ANNUAL REPORT
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NEW ENGLAND TRANSPORTATION CONSORTIUM

NETCR9 January, 1998

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 US Department of Transportation's Federal Highway Administration.

NEW ENGLAND TRANSPORTATION CONSORTIUM

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Gerald M. McCarthy
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A. INTRODUCTION

The New England Transportation Consortium is a cooperative effort of the transportation agencies of the six New England States. Through the Consortium, the states pool their 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 functions through a committee structure consisting of a Policy Committee, an Advisory Committee and Project Technical Committees, a Lead State, and Coordinator.

B. 1997 ACCOMPLISHMENTS

REQUESTS ISSUED FOR RESEARCH PROPOSALS TO ADDRESS FOUR HIGH PRIORITY PROBLEM AREAS:

The following high priority problems facing the region's highway system are the focus of research projects for which requests for proposals were issued in 1997:

-Pavement Deicing:
A significant portion of winter maintenance budgets are used for the purchase of chemical deicers. There is a need to measure the effective amount of deicer concentration on the pavement before, during and after winter storms in order to be better able to control costs and minimize adverse environmental impacts.

-Durability Enhancing Admixtures for Concrete:
Harsh environmental conditions in the Northeast U.S. require the use of chemical and mineral admixtures in structural concrete as a means of enhancing durability. In order for engineers to make more rational product comparisons and decisions regarding use of these admixtures, research is needed to develop guidelines based on performance tests currently being established by the National Cooperative Highway Research Program.

-Erosion and Sedimentation Control During Road Construction:
Erosion prevention and sediment containment are significant highway construction issues. An entire industry of erosion and sediment control products has developed, providing a variety of options for addressing the problem. Wood waste compost has performed at least as well as, and in some cases superior to, traditional erosion and sediment control techniques and materials. Specifications for its use were developed by The Coalition of Northeastern Governors (CONEG) Source Reduction Task Force in February

1996. The preliminary success of wood waste compost suggests that its use should be more widespread. However, prior to more widespread use, the product should be properly analyzed to compare its performance with traditional erosion and sedimentation control products and to demonstrate that wood waste is an effective method for reducing erosion and controlling sediment on highway construction projects.

-Durability of Open-Graded Pavement Surface:
Several segments of New England's highways, recently rehabilitated with Open-Graded Friction Course, have developed early distress, primarily delaminations and ravelling. A study is needed to identify the cause of these unexpected failures and to propose methods to prevent such failures in the future.

In September, 1997, NETC issued requests for proposals totaling $392,474 for the following research projects to address the above problems:

-"A Portable Method to Determine Chloride Concentration on Roadway Pavements"

-"Performance Evaluation and Economic Analysis of Combinations of Durability Enhancing Admixtures in Concrete for Bridge Applications in the Northeast"

-"Determining Properties, Standards and Coefficients for Wood Waste Compost used as an Erosion Control Mulch and a Filter Berm "

-"Early Distress of Open-Graded Friction Course"

NETC PARTICIPATES IN THE 1997 AASHTO TECHNOLOGY TRANSFER FAIR AT SALT LAKE CITY, UTAH:

An exhibit of NETC's current and recently completed research projects, including videos of the crash tests of the NETC-developed bridge rail and the thermoplastic pavement marking implementation project, was displayed at the 1997 AASHTO Technology Transfer Fair at Salt Lake City, Utah. Requests were received from Fair attendants for information on the policies and procedures governing the organization and functioning of NETC, and for information developed through the following NETC research projects: Bridge Rail Crash Test, Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques, Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings, Guidelines for Ride Quality Acceptance of Pavements, and Procedures for the Evaluation of Sheet Membrane Waterproofing for Bridge Decks.

FULL-SCALE CRASH TESTING COMPLETED ON NETC-DEVELOPED 4-BAR, SIDEWALK-MOUNTED BRIDGE RAIL

Crash testing of the NETC-developed 4-Bar, Sidewalk-Mounted Bridge Rail was completed successfully during November-December 1997. Three (3) tests were conducted at Southwest Research Institute, San Antonio, Texas, in accordance with Test Level 4 of National Cooperative Highway Research Program (NCHRP) Report 350. Although the official test report has not yet been issued, preliminary results from all three (3) specified tests were excellent, indicating that all NCHRP requirements were satisfied. After NETC acceptance of the final test report, all test data will be submitted to the Federal Highway Administration for use at appropriate locations on the National Highway System (NHS).

This is the second phase of a two phase project which, in the first phase, developed and successfully crash tested a 2- bar sidewalk mounted bridge rail and submitted the results to the Federal Highway Administration for approval for use on federal-aid highway projects.

MAJOR TECHNOLOGY TRANSFER INITIATIVE PLANNED FOR 1998:

The Consortium has identified a variety of technology transfer activities which will be considered for implementation in 1998 to insure that information developed through the Consortium's research projects is made available to transportation professionals throughout New England and the US. Plans are being developed for workshops, conference presentations, and exhibits.

