The Strategic Highway Research Program (SHRP) Activities in Connecticut

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November 2002

Revised April 2004

Report No.
CT-1213-F-01-10

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipients Catalog No.
CT-1213-F-01-10		

4. Title and Subtitle
Strategic Highway Research Program (SHRP) Activities in Connecticut

5. Report Date
November 2002

6. Performing Organization Code
SPR-1213

7. Author(s)
Anne-Marie H. McDonnell

8. Performing Organization Report No.
CT-1213-F-01-10

9. Performing Organization Name and Address
Connecticut Department of Transportation
Division of Research
280 West Street
Rocky Hill, CT 06067-3502

10. Work Unit No. (TRIS)

11. Contract or Grant No.
CT Study No. SPR-1213

12. Sponsoring Agency Name and Address
Connecticut Department of Transportation
2800 Berlin Turnpike
Newington, CT 06131-7546

13. Type of Report and Period Covered
Final Report
1987-2001

14. Sponsoring Agency Code
SPR-1213

15. Supplementary Notes
A study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. Abstract
In 1987, AASHTO member states initiated the five-year research program entitled, "The Strategic Highway Research Program." It was designed to address needs in five functional areas which were subsequently consolidated into four major program areas: asphalt, concrete and structures, highway operations and long-term pavement performance. It was designed to provide research results which were cost-effective, and deliverable at the conclusion of the five-year program, the exception was the twenty year term of the long-term pavement performance element.

This report describes ConnDOT efforts in the design and planning of SHRP, its execution and field verification studies, and other efforts to implement SHRP research products and results. A summary of lessons learned is presented.

17. Key Words
Strategic Highway Research Program (SHRP), Connecticut, asphalt, concrete, structures, highway operations, implementation, research, long-term pavement performance (LTPP)

18. Distribution Statement
No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (Of this report)	20. Security Classif.(Of this page)	21. No. of Pages	20. Price
Unclassified	Unclassified	54	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGEMENTS

The author wishes to acknowledge the cooperation and support from personnel at the Federal Highway Administration (FHWA), Transportation Research Board (TRB) and the Connecticut Department of Transportation (ConnDOT) throughout the SHRP and LTPP programs.
The author would like to recognize the many personnel from the ConnDOT Offices of Research, Maintenance, Bridge Design, Bridge Maintenance, Soils and Foundations, Pavement Management, Materials Testing and Planning Inventory and Data for their numerous contributions to the project.

Specifically:
Dr. Charles E. Dougan who truly championed the efforts for SHRP, both in Connecticut and nationally.
Mr. Keith R. Lane and Mr. James M. Sime for their continued support of the program.
Mr. Donald A. Larsen for his numerous outstanding contributions, including program coordination, oversight and technical assistance.
Mr. Michael Kasinskas (posthumously) for expert input into the anti-icing and cathodic protection efforts.
Mr. Eric Lohrey for cathodic protection experimental work and friction testing.
Mr. Jeffery Scully, Mr. Edgardo Block, Mr. John Henault and Mr. Lester King for all their efforts and assistance.
Mr. Charles Larson for his work in nomination and selection of test sites.
Ms. Susan Hulme and Ms. Gloria Pomfret for their administrative assistance.
Mr. Robert Seitz for his technical contributions for the collection of traffic data.
For the many cooperative education students who aided in the processing and calibration of traffic data (in chronological order): Ms. Susan Kall, Ms. Yan Liu, Mr. William Borelli, Ms. Anna Parafati, Ms. Jennifer Marsilio, Ms. Karen Zalewski, Mr. Brendan Donovan, Ms. Vivian Tran and Mr. Hari Yarapotina.

All those who have helped over the years from the ConnDOT Materials Testing Division, including: Mr. James Mitchell, Mr. Nicolas Corona, Mr. Steven Gage, Mr. Joseph Varhue, Mr. Nelio Rodrigues, Mr. Raffaele Donato, and Mr. Frederick Nashold.

The extensive field work necessary for this project would not have been possible without the continued support from the ConnDOT Office of Maintenance and the valuable work provided by many dedicated people from numerous maintenance garages.

Mr. Ivan Pecnik, the SHRP North Atlantic Regional Engineer, was instrumental in establishing the program in Connecticut.

The author would like to thank the staff of the North Atlantic Regional Contractor for their outstanding cooperation and patience over the years, in particular: Dr. William Phang (posthumously), Dr. Frank Meyer, Mr. Brandt Henderson, Mr. Basel Abukhater, Mr. Randy Plett, Mr. Doug Marshall, Mr. Scott Comstock, Mr. Alfred Lip, Mr. Andrew Brigg, and Ms. Patricia Finley.

