ANNUAL REPORT
For Calendar Year 1996

NEW ENGLAND TRANSPORTATION CONSORTIUM

NETCR 4 January, 1997

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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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, a Coordinator.

B. 1996 ACCOMPLISHMENTS

NETC Goes Worldwide:

In November 1996, the New England Transportation Consortium established a web site on the worldwide web. The site provides information, accessible from anywhere in the world, on NETC's: membership, mission, goals, organizational structure, source of funding, active projects, and reports.

The New England Transportation Consortium's web site address is:
http://www.eng2.uconn.edu/ti/netc/homepage.htm

Requests for Research Proposals To Address Five High Priority Problem Areas Issued:

In September 1996, NETC issued requests for proposals totaling $490,000 for the following research projects:

- -Procedures for the Evaluation of Sheet Membrane Waterproofing: Estimated Cost = $75,000, Time to Complete = One Year
- -Durability of Concrete Crack Repair Systems: Estimated Cost = $85,000, Time to Complete = Eighteen Months
- -SUPERPAVE Implementation: Estimated Cost = $75,000, Time to Complete = Two Years
- -Optimizing GPS Use in Transportation Projects: Estimated Cost = $120,000, Time to Complete = Two Years
- -Effectiveness of Fiber Reinforced Composites as Structural and Protective Coverings for Bridge Elements Exposed to Deicing-Salt Chlorides: Estimated Cost = $135,000, Time to Complete = Two Years

The above research projects will provide the Consortium with answers to the following high priority problems relating to the planning, construction and maintenance of the region's state highway systems:

- -How to improve existing methods for evaluating bridge deck waterproofing systems
- -Which concrete crack repair materials have the greatest durability and effectiveness
- -How to improve the implementation of SUPERPAVE through a sharing of information among state transportation agencies
- -How to optimize the use of Global Positioning Systems in transportation projects
- -The feasibility of using fiber reinforced composites as structural and protective coatings for bridge elements

Sidewalk-Mounted Bridge Rail, Developed by NETC, to Undergo Crash Testing:

NETC has executed an agreement with the Federal Highway Administration to arrange for the conduct of crash tests on a 4-bar sidewalk-mounted bridge rail design developed by NETC for use by New England's Departments of Transportation. The tests will determine whether or not the design meets the Performance Level Two (PL-2) requirements of the 1989 AASHTO Guide Specifications for Bridge Railings. The project is expected to be completed by the end of 1997.

NETC Funded Tire Chip Research Generates Interest from Agencies Throughout the United States and Canada:

Dr. Dana Humphrey and his associates at the University of Maine at Orono have experienced an ever widening interest in their NETC-funded research on the use of tire chips in transportation projects. Transportation and environmental agencies throughout North America have expressed interest in the NETC funded research project. Dr. Humphrey has presented findings from his NETC funded research to educational, environmental and transportation agencies in: Arkansas, Maine, Nebraska, and Texas in the U.S., and Alberta and Manitoba in Canada.

Furthermore, in early 1996, when Washington state ran into a problem of flames and smoke rising through cracks in the pavements of two road projects built on fill composed of scrap tires, the Federal Highway Administration, knowing of Dr. Humphrey's NETC-funded work on tire chips, sent him to Washington state to help solve the problem.

NETC-Sponsored Research Results in Reports, Papers and Presentations:

The following reports, papers and presentations, arising from Consortium-sponsored research, were produced during 1996:

Construction Costs of New England Bridges:

-"Construction Costs of New England Bridges, Final Report", Alexander, J.A. , Dagher, H. and James, S., November 1996, NETCR1.

Tire Chips As Lightweight Backfill For Retaining Wall, Phase II Full Scale Testing:

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

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

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

-"Civil Engineering Uses for Scrap Tires", Humphrey, D. Presented at 'Scrap Tire '96' in Chicago, IL, August 16, 1996.

New England Vehicle Classification and Truck Weight Program, Phase I:

-"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.

-"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.

