown graphically in Figure 2, Graphical Representation of Fatigue Testing Program.
Testing is duplicated over a range of temperatures. These temperatures are 25 °F (ow), 62.5 °F (ambient), and 100 °F (high). Testing has been completed at ambient and high temperatures. Testing at low temperature is currently under way.

The testing for the freeze-thaw specimens follows a modified ASTM C666 'Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing' procedure. The specimens are subjected to 300 cycles of freezing and thawing. Every 30 to 36 cycles, the specimen weight and fundamental transverse frequency are recorded. Loss in specimen weight and decay of frequency indicate specimen degradation. Modifications to this procedure are primarily in the specimen curing. In order to repair the beams according to manufacturer's specifications, the specimens will be removed from their water curing after 14 days and allowed to dry. After the repair systems have been applied and have had adequate time to cure, they will be replaced in a water bath and allowed to saturate immediately prior to freeze-thaw testing. Another modification is that the specimens are rotated 90 ° when tested for fundamental transverse frequency. This accommodates the location of the crack repair material, and follows previous ASTM C666 standards. Following the freeze-thaw procedure, as recommended by RIDOT representatives, the specimens are tested in fatigue as described above. The final batch of freeze-thaw testing in currently under way.

The testing program utilizes a factorial experimental design to determine the total number of required specimens and for statistical analysis. This design is modified to account for the incompatibility of certain repair systems with certain crack widths. It also is adjusted to reduce the number of control units required. A standard design would require control specimens for each repair system when in fact one set of control units for each crack width and temperature is sufficient for comparisons to be made with all the repair systems.

REPORTS, PAPERS AND PRESENTATIONS:

1. "Durability of Concrete Crack Repair Projects," Robinson, J. Presented at the University of Rhode Island Graduate Seminar Series, Kingston, RI, November 19, 1997.

2. "Durability of Concrete Crack Repair Systems," Tsiatas, G. and Robinson, J. A presentation to representatives of the Chemical Grouting Division of Kajima Corporation (Japan), University of Rhode Island, College of Engineering, October 26, 1999.

PROJECT NUMBER: 95-1

PROJECT TITLE: Use of Tire Chips/Soil Mixtures to Limit Frost Heave and Pavement Damage of Paved Roads

PRINCIPAL INVESTIGATOR:
Dana N. Humphrey, University of Maine, Orono, Maine

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: 12/31/97

PROJECT OBJECTIVES:
The objective of this research is to determine the tire chip/soil mixture ratio, tire chip/soil mixture layer thickness, and thickness of overlying soil cover (distance from top of tire chips/soil mixture layer to bottom of pavement) that will optimize the thermal resistivity and permeability without resulting in excessive deflections in the flexible bituminous pavement layer. This will be accomplished through laboratory measurement of the thermal conductivity and permeability of tire chips and tire chips/soil mixtures. The results of the laboratory tests will be used to design and construct a prototype pavement structure underlain by tire chips and/or tire chip/soil mixtures.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
Laboratory Measurement of Thermal Conductivity. A large scale one-sided mode insulated-hot-plate apparatus was constructed to measure the thermal conductivity of tire chips. The apparatus measures 3 ft. by 3 ft. in plan and can accommodate a 1-ft. thick sample. The sides of the apparatus are insulated with 1 ft. of extruded polystyrene insulation to minimize lateral heat loss. The primary heater, located in the center of the apparatus, supplies a measured amount of energy to the overlying sample. The temperature of a second heater, called a backflow plate, located at the bottom of the apparatus is adjusted to prevent heat loss from the bottom of the apparatus. The temperature gradient through the sample is measured with thermocouples. The gradient along with the energy input to the primary heater provides the information needed to calculate the thermal conductivity. The samples were compacted into the apparatus using 60% of standard Proctor energy. The tests were conducted with three surcharge levels to simulate compression of the tire chips under an overlying soil layer: no surcharge, 187 psf, and 375 psf.

Tests on air dried samples were conducted on gravel, five types of tire chips and six different tire chip/gravel mixtures. It was found that the apparent thermal conductivity[1]

[1]The apparent thermal conductivity includes the effects of conduction through the sample and heat transferred by convection of air through the voids.

of air dried tire chips varies from about 0.11 to 0.18 Btu/hr/ft/°F and that of air dried gravel varies from 0.30 to 0.35 Btu/hr/ft/°F. Tire chips with steel belts had a higher thermal conductivity than chips with glass belts. The apparent thermal conductivity of air dried tire chip/gravel mixtures was 0.23 to 0.34 Btu/hr/ft/°F for 33% tire chips/67% gravel and 0.17 to 0.29 Btu/hr/°F for 67% tire chips/33% gravel. The effect of temperature gradient on thermal conductivity was investigated. It was found that the thermal conductivity of tire chips increases as the gradient increases. This is most likely due to increased heat transfer due to air circulation within the voids as the temperature gradient increases.

Laboratory measurement of the thermal conductivity of moist samples showed that moist gravel has a measured thermal conductivity that is more than two times that of dry gravel. For example, the thermal conductivity of moist gravel at half surcharge was 1.63 W/m°C compared to 0.563 W/m°C for dry gravel at half surcharge. A similar difference was measured for dry and moist samples with 33% Palmer tire chips/67% gravel. In contrast, the thermal conductivities of Palmer tire chips is about the same for dry and moist samples. This is also true for 67% Palmer tire chips/33% gravel. This shows that the thermal conductivity of samples composed primarily of tire chips is not dependent on the moisture condition.

The thermal conductivity of steel belted Pine State tire chips was backcalculated from subsurface temperature measurements made at the Richmond, Maine, field trial. This was possible because the temperature profile had reached a steady state condition by mid-February, 1994. The temperature profile on February 14, 1994 was used to backcalculate a thermal conductivity of 0.20 W/m°C (0.12 Btu/hr/ft/°F) As a check, the modified Berggren equation was used with this value to predict the depth of frost penetration for the winter of 1993-4. The predicted depths agreed very well with the measured depths (-5% to +11% difference). The laboratory measured thermal conductivity of Pine State tire chips at an overburden pressure corresponding to the field value was about 0.26 W/m°C (0.15 Btu/hr/ft/°F). One reason that this value is somewhat higher than the field value is that the temperature gradient used in the laboratory test was higher than the field gradient.