NETC Sponsored Research Results in Reports, Papers and Presentations During 1997:

The following reports and presentations, arising from NETC sponsored research, were produced during 1997:

<u>Tire Chips As Lightweight Backfill for Retaining Walls, Phase II: Full Scale Testing</u>:
-"Full Scale Field Trials of Tire Chips as Lightweight Retaining Wall Backfill-At Rest Conditions," Humphrey, D. Submitted for presentation at the 1998 Annual Meeting of The Transportation Research Board.
-"Tire Shreds as Lightweight Retaining Wall Backfill-Active Conditions," Humphrey, D. Submitted for publication in the ASCE Journal of Geotechnical and Geoenvironmental Engineering.

<u>Bridge Rail Crash Test Phase II: Sidewalk-Mounted Rail</u>
-NETC 2-Bar Curb-Mounted Bridge Rail - Design Plans and Specifications.
-NETC 4-Bar Sidewalk-Mounted Bridge Rail - Design Plans and Specifications.

<u>94-1 Structural Analysis of New England Subbase Materials and Structures:</u>
-"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 to 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. A paper accepted for presentation at the 1998 Annual Transportation Research Board Meeting.

<u>94-2 Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques:</u>
-"Bridge Deck Evaluation with Ground Penetrating Radar," Huston, D., Maser, K., Weedon, W., Fuhr, P.L. and Adam, C. in <u>Structural Health Monitoring</u>, Chang, F., Editor, Technomic Publishing, pp. 91-103. 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.

95-1 Use of Tire Chips/Soil Mixtures to Limit Frost Heave and Pavement Damage of Paved Roads

-"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.

95-2 Suitability of Non-Hydric Soils for the Mitigation of Wetlands:

-"Suitability of Non-Hydric Soils for the Mitigation of Wetlands," Brannaka, L.K. and Evans, C.V., February 28, 1997, NETCR5, Final Report.

95-3 Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes:

-"Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes," Lee, K.W. Presented to the Rhode Island Transportation and Civil Engineering Forum, University of Rhode Island, October 23, 1996.

-"Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes," Lee, K.W. Presented to the Rhode Island Transportation and Civil Engineering Forum, University of Rhode Island, October 15, 1997.

95-5 Buried Joints in Short Span Bridges

-"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.

95-6 Guidelines for Ride Quality Acceptance of Pavements:

-"Guidelines for Ride Quality Acceptance of Pavements," Collura, J., El-Korchi, T., Black, K., Chase, M. and Li, J., April 1997, NETCR6, Final Report.

C. PROGRESS OF ACTIVE PROJECTS

PROJECT NUMBER: None

PROJECT TITLE:
Tire Chips as Lightweight Backfill for Retaining Walls, Phase II: Full Scale Testing

PRINCIPAL INVESTIGATOR(S) :
Dana N. Humphrey and Thomas C. Sandford, University of Maine, Orono

STATUS: Continuing

INITIAL AGREEMENT DATE: 4/15/93

END DATE: N/A

PROJECT OBJECTIVES:
Building on Phase I, which determined the engineering properties of tire chips and found that tire chip backfill has the potential to produce low horizontal stresses on retaining walls, the objectives of Phase II are:

1. To conduct full-scale tests using tire chips as backfill for a 15-ft. high instrumented retaining wall supplemented with numerical analysis of the tests.
2. To prepare design guidelines for use of tire chips as retaining wall backfill.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
Testing Facility. Construction of the full-scale testing facility, the second largest of its kind in the world, was completed on June 30, 1994. The work was accomplished by the project's principal investigator, Dana Humphrey, graduate student, Jeff Tweedie, and several undergraduate students. Much of the structural steel was donated by the Cianbro Corporation, Pittsfield, Maine, and Owen J. Folsom Construction, Old Town, Maine.

Testing Program. Tests were conducted on gravel and tire chips from three producers. For each trial the backfill was compacted in 8-in. lifts with a vibrating plate compactor for the gravel and with a vibrating walk-behind roller for tire chips After the backfill was placed, surcharge blocks were applied. During backfill and surcharge placement, measurements were taken of the pressure exerted by the backfill on the wall. Settlement of the backfill caused by placement of the surcharge was also measured. The trial with gravel was conducted in July and August, 1994. Trials with two types of tire chips were conducted in the Fall of 1994. The trial with the third type of tire chips was conducted in the Summer and Fall of 1995. Testing was completed on October 13, 1995.

Analysis of Results. The pressure at the base of the wall with the full 750 psf surcharge, was less than half of the value expected for gravel backfill. This validates the basic premise of the research project; namely, that tire chips exert a much lower horizontal pressure than typical retaining wall backfills. Settlements measured for the trials with tire chips compared favorably to values expected based on laboratory compressibility tests conducted as part of an earlier NETC project. For a period of 2 months after placement of the surcharge, the tire chips underwent a small amount of time dependent settlement (2 to 3% of the full thickness). Additional settlement after two months was negligible.