94-1 "Structural Analysis of New England Subbase Materials and Structures",

-"Structural Analysis of New England Subbase Materials and Structures", Davis, J. Presented at the 9th Rhode Island Transportation and Civil Engineering Forum, Kingston, RI, October 23, 1996.

94-2 "Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques":

-"Bridge Deck Structural Monitoring Techniques", Huston, D. A presentation at the New England State Materials Engineers Association Conference, Burlington, VT, October 9, 1996.

-"Ground Penetrating Radar for Bridge Deck Monitoring", Huston D. A paper submitted for presentation at the International Conference on Structural Health Monitoring, Stanford, CA, September 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. 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.

95-3 "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 at the 9th Rhode Island Transportation and Civil Engineering Forum, Kingston, RI, October 23, 1996.

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. Submitted for presentation at the 1997 Annual Meeting of the Transportation Research Board, Washington, D.C.

C. PROGRESS OF ACTIVE PROJECTS

PROJECT NUMBER: None

PROJECT TITLE:
Construction Costs of New England Bridges

PRINCIPAL INVESTIGATOR(S) :
John A. Alexander and Habib Dagher, Department of Civil Engineering, University of Maine, Orono, Maine.

STATUS: Completed

INITIAL AGREEMENT DATE:

END DATE:

PROJECT OBJECTIVE(S):
According to FHWA data, the average bridge replacement costs in New England are substantially higher than those in other regions of the nation.

The specific objectives of this study are:

A. To determine if the method of data collection and reporting accurately reflects the relative unit costs of bridge construction.
B. To determine what underlying reasons exist for these cost differences and if these reasons are justified.
C. To draw conclusions and provide recommendations as appropriate for cost saving measures.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1996:
The project was completed.

REPORTS, PAPERS, AND PRESENTATIONS:

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

2. "Construction Costs of New England Bridges Final Report", Alexander, J., Dagher, H., and James, S., November 1996, NETCR 1.

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 OBJECTIVE(S):
Building on Phase I, which determined the engineering properties of tire chips and found that tire chip back fill 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, 1996:
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 the 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, 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.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "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.

2. "Use of Tire Chips as Subgrade Insulation & 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.

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

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

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

6. "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.

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

8 "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.

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

PROJECT NUMBER: None

PROJECT TITLE:
New England Vehicle Classification and Truck Weight Program, Phase I

PRINCIPAL INVESTIGATOR(S) :
John Collura, University of Massachusett, Amherst

STATUS: Completed

INITIAL AGREEMENT DATE:

END DATE:

PROJECT OBJECTIVE(S):
The objective of this study is to determine the suitability of combining traffic volume, vehicle classification and truck weight data collection efforts in the six-state region of New England.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1996:
Phase One, including the identification and review of traffic monitoring data procedures and an analysis of volume classification and weight data for each of the six New England state highway agencies, has been completed. The final report was prepared and distributed.

REPORTS/PAPERS DEVELOPED, PRESENTATIONS MADE FROM THIS PROJECT:

1. "An Analysis of Vehicle Class and Truck Weight Patterns in New England", Collura, J. and Orloski, F. A presentation at the 1994 National Traffic Data Acquisition Conference, Rocky Hill, CT, September 18-22, 1994.

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

3. "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, NETCR 2.

4. "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.

5. "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.

6. "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.

PROJECT NUMBER: None

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

PROJECT OBJECTIVES: To produce a crash tested rail design acceptable to FHWA for use in all New England states.