Laboratory Measurement of Permeability. Permeability tests on tire chips and tire chip/gravel mixtures were completed. In total, one test was performed on gravel, five on tire chips, and six on tire chip/gravel mixtures. Tests were conducted in a 12-in. diameter constant head permeameter constructed for a previous NETC project. The samples were tested at several compressions to simulate the effect of the overburden pressure. The permeability decreases as the void ratio of the sample decreases and as the size of the tire chip decreases. Yet even with smaller tire chips and lower void ratios, the permeability was higher than many gravels used for highway construction. However, the permeability of 67% tire chip/33% gravel mixtures was nearly reduced to the value obtained for 100% gravel. Thus, to take advantage of the high permeability of the tire chips it is necessary

to use 100% tire chips.

Field Trial. The full-scale field trial was constructed on the University of Maine campus in the Fall, 1996. The field trial design consists of three sections underlain by 6 or 12 in. of tire chips and two sections underlain by 12 in. of tire chip/gravel mixtures. The tire chip and tire chip/gravel layers are covered by 19 in. of subbase aggregate except in one section where the tire chip layer is covered by 13 in. of subbase aggregate. Each section has a vertical string of 12 to 20 thermocouples to measure the temperatures above, in, and below the tire chip layer. In addition to the five tire chip sections there is a control section underlain by 25 in. of subbase aggregate. An edge drain with a depth of approximately 3 ft. 6 in. and a width of approximately 2 ft. 3 in. mix was located at one edge of the road. The test section was covered by 5 in. of hot bituminous pavement (3.5 in. of base and 1.5 in. of hot mix bituminous, Type C). The design was summarized in a draft *Field Test Protocol.* This was distributed to the technical advisory committee on July 19, 1996.

Construction of the test section began September 6, 1996. A contractor was hired to perform the excavation required for the test section itself. Next, the tire chip and tire chip/soil mixtures were placed. The material was hauled from a stockpile located about a mile from the project by the investigators using a 3-ton capacity dump trailer pulled by a pickup truck. The tire chips were spread by hand and compacted by a 10-ton vibratory roller. Gravel subbase aggregate was delivered to the site by Owen J. Folsom Construction. The aggregate meets the requirements of Maine DOT Type D subbase aggregate. It was spread with a small tractor and compacted with a 10-ton vibratory roller. Gravel placement was completed on September 30, 1996. The road was paved in late October.

Subsurface temperatures were monitored throughout the winter of 1996-7. Temperature measurements showed that a 12-inch thick layer of tire chips provided significant insulation allowing the frost to penetrate no more than a few inches into the subgrade soil. Somewhat more frost penetration occurred in a section with 6 in. of tire chips. However, in a section with a 12-inch thick mixture of 33% chips and 67% gravel had the same frost penetration as the control section. A section with a mixture of 67% chips and 33% gravel gave intermediate results. Significantly less frost heave was observed in the tire chip sections compared to the control section.

Final Report. The draft final report was submitted for review to the NETC technical committee in July, 1998. Comments were received back from the committee members. The principal investigator met with the committee members to discuss the comments.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "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. A paper submitted to the Transportation Research Board at the session on "Properties of Unconventional Aggregates" at the Annual Meeting of the

Transportation Research Board, Washington, D.C., January 1997.

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

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

4. "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.

PROJECT NUMBER: 95-3

PROJECT TITLE: Implementation and Evaluation of Traffic Marking Recesses For Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes

PRINCIPAL INVESTIGATOR(S):
K. Wayne Lee, University of Rhode Island
Sean Corrigan, University of Rhode Island
Stephen A. Cardi, II, Cardi Corporation

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: 8/31/99

PROJECT OBJECTIVES:
If thermoplastic pavement striping is applied to a constructed recess in the pavement surface, snow plow blades would pass over without damaging either the marking or the pavement. This study will determine the best means of creating traffic marking recesses and the cost effectiveness of this method. To accomplish this task the URI research team will work with a contractor on an existing construction project to carry out a trial field installation of the traffic marking recesses. Construction specifications will be developed for this method by the URI research team with the assistance of the contractor.

After construction, the durability and retroreflectivity of the recessed markings will be monitored three times each year for two years. The monitoring and evaluation period will take place once prior to the winter maintenance season, once during the winter months and once after the winter maintenance season. The durability of the recessed markings will be evaluated by a subjective rating method, and the retroreflectivity will be measured by a retroreflectometer. The URI research team will also produce a narrative videotape of late night wet-weather condition review of the test sections. The final report will be submitted within 3 weeks of the final evaluation and will include pictures of each evaluated section, the late night wet-weather video, as well as comparisons of the recessed and non recessed areas durability and retroreflectivity.

PROGRESS/ACCOMPLISHMENTS THRU DECEMBER 31, 1999:
On June 30, 1999, the last (7th) evaluation was performed on dry night for the comparative purpose. The retroreflectivity measurements were taken by the Retro-Lux 1500 retroreflectometer. Two readings were taken at the first third and second third of each skip strip and then were averaged to represent the retroreflectivity of the entire stripe. The durability of each stripe was also determined by utilizing the percentage-retained method.

A statistical analysis (t-test) of the data collected from the seven durability and

retroreflectivity evaluations of the three (3) test sections were performed.

A draft final report was prepared and submitted to the technical committee for their review on 8/30/99. It included pictures of each evaluated section, and narrative videotape of a late night wet-weather condition review, as well as comparisons of the recessed and non recessed area durability and retroreflectivity.

REPORTS/PAPERS AND PRESENTATIONS:

1. A PowerPoint presentation of the findings was given at the Rhode Island Transportation Forum held on October 15, 1999 at the Chester H. Kirk Center for Advanced Technology, hosted by the University of Rhode Island Transportation Center (URITC) and the Construction Industries of Rhode Island (CIRI.).