Final Report: The draft final report was submitted to the project Technical Committee for review.

REPORTS, PAPERS, AND PRESENTATIONS :

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

2. "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.

3. "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.

4. "Use of Tire Chips in Highway Construction," Humphrey, D. N. A presentation to the New England Environmental Expo, Boston, Massachusetts, May 9, 1995.

5. "Use of Tire Chips in Highway Construction," Humphrey, D. N. A presentation to the AASHTO Region 1 RAC Meeting, Portland, Maine, May 23, 1995.

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

7. "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.

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

9. "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.

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

11. "Full Scale Field Trials of Tire Chips as Lightweight Retaining Wall Backfill-At Rest Conditions," Humphrey, D. Submitted for presentation at the 1998 Annual Meeting of the Transportation Research Board.

PROJECT NUMBER: None

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

PRINCIPAL INVESTIGATOR(S):
Eric C. Lohrey, Connecticut Department of Transportation

STATUS: Continuing

INITIAL AGREEMENT DATE: October 1, 1996

END DATE: August 26, 1998

PROJECT OBJECTIVE: 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, 1997:
Initiated in 1988, Phase I of this project developed the NETC 2-Bar Curb-Mounted Bridge Rail, and successfully crash tested it in accordance with AASHTO Performance Level 2 (PL-2) and NCRP Report 350 Test Level 4 (TL-4). The Phase I testing was completed in December 1994; the Draft Final Report was issued in June 1996; and, distribution of the approved Final Report for Phase I is anticipated to be completed in early 1998.

Based on a recommendation from the Bridge Rail Crash Test Technical Committee, funds were allocated in February 1995 to develop and crash test a sidewalk-mounted version of the Phase I Bridge Rail. With the Technical Committee's approval of a 4-bar, sidewalk-mounted, prototype bridge rail design in September 1995, the NETC Lead Agency was directed by the Advisory Committee to proceed with the development of an agreement with FHWA for crash testing of the 4-bar, sidewalk-mounted prototype design. A scope of work for this Phase II crash testing was developed by FHWA in December 1995, and subsequently approved by the NETC Technical Committee assigned to monitor the project. A Letter of Agreement providing funds, and authorizing FHWA to enter into an agreement with Southwest Research Institute, San Antonio, Texas to conduct the crash tests was executed in October 1996. The Phase II bridge rail test section was constructed, and the three (3) specified crash tests were conducted during November and December 1997. Preliminary results from these crash tests indicate that the NETC 4-Bar Sidewalk-Mounted Bridge Rail has passed the requirements of NCHRP Report 350 for a Test Level 4 Longitudinal Barrier. The Final Reports for Phase I and Phase II of the project are anticipated to be distributed in 1998.

REPORTS/PAPERS DEVELOPED, PRESENTATION MADE:

1. NETC 2-Bar Curb Curb-Mounted Bridge Rail - Design Plans and Specifications.
2. NETC 4-Bar Sidewalk-Mounted Bridge Rail - Design Plans and Specifications.

PROJECT NUMBER: 94-1

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

PRINCIPAL INVESTIGATOR(S):
Professor K. Wayne Lee and Milton T. Huston, University of Rhode Island

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/95

END DATE: 6/30/98

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. To collect data from existing analyses of natural aggregates and recycled material/aggregates blends.
3. Develop recycled material blends.
4. Recommend appropriate testing for state agencies to develop optimum properties for specific sources and various combinations of blended materials projects.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
An extensive literature review was conducted. Published sources were reviewed for the most current research. State specifications for subbase materials of all participating states were collected along with typical pavement structures. A database of properties by aggregate types common to New England was compiled. Data were collected from existing analyses of natural aggregates and recycled material aggregate blends. The collection of aggregates and recycled materials has been completed. The experimental design has been finalized.

Data analysis for Rhode Island materials has been completed. A framework has been formulated to illustrate the application of the data in accordance with T292-91 for estimation of layer coefficients. Permeability testing has been completed on subbase materials. Optimum performance characteristics for aggregate type and recycled material blends have been developed. The effectiveness of the developed parameter values through design examples for the typical pavement structures in New England, using the 1993 AASHTO Guide and/or DARWIN 2.01, has been demonstrated.

An interim report documenting all findings including test results in accordance with T292-91, was submitted to the project Technical Committee for review.

The experimental design has been formulated and the resilient modulus testing, according to the T146 procedure has begun.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "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.

2 "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.

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

4. "Structural Analysis of New England Subbase Materials and Structures," Davis, J., Huston, M., and Lee, K.W. A paper accepted for presentation at the 1998 Annual Transportation Research Board Meeting.

PROJECT NUMBER: 94-2

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

PRINCIPAL INVESTIGATOR(S) :
Dryver R. Huston, University of Vermont

STATUS: Continuing

INITIAL AGREEMENT DATE: 10/16/95

END DATE: 10/15/98

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.