PRINCIPAL INVESTIGATOR(S):
James E. Tukey, Maine Department of Transportation

STATUS: Continuing

INITIAL AGREEMENT DATE: To Be Determined

END DATE: To Be Determined

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1996:
Initiated in 1988, this project, in Phase I, developed the design for a 2-bar curb-mounted bridge rail and successfully crash tested it at AAHSTO Performance Level 2 (PL-2) in December, 1994. The draft final report for Phase I, documenting the results of the test, has been submitted to the project's technical committee for review. In February 1995, based on a recommendation from the Bridge Rail Crash Test Technical Committee, funds were allocated to develop and test a sidewalk-mounted bridge rail. With the Technical Committee's approval of a 4-bar sidewalk mounted bridge rail prototype 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 the crash testing of the 4-bar sidewalk mounted prototype design. A scope of work for the crash test RFP was developed by FHWA in December, 1995 and subsequently approved by the project Technical Committee. A Letter of Agreement providing funds and authorizing FHWA to enter into an agreement with Southwest Research Institute to conduct the crash testing of the NETC 2-Bar Sidewalk Mounted Bridge Rail Design has been executed. It is anticipated that the tests will be completed within twelve months of the effective date of FHWA's contract with Southwest Research Institute.

REPORTS/PAPERS DEVELOPED, PRESENTATION MADE:
-4-Bar Sidewalk-Mounted Prototype Bridge Rail Design

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 OBJECTIVE(S):
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, 1996:
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 has been 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. Fundamental material test results have been completed and sent to technical committee members for review. Permeability testing is underway.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "Structural Analysis of New England Subbase Materials and Structures", Davis, J. Presented at the 9th Rhode Island Transportation and Civil Engineering Forum, Kingston, R.I., October 23, 1996.

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 OBJECTIVE(S):
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, 1995:
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 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 has consisted primarily of adapting existing GPR analysis programs to the specific details of reinforced concrete pavements with overlays. Two separate computer analysis techniques have been obtained and used for the simulations. The first program uses a one dimensional technique that models a highway pavement as a series of discrete material layers with electromagnetic properties that vary with material composition, moisture, and chloride content. The interaction of a radar pulse with the layered media is modeled one-dimensionally as a series of reflected and transmitted pulses. The net reflected pulse is then received and analyzed. This model was originally developed by Halabe at West Virginia University. The one dimensional program has been used to evaluate a variety of deck configurations and conditions, including rebar corrosion and delamination. The second program is two-dimensional. It models the interaction of electromagnetic pulses with layered pavements by setting up a two-dimensional grid of material properties and using a finite difference time stepping scheme. The advantage of the 2D model is that spatial effects, such as rebar spacing and geometry, can be modeled. The 2D model has been used on a variety of configurations that examine the effects of electromagnetic pulse propagation polarization and rebar alignment, chloride distribution, moisture distribution, and the formation of corrosion products.

Phase 2 - Design and Conduct of Laboratory Evaluations: The laboratory studies consist of evaluating the interaction of GPR pulses with concrete slabs. A series of experiments have been designed, and are in progress. The laboratory studies involve building and testing realistic bridge deck models, obtaining the necessary GPR testing hardware, obtaining the appropriate material electromagnetic properties, configuring the system, running the GPR hardware on a variety of deck configurations and conditions, and interpreting the results. Two bridge deck slabs with embedded voids and damages have been fabricated. These slabs conform to the general geometic layout of a typical bridge deck. They do not, however, use a bridge-deck-specific concrete mix. It is anticipated that additional bridge decks with more specific mix proportions will be tested. The GPR testing hardware is in the process of being acquired. It is anticipated that all of the pieces will be in place by the end of the 1996 reporting period. The primary components of the GPR system are:
1. An HP 8753D Network Analyzer for signal generation and analysis;
2. LabView-based controlling computer, 3. High-fidelity cables; 4. Two quad-ridge, polarization sensitive horn antennae, and 5. Power supply for off site testing.