PROJECT NUMBER: 95-5

PROJECT TITLE: Buried Joints in Short Span Bridges

PRINCIPAL INVESTIGATOR(S):
George Tsiatas and K. Wayne Lee, University of Rhode Island

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: Completion of Work

PROJECT OBJECTIVES:
The objective of project 95-5 is to determine the viability of buried joints in short span steel and concrete bridges in New England.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
An extensive study of various expansion joint systems used in the New England states was undertaken. Common types of joints used at present are: buried joints for movements up to 1.5-2 inches, strip seals for movements up to 4 inches, and finger or modular joints for movements greater than 4 inches. In the states of Vermont and Maine a modified strip seal joint and a modified compression seal joint, respectively, are used for movements up to 3-4 inches. Performance and cost information related to the above expansion joint systems was collected.

A parametric study of expected movements for various span lengths due to temperature changes was made. It is found that the 2 inch allowed movement of the joint material can accommodate a large number of existing highway bridges.

An analytical investigation of the following types of joint connections was undertaken for a two span (93 ft. and 84.5 ft.) structure with an expansion joint over the middle pier: no structural connection (asphalt plug), continuous concrete deck over the joint, steel lap plate connecting the top flanges of the girders, connection of the webs of the girders and full moment connection. The analysis was conducted using a detailed model of the bridge which allowed for the determination of the stress field in the vicinity of the expansion joint. Temperature effects were studied in order to evaluate expected movements and required clearances.

Work has been completed on: 1) the literature search 2) identifying the new England State's existing details and specifications for replacing and rehabilitating deck joints and 3) identifying failure mechanisms of existing deck joint systems in New England. The analytical study of buried joints in short span concrete and steel bridges is 95% complete. The evaluation of buried joints as a viable option and the development of recommendations regarding a generic specification, materials and construction methods for incorporating

buried joints into rehabilitated bridges is 90% complete.

REPORTS, PAPERS AND PRESENTATIONS :

1. "State of the Art Study of Bridge Joint Systems in New England," Tsiatas, G. and Chandrasekaran, S. A paper submitted for presentation at the Annual Meeting of the Transportation Research Board, Washington, D.C., January 1997.

PROJECT NUMBER: 96-1

PROJECT TITLE: Implementation of Superpave

PRINCIPAL INVESTIGATOR(S):
Jack E. Stephens and James M. Mahoney, CT Advanced Pavement Laboratory
CT Transportation Institute, University of Connecticut

STATUS: Completed

INITIAL AGREEMENT DATE: 9/1/97

END DATE: 8/31/99

PROJECT OBJECTIVES:
Assist states in implementation of Superpave.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
The final report was completed and distributed.

REPORTS, PAPERS AND PRESENTATIONS:

1. "Superpave Implementation," Mahoney, James, Stephens, Jack E., September 1999, NETCR18 .

PROJECT NUMBER: 96-2

PROJECT TITLE: Optimizing GPS Use in Transportation Projects

PRINCIPAL INVESTIGATORS:
C. Roger Ferguson, University of Connecticut
John E. Bean, Central Connecticut State University

STATUS: Continuing

INITIAL AGREEMENT DATE: 7/1/97

END DATE: 6/30/99

PROJECT OBJECTIVES: Multiple objectives for each of the six project tasks are listed in the project proposal.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
Met with representatives of the three primary GPS equipment vendors to discuss available equipment, equipment features, and equipment prices. Information obtained from these meetings will be used in matrix compilation for Task 2. Arranged for each of the vendors to exhibit their wares and answer questions about GPS equipment and technology at a combined meeting of all of the New England GPS users that will be coordinated as part of this project.

Completed preparation of a web site to disseminate information about this project. Delivery date for the hard drive upon which this will reside is past due at Central Connecticut State University. Site should be up and running by 12/31/98.

Completed draft reports of the summer 1997 individual meetings with each New England State DOT and distributed them to the DOTs for comment, correction, and additional information which was missed in the meeting minutes and we thought other meeting attendees might help us recall. Made calls to all of the DOTs to obtain responses when none were forthcoming after a month. Several responses were obtained after the calls, but one or two are still needed to finalize these reports. Recent communications indicate that these responses will not be forthcoming, so the reports will be completed by 12/31/98 without them.

Completed the draft composite report of the summer 1997 New England State DOT meetings. Completion of this report depends on the same responses mentioned in the above paragraph. 12/31/98 completion anticipated.

Ascertained that all of the states would like to have a New England DOT GPS users meeting in the Concord, NH area, and that most of them are willing to make a presentation about some aspect of their GPS use at the meeting. Initially, the meeting

was to have been in Nov. 1998, but responses to the question about desire for the meeting and willingness to participate came only after a reminder telephone call, and not in time to organize the meeting for November. Respondents indicated they would like to have the meeting in Spring 1999.

Processed purchase order for real-time geodetic GPS base station at Central Connecticut State University (CCSU).

Attended two-day ESRI training class in MapObjects (funded by CCSU).

Worked on survey control portion of website using MApObjects Internet Map Service (MS).

Visited Pacific Northwest Geodetic Array (PANGA) to investigate operation of a large-scale continuously operating GPS network (airfare funded by CCSU). Report of visit posted to web site.

Continued work on Kinematic GPS studies.

A web server was installed at Central Connecticut State University with an enhanced web page. An on-line survey control locator was developed for the New England region. The application features a "point and click" map interface to retrieve NGS data sheets for control points. The implementation uses ESRI's Arc view Internet Map Server Technology. The URL for the project site is http://gps.ccsu.ctstateu.edu

Computer programs have been developed to:
a) continuously download, translate, and archive base station data and b) transfer base station data from remote sites to a central location via network or modem. An automated zip drive-based base station archiving system was developed and working GPS base stations were established at two locations.

Work is continuing on converting to Map Objects Internet map server.