Finally this author would like to recognize all of the people who made SHRP possible at SHRP, FHWA, TRB and the states and provinces by dedicating their years of service and expertise to the promise of a technologically more advanced future for transportation.

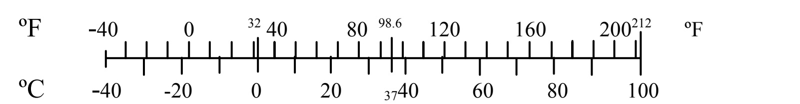
METRIC CONVERSION FACTORS

APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	254	millimeters	cm
ft	feet	304.8	millimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in^2	square inches	254	square millimeters	mm^2
ft^2	square feet	0.092903	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	Acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	2.5	grams	g
lb	pounds	0.453592	kilograms	kg
	short tons (2000 lb.)	0.9	Megagrams	mg
VOLUME				
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
TEMPERATURE (exact)				
ºF	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	ºC

APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.03937	inches	in
cm	centimeters	0.3937	inches	in
m	meters	3.281	feet	ft
m	meters	1.094	yards	yd
km	kilometers	0.6214	miles	mi
AREA				
cm^2	square millimeters	0.00155	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	Megagrams (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
TEMPERATURE (exact)				
ºC	Celsius temperature	9/5 (then add 32)	Farenheit temperature	ºF



List of Abbreviations and Acronyms

AASHTO	American Association of State Highway Transportation Officials
ASR	Alkali Silica Reaction
BBR	Bending Beam Rheometer
CAP Lab	Connecticut Advanced Pavement Laboratory
ConnDOT	Connecticut Department of Transportation
CP	Cathodic Protection
DSR	Dynamic Shear Rheometer
FHWA	(United States) Federal Highway Administration
FWD	Falling Weight Deflectometer
GPS	General Pavement Studies
HPR	Highway Planning and Research
KB	Kilobytes
LTPP	Long Term Pavement Performance
MB	Megabytes
MnDOT	Minnesota Department of Transportation
M_R	Resilient Modulus
MRL	(National) Materials Reference Laboratory
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NECEPT	Northeast Center of Excellence for Pavement Technology
NETC	New England Transportation Consortium
NHI	National Highway Institute
PAV	Pressure Aging Vessel
RTFO	Rolling Thin Film Oven
RWIS	Roadway Weather Information Systems
SHRP	Strategic Highway Research Program
SMP	Seasonal Monitoring Program

List of Abbreviations and Acronyms (continued)

SPR	State Planning and Research
SPS	Specific Pavement Studies
STRS	Strategic Transportation Research Study
SuperPave	Superior Performing Asphalt Pavements
UConn	University of Connecticut
WWW	World Wide Web

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Background and Introduction

In the early 1980's the condition of the highways in the United States began to receive serious attention. The Mianus River Bridge collapse in Greenwich, Connecticut in 1983 was a disastrous event that brought to focus the need to maintain and rebuild an aging infrastructure. Innovation was recognized as an essential parameter. Carefully targeted research was identified as a catalyst to accelerate the search for innovation.

AASHTO in cooperation with the Federal Highway Administration commissioned the Transportation Research Board to study the problem, define the research needs and devise a plan to implement a new research program that was focused on high priority research needs which offered substantial payback on investment. The study was entitled the "Strategic Transportation Research Study (STRS)." /3/ This study approached highway research as a unified industry and as such identified problems that would most likely be neglected in research by the fragmented array of government and institutional organizations, contractors and suppliers.

The select committee who directed the STRS study was made up of leaders from state and local government (transportation) agencies, industry, corporations, highway researchers, as well as liaisons from the FHWA and the Congress. At an early stage in the STRS project the individual states were polled in a survey and included to identify potential areas of need and payoff. The primary focus of the initial recommendations was on highway materials. It was recognized also that continued research initiatives in the other transportation areas is vitally needed.

Strategic Highway Research Program

The product of STRS, a five-year plan for a strategically focused research program was developed. This program was approved by Congress and named the Strategic Highway Research Program (SHRP). It was a five-year $150 million research program managed by the Transportation Research Board and funded via set-aside of state-apportioned federal-aid highway funds. The program was carefully developed and defined as, "… a time-specific, concentrated, short-term and results-oriented research effort aimed at closing specific technological gaps that have impeded the effective advancement of the highway program." /3/

SHRP was focused on six priority areas that targeted research where innovation could produce cost savings, increased productivity and/or improve safety of the nation's highways. Individual projects were then placed into five areas of the program, specifically: Asphalt, Long-Term Pavement Performance, Concrete and Structures, Winter Maintenance and Highway Operations. Descriptions of these areas are listed under the section, "Primary Objectives of Each Functional Area of SHRP," /3/ page 3. The goal was to deliver practical results for use by transportation agencies within five years. Planning for implementation of the research results was to begin while research was underway.