Phase 3 - Development of Radar Data Processing Software: The radar data processing software has two main components: 1. Analyzing the radar signals at a specific location; and 2. Integrating the results from a series of point measurements to give an assessment of the spatial condition of the bridge, and to identify areas of variation that indicate the presence of damage. The GPR system that is to be used in this project uses the technique of pulse synthesis, i.e. an arbitrarily-shaped radar pulse is created by synthesizing a series of carefully specified and controlled sinusoidal electromagnetic waves. A preliminary version of the pulse synthesis software has been created and tested on a network analyzer at Northeastern University. Software for integrating the point information from a single radar pulse test location to that of an assessment of an entire bridge deck has also been partially developed. The key feature with this software is to create a visual presentation of the pulse return signals from a grid of points that can be readily examined by the investigator to determine damaged locations. The current version of this software color encodes the individual radar pulses and then assembles them on the computer screen. The use of simulated return pulses from Phase 2 of this study, as well as return pulses from a previous study have been used.

REPORTS, PAPERS, AND PRESENTATIONS:

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

2. "Ground Penetrating Radar for Bridge Deck Monitoring", Huston, D. A paper submitted for presentation at the International Conference on Structural Health Monitoring, Stanford, CA, September 1997.

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: 8/31/97

PROJECT OBJECTIVE(S):
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, 1996:
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 [1] 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 were 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 these values are reasonable for air dried gravel, they are much lower than would be expected for moist gravel. They 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.

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 is 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. is 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 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.

Temperatures and pavement performances will be monitored throughout the winter of 1996-7.

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, 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: 95-2

PROJECT TITLE:
Suitability of Non-Hydric Soils for the Mitigation of Wetlands

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

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/95

END DATE: 2/28/97

PROJECT OBJECTIVE(S):
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, 1996:
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 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. The information contained in reports such as these for the study sites on the hydrological conditions 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 cloverlead 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 (SDWS) 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 out from either the site owner, or the engineering firms which did the design and supervised the construction of the mitigation sites. The selection of sites 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 specifies in addition to limited plantings of woody shrubs and bushes.

The field data was analyzed for hydrologic and soil characteristics. Hydraulic conductives 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. An estimate was made at the sites with available long-term water level data as to the percent saturation and duration of saturated conditions for successive depths in the soil profile. Tables were prepared relating to the profile depth and percent saturations. Similar tables were generated relating the annual percentage of time that soils were saturated when the temperatures were below biological zero to profile depths in an effort to characterize and compare microbial activity. Comparisons were made between the degree and duration of saturation and the hydric indicators for the soil samples at successive depths. The results were compared between sites of differing hydrologic control, and sites of different soil characteristics.

The hydric indicators found in the sites were compared with respect to the age of the sites, and also the amount of organic material in the wetland soils and the non-hydric soils used in the construction. A laboratory analysis was performed taking soils from several of the sites, adding different amounts of organic material, and placing them under saturated conditions to create hydric conditions. The analyses were intended to evaluate the time required for each soil to form hydric conditions based on the organic content. In several samples, nutrients in the form of sugar were added to evaluate the nutrient requirement for the formation of hydric soils.

From preliminary results, it appears that a wide variety of non-hydric soils may be appropriate for use in wetland mitigation projects, provided they contain at least 3% organic material. It may be 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. Final conclusions and a set of guidelines will be provided in the final report.

REPORTS, PAPERS, AND PRESENTATIONS:

None.

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 OBJECTIVE(S):

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 from snow plow blades.
2. To develop traffic marking recess application and equipment specifications for use by highway agencies.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1996:
Some of the most important accomplishments for this project include: obtaining RIDOT's permission to utilize a section of I-95 northbound for the location of the three proposed test sections, the development of the recessed traffic marking placement plans for the three test sections, the evaluation of RIDOT's Mirolux 12 retroreflectometer, the purchase of the Retro-lux 1500, the subcontracting of the test section installation and traffic control, and the placement of inlaid tabs and measurements for the future placement reference for the recessed markings.

After receiving RIDOT's permission to install the three test sections on the I-95 northbound resurfacing site, the URI research team developed recessed traffic marking placement plans for each test section. These plans include the location of the three types of recesses within each test section along with the control portion of each test section. This control section is necessary due to the utilization of permanent inlaid marking tape for the skip stripes along this area of the I-95 resurfacing project.