REPORTS, PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 96-3

PROJECT TITLE: Effectiveness of Fiber Reinforced Composites as Structural and Protective Coverings for Bridge Elements Exposed to Deicing-Salt Chlorides

PRINCIPAL INVESTIGATOR(S):
Perumalsamy Balaguru, Rutgers, The State University of New Jersey
K. Wayne Lee, University of Rhode Island

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/31/97

END DATE: 4/30/00

PROJECT OBJECTIVES:
The primary objective of the proposed research is to identify a cost effective composite system that will provide long-term performance under freeze-thaw, wet-dry, and deicing salt environments. The primary tasks are (1) selecting the promising candidates in terms of materials, combination of fibers and matrices, and application techniques, and (2) evaluation of the selected materials and systems for long-term performance.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
The major accomplishments are: durability study consisting of wet-dry, freeze-thaw, scaling conditions and field applications. Special set-ups were fabricated for wet-dry apparatus and measurement of fundamental frequency. A field application was made in Rhode Island using a self-containing sprayer.

The applications made during October 1998 are performing well. The third field application was made during the summer of 1999.

For the durability study, concrete prisms were coated on three and four sides using (1) one organic matrix, (2) two polymer modified cementitious matrices, and (3) four silicate matrices. In the area of reinforcement; microfibers, discontinuous and continuous carbon fibers, and carbon sheets were used. Most of the samples were subjected to 200 wet-dry cycles and 50 cycles in scaling tests. Some of the samples were subjected to 200 free-thaw cycles.

Specimens with micro fibers were evaluated using non-destructive testing. The samples strengthened with continuous fibers and sheets were tested in flexure. The load deflection behavior was used for the evaluation.

The results obtained indicate that durable inorganic coatings can be developed for the surface protection and moderate strength increase.

The results obtained were presented at the Visiting Scholar lecture in the University of Rhode Island, URITC Transportation Forum Program on October 15, 1999. The results were also part of the following presentations.

REPORTS, PAPERS AND PRESENTATIONS:

1. "Inorganic Matrices for Composites," NSF Workshop on Composites, Hanover, NH, March 15, 1998.

2. "Behavior of Geopolymer Reinforced with Various Types of Fabrics," SAMPE 1998, Anaheim, CA, May 1998.

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

4. "Advances in Composites," National University of Singapore, July 19, 1998.

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

6. "Inorganic Coatings for Transportation Infrastructures," Geopolymer Conference, St. Quentin, France, July 2, 1999.

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

8. "Effectiveness of Fiber Reinforced Composities as Structural and Protective Coverings for Bridge Elements Exposed to Deicing -Salt Chlorides," Visiting Scholar Lecture, Transportation Forum, University of Rhode Island, October 15, 1999.

PROJECT NUMBER: 97-1

PROJECT TITLE: A Portable Method to Determine Chloride Concentration on Roadway Pavements

PRINCIPAL INVESTIGATOR(S):
Norman W. Garrick and Nikolaos P. Nikolaidis, University of Connecticut

STATUS: Continuing

START DATE: 09/01/98

END DATE: 8/31/00

PROJECT OBJECTIVES:
The objective of this work is the development of technology to be used in conjunction with a management framework for effective deicer deployment. The goal is a system that will result in the optimum use of road deicer, thereby, reducing the cost and minimizing the undesirable water quality effects of chlorine, while, at the same time, preserving highway safety.

ACCOMPLISHMENT THROUGH DECEMBER 31, 1999:
In August the PI's met with the technical advisory committee in Storrs. The outcome of this meeting was an understanding that the project should proceed in two distinct tracks: i) development of a measurement technology using XRF for dry pavement conditions and ii) development of a measurement technology for wet pavement conditions. The technology for wet measurement is roughly based on work done by the Japanese Highway department. Specifically, the sample collection component of our system is modeled similar to the Japanese system, however, we are using a completely different approach for salinity measurement.

The system consists of three major components: the sample collection assembly, the pump and the measurement unit. This system is designed to collect in the storage box any slush that is splashed up by the front vehicle tire. This slush will be heated in the box and then pumped through appropriate filters to the measurement chamber. The salinity of the water in the chamber will be measured using a conductivity meter. The meter which has been selected, is designed to continuously measure and record the salinity of water that is pumped through the measurement chamber. We have also selected and ordered the conductivity system, the laptop computer that is required to run the system and the pump. The collection system has been designed and is being manufactured. The first prototype mockup is expected to be completed by the end of December.

Work is proceeding on developing the hand-held XRF unit as the dry measurement system. The work that was done in year 1 was based on a laboratory XRF system since the specially manufactured hand-held unit was not received until early August.

Consequently, the basic tests for characterizing this new device are currently being conducted. The results for the hand-held device were found to be different from that of the laboratory XRF. Laboratory testing is finished and field testing has started.

REPORTS, PAPERS, AND PRESENTATIONS: None.

PROJECT NUMBER: 97-2

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

PRINCIPAL INVESTIGATOR:
Dr. Scott A. Civjan, University of Massachusetts, Amherst

STATUS: New

INITIAL AGREEMENT DATE: 8/30/98

END DATE: 8/30/01

PROJECT OBJECTIVES:
To evaluate the performance of chemical and mineral durability enhancing admixtures in structural reinforced concrete mixes typical of those specified by State Transportation Agencies in New England.

To develop guidelines, for the New England State Transportation Agencies, on the specification and usage of chemical and mineral admixtures that will address their expected long-term durability enhancement and their overall life cycle economic impacts.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
The literature search and written literature review have been completed. The experimental research plan was reviewed by the Technical Committee and the Committee's comments have been incorporated.

Dr. LaFave left the University of Massachusetts in August 1999 to join the faculty at the University of Illinois. Dr. Civjan has replaced Dr. LaFave as Principal Investigator.