Specifically the objectives of the project are:
1. To develop a numerical model of the interaction of defects in concrete bridge decks and GPR.
2. To verify the numerical model through laboratory testing of specimens with known defects.
3. To develop radar waveform image processing techniques which will readily identify defects.
4. To field test the techniques on selected New England bridge structures.
5. To document the developed technology for use by state transportation agencies.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
A comprehensive literature review was undertaken. This review examined two areas. One was the general area of ground penetrating radar, the physics involved, and numerical modeling techniques. The second focused more specifically on the problem of applying ground penetrating radar to the examination of pavement and highway structures. This literature review encompassed obtaining and reading over 100 technical reports and journal articles. In addition to reading articles and reports that are readily available to the public, specific contacts were made with investigators at the Virginia Polytechnic Institute and State University, the University of West Virginia Constructed Facilities Research Center, the Kansas Department of Transportation, and Sandia National Laboratories; each of which has an active GPR or electromagnetic research effort that is relevant to this project.

Reports were obtained from these groups, as well as conversations held with the key investigators.

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. The numerical modeling effort involved adapting programs to the specific details of reinforced concrete pavements with overlays. A one-dimensional and a separate two-dimensional analysis were used. Defects in the form of water-filled and air-filled delaminations, as well as other features, such as reinforcing bars were simulated. The software programs would simulate the return waveforms from the concrete deck and from these various defects. Some of the features, such as pavement layer boundaries and rebars were quite easy to identify from the simulated traces. Water-filled and air-filled delaminations were also identifiable from the traces. However, the air-filled delamination required some signal enhancement to make it more visible. The software also estimated the amount of transmitted and reflected electromagnetic energy. The reflected power simulations indicated that the amount of reflected energy could be highly dependent on the radar position and the concrete features. This task is 95% complete.

Phase 2 - Design and Conduct of Laboratory Evaluations: The laboratory studies consist of evaluating the interaction of GPR pulses with concrete slabs. Evaluating the interactions of GPR pulses with the radar hardware is also very important to building an effective system. To this end several different radar horn antennas were designed, fabricated and tested. It turns out that an elongated horn with a perpendicular feed-through and no balun seems to work the best for 0.5 to 6 GHz frequency range of the test. However, there appears to be considerable room for improvement. The laboratory tests which indicated that it was possible to identify the presence of simulated defects, such as a 1/8 in thick slice of Styrofoam, have yet to be tested. The transmission testing technique was also used to measure the change in the dielectric properties of concrete with curing. The results seemed reasonable, but were somewhat dependent on the specific antenna that was used. This task is 60% complete.

Phase 3 - Development of Radar Data Processing Software: One of the key features of a useful radar system is to present the data from the acquired electromagnetic waveforms in a manner that is readily used by an operator. The industry-standard technique of using color to represent an array of waveforms that were acquired at a set of different locations was implemented. Simulations with somewhat idealized simulated data indicated that the color technique could be used to identify most features. Air-filled delaminations were difficult to identify. A signal enhancement method that used a subtraction scheme enabled the detection of air-filled delaminations. The color method will probably be adequate for this project. However, more sophisticated deconvolution algorithms are being investigated. This task is 35% complete.

Phase 4 - Correlation of Software with Laboratory and Field Data: A single field test has been conducted on a new bridge in Milton, Vermont. At the bridge the radar system was able to identify features such as rebars and the deck bottom. The task is 15% complete.

Phase 5 - Implementation of Research Results: The documentation of Phases 1-3 has been partially completed. This task is 10% complete.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "Bridge Deck Structural Monitoring Techniques," Huston, D. Presented at the New England State Materials Engineers Association Conference, Burlington, Vermont, October 9, 1996.

2. "Bridge Deck Evaluation with Ground Penetrating Radar," Huston, D., Maser, K., Weedon, W., Fuhr, P.L., and Adam, C. in <u>Structural Health Monitoring</u>, Chang, F., Editor, Technomic Publishing, pp. 91-103. Proceedings of the International Workshop on Structural Health Monitoring, Stanford, California, September 1997.

3. "Ground Penetrating Radar for Non-Destructive 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.

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

PROJECT NUMBER: 94-3

PROJECT TITLE: Procedures for the Evaluation of Sheet Membrane Waterproofing

PRINCIPAL INVESTIGATOR (S): Charles J. Korhonen, Cold Regions Research and Engineering Laboratory (CRREL) , Corps of Engineers

STATUS: New

INITIAL AGREEMENT DATE: 12/31/97

END DATE: 12/31/98

PROJECT OBJECTIVE: To develop new or modify existing laboratory prequalification tests for the evaluation of sheet membrane waterproofing systems.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
The agreement with CRREL has been executed.

REPORTS, PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 94-4

PROJECT TITLE: Durability of Concrete Crack Repair Systems

PRINCIPAL INVESTIGATOR (S): George Tsiatas, University of Rhode Island (URI)

STATUS: New

INITIAL AGREEMENT DATE: 9/1/97

END DATE: 2/28/99

PROJECT OBJECTIVE: To determine the fatigue life, durability, and effectiveness of the intrusion prevention characteristics of various structural concrete crack repair systems when subjected to dynamic flexural and compressive stresses and freezing and thawing.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
The agreement with URI has been executed.