Two different subgrant agreements were issued to Cardi Corporation: (1) the test section installation and (2) traffic control.

The URI research team visited the test section site on the night of

September 10 and observed the application of the Modified Open-Graded Friction Course (MOGFC) layer and installation of the permanent inlaid tape skip markings. The striping crew was directed to substitute 6 inch tabs of inlaid tape at the beginning of the stripes along the 1000 ft test section and the 500 ft exit ramp test section which corresponded to the future placement of the recessed stripes as shown on the URI recessed traffic marking placement plans. All activities were video taped. The same procedure was repeated by the URI research team on the night of September 26, when the 500 ft. curved test section was paved with MOGFC.

As stated above the test sections should be installed by the subcontractor before the October 30, 1996 deadline. Once the test sections have been installed the URI research team will evaluate the recessed markings for durability and retroflectivity during a wet day in late October or early November.

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 9th Rhode Island Transportation and Civil Engineering Forum, Kingston, R.I., October 23, 1996.

PROJECT NUMBER: 95-5

PROJECT TITLE:
Buried Joints in Short Span Bridges

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

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: 2/28/97

PROJECT OBJECTIVE(S):
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, 1996:
An extensive study of various expansion joint systems used in New England States was undertaken. Common types of joints used at present are buried joints for movements up to 1.5"-2", 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 are respectively used for movements up to 3"-4". 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. A detailed analysis using the softwre IDEAS and ANSYS is currently under way.

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 Massachusett and Tahar El Korchi, Worcester Polytechnic Institute

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/95

END DATE: 2/30/97

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

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1996:
Literature from previous ride quality studies along with other research related to pavement ride quality was collected and reviewed. A central file containing research material obtained from FHWA, NCHRP, RPUG, SHAs and TRB was also established. Other materials were acquired using a TRIS computerized search.

A survey was carried out with all State Highway Agencies (SHAs) to determine their ride quality practices. Each SHA received a questionnaire and was asked to review it and gather as much written material available. A meeting was then conducted with these agencies where the questionnaire was used to guide the discussions.

A state-of-the-art summary table was prepared containing all information related to pavement ride quality in New England; this table was then reviewed with all the agencies. Information collected in Task 1 was used to establish another state-of-the-art table displaying such information related to SHAs outside of New England. This information was used to determine the SHAs' opinions and status concerning the ride quality issue. These tables were circulated among the SHAs and other persons deemed appropriate by the NETC Project 95-6 Technical Committee for their review.

Information collected from each SHA was used to identify paving practices. These practices were categorized into different types of construction, pavement type and highway functional classification. This information will be used as a basis for the design of acceptable ride quality levels and the establishment of recommended measurement procedures.

In conjunction with the research project staff the SHAs participated in field tests in which data was collected with SHA devices and statistical tests were performed by the staff. These data were reviewed to identify minimum requirements for devices used to measure ride quality and to formulate bonus/penalty payment schedules. Emphasis was placed on the ride quality indices and measurement equipment that are currently being used in the SHAs in New England.

REPORTS, PAPERS AND PRESENTATIONS:

None.

D. FINANCIAL STATUS
Active Projects

Table 1: Financial Status Of Projects Active During 1996 (As Of 12/31/96)

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
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 *PI: James E. Tukey, Maine DOT*	134,127.00	0.00	0.00
New England Vehicle Classification And Truck Weight Program, Phase I *P.I.: John Collura, University of Massachusetts*	75,000.00	66,397.78	8,602.22
94-1: Structural Analysis of New England Subbase Materials And Structures *P.I.: K. Wayne Lee, University of Rhode Island*	111,497.00	47,641.88	63,855.12
94-2: Nondestructive Testing Of Reinforced Concrete Bridges Using Radar Imaging *P.I.: Dryver Huston, University of Vermont*	224,902.00	56,879.61	168,022.39

Table 1: Financial Status Of Projects Active During 1996 (As Of 12/31/96 (continued)