REPORTS, PAPERS, AND PRESENTATIONS: None

PROJECT NUMBER: 97-3

PROJECT TITLE: Determining Properties, Standards and Performance of Wood Waste Compost as an Erosion Control Mulch and as a Filter Berm

PRINCIPAL INVESTIGATORS:
Richard P. Long and Kenneth R. Demars, University of Connecticut

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/98

END DATE: 7/31/00

PROJECT OBJECTIVE(S):
The objective of this proposed study is to perform laboratory and field testing of the physical and chemical properties and behavior of wood waste compost for use in erosion control on construction projects. The two applications of interest are the use of compost as an erosion control mulch on slopes and as an erosion control filter berm. Particular goals include 1) determine the minimum effective thickness of wood waste compost for protecting slopes from erosion during rain events, 2) evaluate the limits of stability and shear strength for wood waste compost, 3) a comparison of alternate methods of containing eroded soil including hay bales, geotextiles, and filter berms containing composted materials, 4) the development of criteria to predict the field behavior of wood waste compost for various uses, and 5) recommendation of product standards.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
The layout and basic design of the cells for the field test site were completed and the cells were constructed in the Spring. Design included a method to measure the total amount and rate of rainfall, and the amount of run off. The physical and chemical properties of the samples of wood waste materials used at the field site have been tested in the laboratory

The field installation was completed in late April. There are 14 cells: three each for the three composted materials being evaluated and two control cells. The installation also contains one cell with a berm of composted material, one with a silt fence, and one with hay bales. Each composted material was applied in thicknesses of 3.0, 1.5, and 0.75 inches. New arrangements were developed to measure the amount of soil material eroded, and to measure the amount and rate of rainfall and the amount of flow out of the cells.

Although the summer of '99 was very dry, there were enough thunder storms that produced measurable rainfall events to show the effectiveness of the wood waste compost in preventing erosion in these intense periods of rain. During the thunder storms, the control cells showed significant runoff and erosion, while the protected cells showed less

runoff and little erosion.

The hurricane Floyd brought not only a significant storm rainfall but also a period of regular rain showers, most of which have been less intense and of longer duration than those experienced during the summer. As a result we have a good range of storm types that tested the wood waste materials.

REPORTS, PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 97-4

PROJECT TITLE: Early Distress of Open-Graded Friction Course (OGFC)

PRINCIPAL INVESTIGATOR(S):
Jack E. Stephens, James M. Mahoney and Charles E. Dougan
CT Advanced Pavement Laboratory, CT Transportation Institute
University of Connecticut

STATUS: Completed

START DATE: 06/01/98

END DATE: 12/31/99

PROJECT OBJECTIVES:

1. Determine the type and extent of failures in OGFC being experienced in New England.

2. Compare failures in OGFCwith sections that are performing well.

3. Develop specification requirements for OGFC based on the state-of-the-art.

4. Prepare recommended maintenance and rehabilitation practices and specifications for use on failed sections of OGFC.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:

The final report was completed and distributed.

REPORTS, PAPERS, AND PRESENTATIONS:

"Early Distress in Open-Graded Friction Course," Stephens, Jack E., Mahoney, James M., Dougan, Charles E., July 1999, NETCR16.

PROJECT NUMBER: 99-1

PROJECT TITLE: Bridge Rail Transitions

PRINCIPAL INVESTIGATOR:
Jerry Zoller, New Hampshire Department of Transportation

STATUS: Continuing

INITIAL AGREEMENT DATE: 06/05/98

END DATE: To be determined

PROJECT OBJECTIVES:
To produce a crash tested bridge rail transition design for use with the NETC 2-bar curb-mounted and 4-bar sidewalk-mounted steel bridge railing acceptable to FHWA.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
The technical committee effort is a continuation of the NETC 2-bar and 4-bar bridge rail design and crash testing project of 1988-1999 which ended with NETC issuing reports R10 and R14.

The committee has developed a transition design for both the 2-bar and 4-bar NETC bridge rail systems. In addition, a third transition design has been developed utilizing a concrete end block.

These transition designs are nearing readiness for review and concurrence by FHWA prior to turning the designs over to NETC to secure crash testing by contract.

REPORTS/PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 99-3

PROJECT TITLE: Development of Priority Based Statewide Scour Monitoring Systems in New England

PRINCIPAL INVESTIGATOR:
Carlton L. Ho, University of Massachusetts, Amherst

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/01/99

END DATE: 3/31/01

PROJECT OBJECTIVES:
To examine the feasibility of developing a statewide network of scour monitoring devices to assist in the allocation of resources during potentially destructive flood events. Such a system will be made part of a method to classify and prioritize bridges susceptible to scour failure based on a real-time monitoring network.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
This project began on September 1, 1999. The initial phase of the project was to evaluate current methodologies for evaluating bridge scour and determining needed parameters. A literature and web search is currently being conducted. It is anticipated that the search will provide insight into what archival and real-time data might be available for the intended bridge scour assessment.

Before the end of the year, the research team will begin a series of meetings with public agencies such as departments of transportation, departments of environmental protection and the National Weather Service. Only a portion of this will be done prior to the end of the year.

REPORTS, PAPERS, AND PRESENTATIONS: None.

PROJECT NUMBER: 99-4

PROJECT TITLE: Quantifying Roadside Rest Area Usage

PRINCIPAL INVESTIGATOR:
Per Gårder, University of Maine

STATUS: New

INITIAL AGREEMENT DATE: 9/1/99

END DATE: 2/28/01

PROJECT OBJECTIVES:
To use public input in determining the need for and spacing between roadside rest areas along different types of highways.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:
The surveying of travelers has been initiated and the first meeting with the project technical committee was held.

REPORTS/PAPERS PUBLISHED, AND PRESENTATIONS: None

PROJECT NUMBER: 99-6

PROJECT TITLE: Analytical and Experimental Investigation of the Effects of Concrete Removal Operations on Adjacent Concrete That is to Stay.