REPORTS, PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 95-1

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

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

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: 12/31/97

PROJECT OBJECTIVE:
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.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
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 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 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.

The laboratory measured thermal conductivity of air-dried gravel was 0.30 to 0.35 Btu/hr/ft/°F. While values in this range are reasonable for air dried gravel, they are much lower than would be expected for moist gravel. These results pointed out the necessity for adding tests on moist samples to the test protocol. This was proposed to the project Technical Committee in a letter from the Principal Investigator dated April 12, 1996. It was proposed that five tests on moist samples be conducted.

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.

The portions of the final report dealing with the laboratory measurements of thermal conductivity were completed.

<u>Laboratory Measurement of Permeability</u>. 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 perimeter constructed for a previous NETC project. The samples were tested at several compressions to simulate the effect of the overburden pressure. The permeability decreased as the void ratio of the sample decreased and as the size of the tire chip decreased. 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.

<u>Field Trial</u>. The full-scale field trial was constructed on the University of Maine campus in the Fall, 1996. The field trial design consisted 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 were covered by 19 in. of subbase aggregate except in one section where the tire chip layer was covered by 13 in. of subbase aggregate. Each section had 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 was 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 mix 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 met 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, 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.

Pavement deflections were measured with a Benkelmann Beam and a Falling Weight Deflectometer in April and August, 1997. Pavement deflections increased as the thickness of soil cover over the tire chip layer decreased. Results from analytical methods compared favorably with measured field deflections. Undesirable tensile strains in the pavement can be controlled with a sufficient thickness of soil cover.

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 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.

PROJECT NUMBER: 95-2

PROJECT TITLE:
Suitability of Non-Hydric Soils for Wetland Mitigation

PRINCIPAL INVESTIGATOR(S):
Larry K. Brannaka and Christine Evans, University of New Hampshire

STATUS: Completed

INITIAL AGREEMENT DATE: 9/1/95

END DATE: Completion of Work

PROJECT OBJECTIVES:
The objectives of this research are three-fold. Specifically they include the following:

1. Identify the characteristics and properties of non-hydric soils which have been successfully used in existing wetland mitigation projects.
2. Describe the site conditions that will influence the success of using non-hydric soils for wetland mitigation.
3. Develop recommendations for the selection of non-hydric soils or non-hydric soil amendments for mitigation purposes based on existing site conditions.

The final objective depends on successfully completing the preceding objectives.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
The literature review indicated that the hydrologic conditions govern the formation of the hydric soils. Of primary concern is whether the soils are periodically saturated, and the annual duration of saturation. Hydric conditions are formed when soils are poorly drained, and have a water table within 1-1.5 ft. from the surface for extended periods of time, typically one week or more. Alternately, soils may also be ponded for long durations during the growing season. Organic matter also influences the formation of redoximorphic features characteristic of wetlands. Redoximorphic features did not form in soils with less than 1.5% organics, while soils with 3% or greater were most effective in producing redox depletion in flood plots.

There was a distinct lack of information to be found in the literature documenting the use of non-hydric soils for wetland mitigation. This type of construction (specifically for mitigation purposes) was typically documented in engineering reports describing wetland mitigation designs and construction, and is not generally published in scientific journals. Such descriptions usually describe the soils used from an engineering view and consequently were of limited use to this study. However, the information contained in reports such as these pertaining to hydrological conditions for the study sites, proved quite valuable.

The second phase of the project entailed selecting at least five sites where wetland mitigation projects had either been completed or were underway utilizing non-hydric soils. Five such sites were located in three New England states. They included the Pine Road Wetland Mitigation Site in Brentwood, NH, the Bangor Hydroelectric Graham Lake Dam remediation wetland mitigation site in Ellsworth, ME; the Maine Department of Transportation wetland mitigation site at the old Maine Turnpike southbound Exit 6 in Scarborough, ME; the cloverleaf exit from I-691 to Route 10 in Cheshire, CT; and the Michelle Memorial Park wetland mitigation in Salem, NH. Each site was visited, and measurements were made of the hydrologic conditions. Three to four small diameter wells (SDW) were installed at each site to measure the groundwater levels, and to test for hydraulic conductivity. The installed wells, and any existing site wells, were tied together by a survey to facilitate creating a groundwater piezometric map. Test pits were dug in at least three locations at each site for the purpose of characterizing the soils according to color, redoximorphic features, and temperature. Soil samples were taken back to the laboratory to measure the organic content, evaluate the nutrients in the soil and measure the particle size distribution.