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
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	13,479.22	61,520.78
95-2: Suitability Of Non-Hydric Soils For Wetland Mitigation *P.I.s: Larry Branaka & Christine Evans University of New Hampshire*	39,914.00	32,708.02	7,205.98
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	40,946.10	66,366.90
95-5: Buried Joints In Short Span Bridges *P.I.s: George Tsiatas and K. Wayne Lee, University of Rhode Island*	64,910.00	38,861.22	26,048.78
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	18,381.28	87,742.72

Fund Balance

Table 2: NETC Fund Balance (As Of 12/31/96)

ITEM	ALLOCATION	ENCUMBRANCE/ EXPENDITURE	CUM. BALANCE
Unexpended balance 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		39500.00	484769.05
Tire Chips as Lightweight Backfill, Phase II:Full-Scale Testing (Supplemental Funding)		16000.00	468769.05
Bridge Rail Crash Test, Phase II: Sidewalk-Mounted Rail		134127.00	334642.05
New England Vehicle Classification and Truck Weight Program, Phase I		6714.78	327927.27
Member Allocations 1995 = 7 x $75,000	525000		852927.27
"95" Project Series:			
95-1:Use of Tire Chips/Soil Mixtures to Limit Pavement Damage of Paved Roads		75000.00	777927.27
95-2:Suitability of Non-Hydric Soils for Wetland Mitigation		39914.00	738013.27
95-3:Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes		107313.00	630700.27
95-5:Buried Joints in Short Span Bridges		64910.00	565790.27
95-6:Guidelines for Ride Quality Acceptance of Pavements		106124.00	459666.27
"94" Project Series:			
94-1:Structural Analysis of New England Subbase Materials And Structures		111497.00	348169.27
94-2:Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques		224902.00	123267.27
Member Allocations 1996 = 6 x $75,000	450000		573267.27
Coordination/Administration of NETC: Calendar Year 1996		75000.00	498267.27
"96" Project Series (Cost Estimate of RFPs Issued)		490000.00	8267.27
Member Allocations 1997 = 6 x $75,000	450000		458267.27
Coordination/Administration of NETC: Calendar Year 1997		77244.00	381023.27

E. NETC REPORTS, PAPERS AND PRESENTATIONS

PROJECT NUMBER	TITLE
None	**Annual Reports:** "ANNUAL REPORT For Calendar Year 1995", March 1996, NETCR 3 "ANNUAL REPORT For Calendar Year 1996", January 1996, NETCR 4
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, NETCR 1 **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** **Papers and Presentations:** "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 & 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. A presentation to the New England Environmental Expo, Boston, MA, May 9, 1995.

"Use of Tire Chips in Highway Construction", Humphrey, D., N. A presentation to the AASHTO Region 1 RAC Meeting, Portland, ME, 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 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.

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

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

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

Reports:

"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, NETCR 2.

-"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**

Papers and Presentations:

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

"New England Vehicle Classification and Truck Weight Program", Collura, J. and Orloski, F. A presentation 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: None

Papers and Presentations:

4-Bar Sidewalk-Mounted Prototype Bridge Rail Design

94-1 — **Structural Analysis of New England Subbase Materials and Structures**

Reports: None

Papers and Presentations:

Structural Analysis of New England SubbaseMaterials and Structures", Davis, J. Presented at the 9th Rhode Island Transportation and Civil Engineering Forum, Kingston, R.I., October 23, 1996.

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. A presentation at the New England State Materials Engineers Association Conference, Burlington, VT, October 9, 1996.
	"Ground Penetrating Radar for Bridge Deck Monitoring", Huston, D. A paper submitted for presentation at the International Conference on Structural Health Monitoring, Stanford, CA, September 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.

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

PROJECT NUMBER	TITLE
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 9th Rhode Island Transportation and Civil Engineering Forum, Kingston, R.I., October 23, 1996.

PROJECT NUMBER	TITLE
95-5	**Buried Joints in Short Span Bridges**

Reports: None

Papers and Presentations:

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