PRINCIPAL INVESTIGATOR:
Rusk Masih, University of Connecticut

STATUS: New

INITIAL AGREEMENT DATE: 8/23/99

END DATE: 8/31/01

PROJECT OBJECTIVES:
To achieve a simplified guideline, indicating the effect of the powerful demolition equipment on the concrete to stay. Such a guideline can help in future NETC project planning.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1999:

1. Acquisition of monitoring equipment from three vendors. The equipment is needed for the experimental purpose of monitoring the bridge demolition.
2. Acquisition of software to be used in the analysis.
3. Hiring students to help in literature survey and equipment installation and operation.
4. Continuation of literature survey.
5. Visiting the site of the bridge in VT to become familiar with the site.
6. Laying out the location of the strain gages on the bridge plan in accordance with the demolition plan.
7. Finding an alternative to the expensive rental cost of the snooper, which does not have money in the budget, since the budget was drawn on a different bridge that can be reached from the ground.
8. Studying the equipment manufacturer catalog and their operation manuals.
9. Installation of the strain gages in accordance with the plan and operation manuals. Such installation should take place before the cold weather. The gages must be winterized, since the demolition will take place in the spring of 2000. Gages installation is a very tedious and delicate operation; it requires skilled workmanship. It is also time consuming with several delicate operational stages to make the process successful.
10. Idealizing the engineering drawings to an engineering problem that can be put in the computer and using the software to analyze it by using the energy method.
11. Mathematical modeling of the bridge to be able to get the differential equations governing the wave equations.
12. Continuing the literature survey.

REPORTS/PAPERS PUBLISHED, AND PRESENTATIONS: None

1. "The Effect of Powerful Demolition Equipment on The Remaining Part of the Concrete Bridge," Masih, R. A paper submitted for presentation at the International Conference on Computational Methods for Smart Structures and Materials to be held in Madrid, Spain, June 2000.

2. "Effect of Demolition on Remaining Part of Concrete Bridge," Masih, R. A paper submitted for presentation at the IKM 2000 International Conference to be held in Germany, June 2000.

D. FINANCIAL STATUS
Active Projects

Table 1: Financial Status of Projects Active During 1999
(As of 12/31/99)

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
Full-Scale Crash Evaluation of the NETC 4-Bar Sidewalk-Mounted Steel Bridge Railing *P.I.s: C.E. Kimball and J.B. Mayer* *Southwest Research Institute* *6220 Culebra Road* *San Antonio, TX 78238-5166*	134,127.00	134,127.00	0.00 Project Closed: 8/4/99
94-1: Structural Analysis of New England Subbase Materials and Structures *P.I.: K. Wayne Lee* *University of Rhode Island*	111,497.00	110,057.38	1,439.62
94-2: Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging *P.I.: Dryver Huston* *University of Vermont*	224,902.00	214,786.23	10,115.77
94-3: Procedures for the Evaluation of Sheet Membrane Waterproofing *P.I.: Charles J. Korhonen* *Cold Regions Research and Engineering Laboratory, Corps of Engineers*	67,000.00	67,000.00	0.00 Project Closed: 12/1/99
94-4: Durability of Concrete Crack Repair Systems *P.I.: George Tsiatas* *University of Rhode Island*	84,850.00	72,036.04	8,276.96
95-1: Use of Tire Chips/Soil Mixtures to Limit Frost Heave and Pavement Damage of Paved Roads *P.I.: Dana Humphrey* *University of Maine, Orono*	75,000.00	73,120.10	1,879.90

Table 1: Financial Status of Projects Active During 1999 (As of 12/31/99) Continued

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
95-3: Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes *P.I.: K. Wayne Lee* *University of Rhode Island*	132,313.00	103,234.06	29,079.94
95-5: Buried Joints in Short Span Bridges *P.I.s: George Tsiatas and K. Wayne Lee* *University of Rhode Island*	64,910.00	61,705.61	3,204.39
96-1: Superpave Implementation *P.I.: Jack Stephens* *University of Connecticut*	74,978.00	12,942.16	62,035.84
96-2: Optimizing GPS Use in Transportation Projects *P.I.: C. Roger Ferguson* *University of Connecticut*	120,000.00	31,300.80	88,699.20
96-3: Effectiveness of Fiber Reinforced Composites as Structural and Protective Coverings for Bridge Elements *P.I.s: Perumalsamy N. Balaguru, Rutgers University; K.Wayne Lee, University of Rhode Island*	135,000.00	80,216.48	54,783.52
97-1: A Portable Method to Determine Chloride Concentration on Roadway Pavements-Phase I *P.I.s: Norman W. Garrick, Nikolais P. Nikolaidis; University of Connecticut*	97,502.00	29,191.61	68,310.39
97-1: A Portable Method to Determine Chloride Concentration on Roadway Pavements-Phase II *P.I.s: Norman W. Garrick, Nikolais P. Nikolaidis; University of Connecticut*	107,162.00	0.00	107,162.00

Table 1: Financial Status of Projects Active During 1999 (As of 12/31/99) Continued

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
97-2: Performance Evaluation and Economic Analysis of Combinations of Durability Enhancing Admixtures (Mineral and Chemical) in Structural Concrete for the Northeast USA *P.I.: J. LaFave* *University of Massachusetts*	118,473.00	31,494.56	86,978.44
97-3: Determining Properties, Standards and Performance of Wood Waste Compost as an Erosion Control Mulch and as a Filter Berm *P.I.s: Kenneth R. Demars, Richard P. Long* *University of Connecticut*	54,649.00	23,476.26	31,172.74
97-4: Early Distress of Open-Graded Friction Course (OGFC) *P.I.s: Jack Stephens, James Mahoney, Charles Dougan* *University of Connecticut*	79,865.00	56,112.90	23,752.10
99-1: Bridge Rail Transitions-Development and and Crash Testing *P.I.: Jerry Zoller* *New Hamphire Department of Transportion*	240,000.00	0.00	240,000.00
99-3: Development of Priority Based Statewide Scour Monitoring Systems in New England *P.I.: C. Ho* *University of Massachusetts, Amherst*	79,999.00	6,748.13	73,250.87
99-4: Quantifying Roadside Rest Area Usage *P.I.: Per Garder* *University of Maine*	44,857.00	0.00	44,857.00
99-6: Analytical and Experimental Investigation of the Effects of Concrete Removal Operations on Analytical Concrete That is to Stay *P.I.: Rusk Masih* *University of Connecticut*	99,689.00	0.00	99,689.00