In addition to the field data, existing information on the site construction and source of the non-hydric soils was sought from either the site owner, or the engineering firms which did the design and supervised the construction of the mitigation sites. The selection included sites that were 1.5, 3, 4 and 10 years old. Site soils ranged from a grey silty fine sand to a brown till, with a significant silt and clay content. The hydrology of the sites varied from a site primarily fed by groundwater to one maintained by a combination of groundwater and surface water. The surface water created ponded conditions over a portion of the site. Three of the sites examined had ponded water over a portion of the site. Each site contained at least some sedge wetlands. Each site was deemed a successful mitigation project. Several sites, the Bangor Hydroelectric Graham Lake wetland mitigation site in particular, had a significant portion of volunteer vegetative wetland specifics in addition to limited plantings of woody shrubs and bushes.

The field data were analyzed for hydrologic and soil characteristics. Hydraulic conductivities ranged from 1×10^{-2}cm/s to 8×10^{-5} cm/s. The soils ranged from a sand which demonstrated distinct hydric conditions to the high chroma reddish brown mineral soils at the Connecticut site which served to mask some of the hydric indicators. Soils evaluated included sands, loamy sands, sandy loams, and silty clays. In every instance where long term hydrologic data were available, it appeared the water table came within one foot of the surface for a minimum of a one month period throughout the year. The study found that saturation alone was not sufficient to develop all of the many hydric soil Field Indicators. Depletion of oxygen was found to be an important condition for the full development of the Field Indicators. In the case of the Connecticut site, the water source was theorized as being too oxygenated to develop the gray colors indicative of redoximorphic features. Surficial soils from the Pine Road site did not qualify as hydric according to the Field Indicators, yet did meet the Hydric Soil Criteria, using an 'alpha', 'alpha prime', dipyridyl test.

The morphological index values were calculated for all sampled soils. The values demonstrated that there was a distinct statistical difference between the hydric and the non-hydric soils among those collected. Texture of the soil did not correlate to the morphological index, indicating that texture was not an important factor for the development of hydric characteristics. Two of the coarser hydric soils did not react with 'alpha', 'alpha prime' dipyridyl, presumably due to removal of the soluble reduced iron by percolating water. Age of the site did not significantly correlate with the morphological index. This indicated that the hydric characteristics formed relatively rapidly in the non-hydric mitigation soils, at least within the first two years. This was substantiated by a laboratory experiment performed to evaluate the effect of organic content of the soils.

Organic content was found to be strongly correlated to the morphological index of the soils. To confirm this finding, a laboratory experiment was performed taking soils from four of the sites, adding varying amounts of organic material, and placing them in saturated conditions to create hydric conditions. Four samples were tested from each of the four sites; one with no organic matter, one with 1.5% organic matter, one with 3% organic matter, and one with 3% plus sugar added as an additional nutrient. The analyses were intended to evaluate the time required for each soil to form hydric conditions based on the Field Indicators. The soils with the 3% organic matter added showed distinct signs of the potential to develop the soil color features associated with reduced iron. In 90 days, each of the soils moved in that direction. The added nutrients accelerated the color characteristic development.

The overriding requirement for the use of non-hydric soils for wetland mitigation is that the hydrological conditions must be appropriate. The hydroperiod and depth of groundwater fluctuations must be such that the surficial soil profile is saturated for at least 7 days of the growing season, and sufficient moisture is maintained throughout the growing season to sustain hydrophytic vegetation. The non-hydric mitigation soil should have at least 3% organic content to facilitate the formation of hydric characteristics. Within these requirements, almost any soil should become a hydric soil.

Guidelines were developed to match appropriate soils to the wetland type and the site hydrology. It was suggested that more permeable soils are better suited to endosaturated wetland areas (groundwater fed) while less permeable fine-grained soils are more suited for episaturated (surface water) fed systems. Nutrient additions may be required for initial planting of wetland vegetation, and should be tailored to the vegetation selected for the site.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "Suitability of Non-Hydric Soils for the Mitigation of Wetlands," Brannaka, L.K. and Evans, C.V., February 28, 1997, NETCR5, Final Report.

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

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: 8/31/98

PROJECT OBJECTIVES:

1. To determine the best means, taking into account retroflectivity, durability and cost effectiveness, by which traffic marking recesses can be created to eliminate damage to thermoplastic pavement markings from snow plow blades.
2. To develop traffic marking recess application and equipment specifications for use by highway agencies.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
On Thursday, December 5, 1996, three test sections of recessed (and non-recessed) thermoplastic traffic markings were successfully installed on I-95 Northbound by Cardi Corporation under the direction of the URI research team. The creation of the traffic marking recesses and the application of thermoplastic traffic markings to the recesses were well-documented with photographs and video, taken by the URI research team. Detailed construction specifications for the creation of traffic marking recesses were developed from this documentation.

The first retroreflectivity and durability evaluations of the recessed thermoplastic traffic markings within the three test sections were performed by the URI research team on December 30, 1996 and January 7, 1997. The Retro-Lux 1500 retroreflectometer was used to measure the retroreflectivity of the traffic markings. Two readings were taken at the first third and second third of each skip stripe and then averaged to represent the retroreflectivity of the entire stripe. Durability was determined by utilizing the percentage retained method.