Table 2: NETC Fund Balance

(As Of December 30, 1999)

ITEM	ALLOCATION	ENCUMBRANCE/ EXPENDITURE	CUMULATIVE BALANCE
Unexpended Balance of NETC funds from AASHTO			
as of 6/5/95 (Per AASHTO memo 12/4/95)			132777.07
Member Allocations 1994 = 6 X $75,000	450000		582777.07
Coord./Admin. of NETC: Calendar Year 1995 Bdgt. = $73042		58508.02	524269.05
Continued Projects:			
- Construction Costs of New England Bridges-Phase II		39500	484769.05
- Tire Chips as Lightweight Backfill-Phase II: Full-Scale Testing			
(Supplemental Funding)		16000	468769.05
- Bridge Rail Crash Test - Phase II:Sidewalk-Mounted Rail		134127	334642.05
- New England Vehicle Classification and Truck Weight Program		6752.57	327889.48
Member Allocations 1995 = 7 X $75,000	525000		852889.48
"95" Project Series:			
95-1: Use of Tire Chips/Soil Mixtures to Limit Pavement Damage			
of Paved Roads		75000	777889.48
95-2: Suitability of Non-Hydric Soils for Wetland Mitigation		39867.7	738021.78
95-3: Implementation and Evaluation of Traffic Marking Recesses			
for Application of Thermoplastic Pavement Markings			
on Modified Open Graded Mixes		132313	605708.78
95-5: Buried Joints in Short Span Bridges		64910	540798.78
95-6: Guidelines for Ride Quality Acceptance of Pavements		106124	434674.78
"94" Project Series:			
94-1: Structural Analysis of New England Subbase Materials and			
Structures		111497	323177.78
94-2: Nondestructive Testing of Reinforced Concrete Bridges			
Using Radar Imaging Techniques		224902	98275.78
Member Allocations 1996 = 6 X $75,000	450000		548275.78
Coord./Admin.of NETC: Calendar Year 1996; Bdgt. = $75,000		69123.85	479151.93
Member Allocations 1997 = 6 X $75,000	450000		929151.93
Coord./Admin. of NETC: Calendar Year 1997; Bdgt. = $82,494		77244.35	851907.58
"94" Project Series:			
94-3: Procedures for The Evaluation of Sheet Membrane Waterproofing		67000	784907.58
94-4: Durability of Concrete Crack Repair Systems		84850	700057.58
"96" Project Series:			
96-1: SUPERPAVE Implementation		74978	625079.58
96-2: Optimizing GPS Use in Transportation Projects		120000	505079.58
96-3: Effectiveness of Fiber Reinforced Composites as Protective			
Coverings for Bridge Elements, etc.		135000	370079.58
T2 (per 12/2/97 Adv. Committee Mtg.) for 1998 = $10,000		9551.06	360528.52
Coord./Admin. of NETC: Calendar Year 1998; Bdgt = $73,021		70871.59	289656.93
Member Allocations 1998 = 6 X $75,000	450000		739656.93
"97" Project Series:			
97-1: A Portable Method for Determining Chloride			
Concentration on Roadway Pavements		204664	534992.93
97-2: Performance Evaluation & Economic Analysis			
of Durability Enhancing Admixtures, etc.		118473	416519.93
97-3: Determining Properties, Standards & Performance			
of Wood Waste Compost, etc.		54649	361870.93
Alloc. to ConnDOT for Constr. Costs of Test Site (Approved 1/21/99 Ballot)		11000	350870.93
97-4: Early Distress of Open-Graded Friction Course		79865	271005.93

netcfin2.xls

Table 2: NETC Fund Balance (Cont'd)

(As Of December 30, 1999)

ITEM	ALLOCATION	ENCUMBRANCE/ EXPENDITURE	CUMULATIVE BALANCE
Travel Tech. Comm. (Aug. 98 tel. poll) for 1998 = $5,000		0	271005.93
Member Allocations 1999 = 6 X $75,000	450000		721005.93
Coord./Admin. of NETC: Calendar Year 1999:			721005.93
- Administration = $77,666			
-Technology Transfer & Technical Committee			
Travel = $20,400			
-Total =$98,066		98066	622939.93
"99" Project Series:			
99-1: Bridge Rail Transitions		240000	382939.93
99-2: Evaluation of Asphaltic Expansion Joints		80,000	302939.93
99-3: Bridge Scour Monitoring Systems		79999	222940.93
99-4: Quantifying Roadsie Rest Area Usage		44857	178083.93
99-6: The Effects of Concrete Removal Operations on Adjacent			
That Is to Remain		99689	78394.93
Member Allocations 2000 = 6 X $100,000	600000		678394.93
Coord./Admin. of NETC: Calendar Year 2000:		102,588	575806.93
- Administration = $ 85,788			
- Technology Transfer & Technical Committee			
Travel =$ 16,800			
- Total =$102,588			
"00" Project Series Estimated Cost		500000	75806.93
Notes:			
- Member allocations are obligated between October 1 and December 31 of the previous year			

E. NETC REPORTS, PAPERS AND PRESENTATIONS

PROJECT NUMBER	TITLE
N/A	**REPORTS, PAPERS AND PRESENTATIONS 1988-1994:**

"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.

"The Development of a Common Regional System for Issuing Permits for Oversize and Overweight Trucks Engaged in Interstate Travel," Humphrey, T.F., May 1986.

"New Technology for Bridge Deck Assessment - Phase I Final Report," Vols. I and II, Maser, Kenneth R., MIT Center for Transportation Studies, October 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.

"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.

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

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

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

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

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER	TITLE
N/A	**REPORTS, PAPERS AND PRESENTATIONS 1988-1994 (cont'd):**

"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.

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

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

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER	TITLE
N/A	**REPORTS, PAPERS AND PRESENTATIONS 1988-1994 (cont'd):**
	"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.
N/A	**POLICIES AND PROCEDURES:**
	"Policies and Procedures, New England Transportation Consortium," July 1995.
N/A	**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

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER	TITLE
NONE	**CONSTRUCTION COSTS OF NEW ENGLAND BRIDGES:**

Reports:

"Construction Costs of New England Bridges," Final Report, 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.

NONE	**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, Thomas C., March 11, 1998, NETCR8.

Papers and Presentations:

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

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

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

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER	TITLE
NONE	**TIRE CHIPS AS LIGHTWEIGHT BACKFILL FOR RETAINING WALLS, PHASE II: FULL-SCALE TESTING cont'd):**

Papers and Presentations (cont'd):

"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. N. 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. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER	TITLE
NONE	**TIRE CHIPS AS LIGHTWEIGHT BACKFILL FOR RETAINING WALLS, PHASE II: FULL-SCALE TESTING cont'd):**

Papers and Presentations (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 in each to the RI DOT, April 1999.

NONE	**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.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER	TITLE
NONE	**NEW ENGLAND VEHICLE CLASSIFICATION AND TRUCK WEIGHT PROGRAM, PHASE I (cont'd)**

Reports (cont'd):

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

Papers and Presentations:

"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.

NONE	**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

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER **TITLE**

94-1 STRUCTURAL ANALYSIS OF NEW ENGLAND SUBBASE MATERIALS AND STRUCTURES

Reports: None

Papers and Presentations:

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

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

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

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

"Structural Properties of New England Subbase Materials of Flexible Pavements." Presented at the 5th International Conference on the Bearing Capacity of Roads and Airfields on July 9, 1998.

"Characterization of Subbase Materials of Flexible Pavements With and Without Reclaimed Asphalt Pavement, K. Wayne Lee, Jeffrey Davis and Sekhar Vajhalla. Presented at the 199 World Congress for Korean Scientists and Engineers, July 7, 1999.

"Characterization of Subbase Materials of Flexible Pavements With and Without Reclaimed Asphalt Pavement, K. Wayne Lee, Jeffrey Davis and Sekhar Vajhalla. Presented at the 12th Rhode Island Transportation Forum, University of Rhode Island, October 15, 1999.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER **TITLE**

94-2 **NONDESTRUCTIVE TESTING OF REINFORCED CONCRETE BRIDGES USING RADAR IMAGING TECHNIQUES**

Reports: None

Papers and Presentations:

"Bridge Deck Structural Monitoring Techniques," Huston, D. Presented at the New England State Materials Engineers 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. in Structural Health Monitoring, Chang F., Editor, Technomic Publishing, pp. 91-109 Proceedings of the International Workshop on Structural Health Monitoring, Stanford, California, September 1997.

"Ground Penetrating Radar for Nondestructive Evaluation of Concrete Bridge Decks," Adam, C.S., Huston, D.R., Fuhr, P.L., Maser, K.R., and Weedon, W.H. Submitted to the American Concrete Institute student paper competition and American Concrete Institute Materials Journal, September 1997.

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

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

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

PROJECT NUMBER	TITLE
94-2	**NONDESTRUCTIVE TESTING OF REINFORCED CONCRETE BRIDGES USING RADAR IMAGING TECHNIQUES (cont'd)**

Papers and Presentations (cont'd):

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

"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, July 1999.

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

"Good Impedance Match Antenna (GIMA) Design and Its Applications for Ground Penetrating Radar in Concrete Structures NDE Applications," Hu, J., Masters Thesis Mechanical Engineering, University of Vermont, August 1999.

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

94-3	**PROCEDURES FOR THE EVALUATION OF SHEET MEMBRANE WATERPROOFING**

Reports:

"Procedures for the Evaluation of Sheet Membrane Waterproofing," Korhonen, Charles J., Buska, James S., Cortez, Edel R., and Greatorex, Alan R., August 1999, NETCR13.

Papers and Presentations: None

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER **TITLE**

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 Systems," Tsiatas, G. and Robinson, J. Presentation to representatives of the Chemical Grouting Division of Kajima Corporation (Japan), University of Rhode Island, College of Engineering,
October 26, 1999.

95-1 **USE OF TIRE CHIPS/SOIL MIXTURES TO LIMIT FROST HEAVE AND PAVEMENT DAMAGE OF PAVED ROADS**

Reports: None

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.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE
95-2	**SUITABILITY OF NON-HYDRIC SOILS FOR WETLAND MITIGATION**

Reports:

"Suitability of Non-Hydric Soils for Wetland Mitigation," Final Report, 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 PAVEMENT MARKINGS ON MODIFIED OPEN GRADED MIXES**

Reports: None

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." 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

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE
95-5	**BURIED JOINTS IN SHORT SPAN BRIDGES (cont'd)**

Papers and Presentations:

"State of the Art Study of Bridge Joint Systems in New England," Tsiatas, G. 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," Final Report, 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, NETCR 18.

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: None

Papers and Presentations:

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

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE

96-3 EFFECTIVENESS OF FIBER REINFORCED COMPOSITE AS STRUCTURAL AND PROTECTIVE COVERINGS FOR BRIDGE ELEMENTS EXPOSED TO DEICING SALT CHLORIDES (cont'd)

Papers and Presentations: (cont'd)

"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.

"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.

"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.

97-4 EARLY DISTRESS OF OPEN-GRADED FRICTION COURSE (OGFC)

Report:

"Early Distress in Open-Graded Friction Course," Stephens, Jack E., Mahoney, James M., Dougan, Charles E., July 1999, NETCR 16.

Papers and Presentations: None

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE
99-6	**ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF CONCRETE REMOVAL OPERATIONS ON ADJACENT CONCRETE THAT IS TO STAY**

Reports: None.

Papers and Presentations:

"The Effect of Powerful Demolition Equipment on the Remaining Part of the Concrete Bridge," Masih, R. A paper submitted for presentation at the International Conference on Computational Methods for Smart Structures and Materials to be held in Madrid, Spain, June 2000.

"Effect of Demolition on Remaining Part of Concrete Bridge," Masih, R. A paper submitted for presentation at the IKM 2000 International Conference to be held in Germany, June 2000.