The second pair of retroreflectivity and durability evaluations of the recessed thermoplastic traffic markings within the three test sections were performed by the URI research team on April 7, 1997 and April 9, 1997. Photographs were taken of any skip stripes with noticeable snowplow blade damage.

The third evaluation was performed on the evening of July 30, 1997 according to the European Committee for Standardization (CEN) specifications for the measurement of retroreflectivity during simulated wet night conditions. In order to simulate wet night conditions, the URI research team poured a measured amount of water on each traffic marking section being evaluated one minute before the retroreflectivity measurements were taken with the Retro-Lux 1500 retroflectometer.

A statistical analysis (t-test) of the data collected from the three durability and retroreflectivity evaluations of the three test sections was performed. The cost and cost effectiveness of recessing thermoplastic traffic markings was also determined. The cost effectiveness was determined through a 20 year life cycle cost analysis comparing recessed to non-recessed thermoplastic markings.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "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.

2. "Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes," Lee, K.W. Presented at the Rhode Island Transportation and Civil Engineering Forum, University of Rhode Island, October 15, 1997.

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 OBJECTIVE:
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, 1997:
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.

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: 95-6

PROJECT TITLE:
Guidelines for Ride Quality Acceptance of Pavements

PRINCIPAL INVESTIGATOR(S):
John Collura, University of Massachusetts and Tahar El Korchi, Worcester Polytechnic Institute

STATUS: Completed

INITIAL AGREEMENT DATE: Completion of Work

END DATE: 2/30/97 ? 2/28/97

PROJECT OBJECTIVE(S):
To formulate appropriate specifications and implementation procedures for ride quality on new pavements.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
The final report was prepared and distributed.

REPORTS, PAPERS AND PRESENTATIONS:

1. "Guidelines for Ride Quality Acceptance of Pavements," Collura, J., El-Korchi, T., Black, K., Chase, M. and Li, J., April 1997, NETCR6, Final Report.

PROJECT NUMBER: 96-1

PROJECT TITLE:
SUPERPAVE™ Implementation

PRINCIPAL INVESTIGATOR(S):
Jack Stephens, University of Connecticut

STATUS: New

INITIAL AGREEMENT DATE: 9/1/97

END DATE: 8/31/99

PROJECT OBJECTIVE(S):
Provide a forum for the communication of ideas, problems, and solutions for the implementation of SHRP SUPERPAVE™ concepts. Establish a means for the state highway agencies to develop confidence with the equipment and procedures of the SHRP binder equipment obtained under the FHWA pooled fund purchase.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
The agreement has been executed.

REPORTS, PAPERS AND PRESENTATIONS: None

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: New

INITIAL AGREEMENT DATE: 7/1/97

END DATE: 6/30/99

PROJECT OBJECTIVES:
1. Investigate the factors which drive the use of GPS within transportation departments in New England.
2. Analyze the conditions which determine base station spacing and develop objective guidelines to be used when selecting multiple base station sites.
3. Examine the parameters which affect data collection, processing, dissemination and storage both in the field and at base stations.
4. Explore new and innovative uses of GPS in the transportation arena including terrestrial and airborne mapping applications.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
The agreement has been executed.

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 University and K. Wayne Lee, University of Rhode Island

STATUS: New

INITIAL AGREEMENT DATE: 8/31/97

END DATE: 7/31/99

PROJECT OBJECTIVE(S):
To identify a cost-effective composite system for structural and protective coverings for bridge elements that will provide long-term performance under freeze-thaw, wet-dry, and deicing salt environments.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1997:
The agreement has been executed.

REPORTS, PAPERS AND PRESENTATIONS: None

D. FINANCIAL STATUS
Active Projects

Table 1: Financial Status Of Projects Active During 1997 (As Of 12/31/97)

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
Construction Costs of New England Bridges, PHASE II *P.I.: John Alexander, University of Maine, Orono*	39,500.00	39,500.00	0.00 Project Closed 12/02/97
Tire Chips As Lightweight Backfill:PHASE II: Full-Scale Testing *P.I.: Dana Humphrey, University of Maine, Orono*	111,000.00	111,000.00	0.00
Bridge Rail Crash Test, PHASE II: Sidewalk Mounted Rail *P.I.: Eric C. Lohrey, Connecticut DOT*	134,127.00	134,127.00	0.00
New England Vehicle Classification And Truck Weight Program, Phase I *P.I.: John Collura, University of Massachusetts*	75,000.00	66,435.81	8564.19 Project Closed 12/02/97
94-1: Structural Analysis of New England Subbase Materials And Structures *P.I.: K. Wayne Lee, University of Rhode Island*	111,497.00	78,768.00	32,729.00
94-2: Nondestructive Testing Of Reinforced Concrete Bridges Using Radar Imaging *P.I.: Dryver Huston, University of Vermont*	224,902.00	119,863.12	105,038.88

Table 1: Financial Status Of Projects Active During 1997 (As Of 12/31/97) (cont'd)

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
94-3: Procedures for the Evaluation of Sheet Membrane Waterproofing *P.I.: Charles J. Korhonen, Cold Regions Research and Engineering Laboratory, Corps of Engineers*	67,002.00	0.00	67,002.00
94-4: Durability of Concrete Crack Repair Systems *P.I.: George Tsiatas University of Rhode Island*	84,850.00	0.00	84,850.00
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	70,195.10	4,804.90
95-2: Suitability Of Non-Hydric Soils For Wetland Mitigation *P.I.s: Larry Brannaka & Christine Evans University of New Hampshire*	39,914.00	39,867.70	46.30 Project closed 12/02/97
95-3: Implementation and Evaluation of Traffic Marking Recesses For Application Of Thermoplastic Pavement Markings On Modified Open Graded Mixes *P.I.s: K. Wayne Lee University of Rhode Island*	107,313.00	87,196.62	20,116.38
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

Table 1: Financial Status Of Projects Active During 1997
(As Of 12/31/97) (cont'd)

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
95-6: Guidelines for Ride Quality Acceptance of Pavements *P.I.s: John Collura, University of Massachusetts, Amherst; Tahar El Korchi, and N. Wittels, Worcester Polytechnic Institute, Worcester*	106,124.00	70,205.89	35,918.11
96-1: SUPERPAVE™ Implementation *P.I.: Jack Stephens, University of Connecticut*	74,978.00	0.00	74,978.00
96-2: Optimizing GPS Use in Transportation Projects *P.I.: C. Roger Ferguson, University of Connecticut*	120,000.00	0.00	120,000.00
96-3: Effectiveness of Fiber Reinforced Composites As Structural and Protective Coverings for Bridge Elements Exposed to Deicing-Salt Chlorides *P.I.s: Perumalsamy N. Balaguru, Rutgers University; K. Wayne Lee, University of Rhode Island*	135,000.00	0.00	135,000.00

Table 2: NETC Fund Balance

(As Of 12/31/97)

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
Coordination/Administration of NETC: Calendar Year 1995		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		107313	630708.78
95-5: Buried Joints in Short Span Bridges		64910	565798.78
95-6: Guidelines for Ride Quality Acceptance of Pavements		106124	459674.78
"94" Project Series:			
94-1: Structural Analysis of New England Subbase Materials and Structures		111497	348177.78
94-2: Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques		224902	123275.78
Member Allocations 1996 = 6 X $75,000	450000		573275.78
Coordination/Administration of NETC: Calendar Year 1996		69123.85	504151.93
Member Allocations 1997 = 6 X $75,000	450000		954151.93
Coordination/Administration of NETC: Calendar Year 1997		82494	871657.93
"94" Project Series:			
94-3: Procedures for The Evaluation of Sheet Membrane Waterproofing		67002	804655.93
94-4: Durability of Concrete Crack repair Systems (Proposal)		84850	719805.93
"96" Project Series:			
96-1: SUPERPAVE Implementation		74978	644827.93
96-2: Optimizing GPS Use in Transportation Projects		120000	524827.93
96-3: Effectiveness of Fiber Reinforced Composites as Protective Coverings for Bridge Elements, etc.		135000	389827.93
"97" Project Series = $392474 (See Note 1.)			
Technology Transfer (per Dec. 2, 1997 Adv. Committee Mtg.)		10000	379827.93
Member Allocations 1998 (See Note 2.)			
Coordination/Administration of NETC: Calendar Year 1998		73021	306806.93
FUND BALANCE As of 12/31/97			306806.93

Notes:

1. RFPs have been issued for the "97" Project Series. Funds will be encumbered at the March 1998 meeting of the NETC Advisory Committee. Anticipated cost of the "97" Project Series = $392474
2. Member allocations are obligated between October 1 and December 31of the previous year. However, member allocations for 1988 are dependant upon pending federal legislation for transportation funding.

E. NETC REPORTS, PAPERS AND PRESENTATIONS

PROJECT NUMBER	TITLE
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
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: None

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:

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

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

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

"Use of Tire Chips as Subgrade Insulation and as Lightweight Fill for Highway Construction," Humphrey, D. N. Presented at the 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.

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 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," Humphrey, D. Submitted for presentation at the 1998 Annual Meeting of the Transportation Research Board.

None	**New England Vehicle Classification and Truck Weight Program, Phase I**

Reports:

"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.

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

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

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

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

None	**Bridge Rail Crash Test, Phase II: Sidewalk-Mounted Rail**

Reports:

"NETC 2-Bar Curb-Mounted Bridge Rail Design - Plans and Specifications."
"NETC 4-Bar Sidewalk-Mounted Bridge Rail Design - Plans and Specifications."

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 (cont'd)**

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. A paper accepted for presentation at the 1998 Annual Transportation Research Board Meeting.

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.

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

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., 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.

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.

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 Thermoplastic 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