SHRP at the Connecticut Department of Transportation:

The Connecticut Department of Transportation participated in both STRS and SHRP from the onset, as well as being a stakeholder. The Office of Research and Materials was identified as the appropriate area of the Department to coordinate the subsequent activities. This decision was based on the fact that central coordination was necessary to address and correctly funnel and follow up on the numerous written requests, surveys, telephone inquiries and SHRP contractors to the correct ConnDOT offices and staff. Participation was routinely sought and encouraged from other sections of ConnDOT by the Office of Research and Materials. The Director of Research and Materials, Dr. Charles E. Dougan was appointed the State SHRP and LTPP Coordinator from 1986 until 1997 (retirement). Currently, Mr. James M. Sime, the Manager of Research, is the SHRP Coordinator and he oversees SHRP activities in Connecticut.

Primary Objectives of Functional Areas of SHRP

The original work set forth by the STRS program defined the objectives of each of the strategic areas of study. These original objectives are listed below /3/ for the purpose of understanding the focus and intent of the program.

“Asphalt: To improve pavement performance through a research program that will provide increased understanding of the chemical and physical properties of asphalt cements and asphaltic concretes. The research results would be used to develop specifications, tests, and construction procedures needed to achieve and control the pavement performance desired." /3/

The following two areas of Cement and Concrete in Highway Pavements and Structures were later combined in the program into Concrete and Structures.

"Protection of Concrete Bridge Components: To prevent the deterioration of chloride-contaminated concrete components in existing bridges and to protect new, uncontaminated bridge components from chlorides." /3/ p. 107

"Cement and Concrete in Highway Pavements and Structures: To improve the economy, versatility, and durability of concrete in highway pavements and structures through an increased understanding of the chemistry of cement hydration and the properties of concrete." /3/ p. 119

"Long Term Pavement Performance Program: Increased pavement life by the investigation of long-term pavement performance of various designs of pavement structures and rehabilitated pavement structures, using different materials and under different loads, environments, subgrade soils, and maintenance practices." /3/ p. 80

The two areas of Maintenance Cost-Effectiveness and Chemical Control of Snow and Ice on Highways were later combined in the program into Highway Operations.

“Maintenance Cost-Effectiveness: To improve the cost-effectiveness of maintenance through research that will provide technological improvements in equipment, materials, and processes and will improve the administration of maintenance programs in the areas of budget development, program management, and resource allocation. /3/, p. 97

“Chemical Control of Snow and Ice on Highways: To avoid costly deterioration of bridges, pavements, and vehicles and other adverse environmental effects by reducing the dependence on chlorides for snow and ice control; improving mechanical, thermal, and other removal techniques; and producing environmentally safe alternative chemicals. /3/, p. 132

Connecticut’s Participation

Implementation Methods and Efforts

The work of developing, organizing and conducting SHRP was followed by a major effort to implement the results in the form of “products” at the state level. Product implementation efforts at the state level included distribution of information, meetings and presentations, financial support, field trials, demonstrations, workshops and presence at appropriate forums.

For many of the ConnDOT employees, the products provided the first introduction to the SHRP program. Any and all informational materials and products were distributed to the appropriate functional areas as they arrived. A copy of each report and video was kept in the Office of Research and Materials and another set was made available at the Connecticut Department of Transportation Library; both sets were made available for requests. In 1997 additional copies of the SHRP reports were made available to the states from NCHRP, who was consolidating their stock. The response was positive from ConnDOT personnel and additional copies of reports were distributed, as requested and available.

In an implementation effort, meetings were held with specific sections of the Department to present program materials. A meeting was conducted with personnel from ConnDOT Maintenance in 1993, which included a presentation and discussion of products for their use. This meeting resulted in a listing of the products, which were of primary interest. The progress of particular products, selected from the SHRP Product Catalog /17/ were tracked and followed. Unfortunately, the products of interest, which were specifically identified by ConnDOT Maintenance: the snowplow ice blade and the diverging lights were not available for implementation at the time and the 1992 version of the multi-directional barricade-sign had not been accepted by MUTC.

When possible, financial support was offered by ConnDOT Division of Research to facilitate the product trials. This was done for the evaluation of a set of multi-directional barricade-signs bought in June 1998 (See Image 1).

Image 1: Directional Indicator Barricade Field Trial ConnDOT 1998

National Involvement

"SHRP's implementation effort succeeded, just as its research did, because it was built on partnerships. From the very beginning, SHRP was guided not only by FHWA, AASHTO and TRB, but also by highway professionals from every region of the country, from academia and from industry." /7/ As described in this FHWA publication, professionals such as those at the Connecticut Department of Transportation have played an important role in SHRP. The partnership with the State of Connecticut began even prior to the onset of the official program. Connecticut transportation researchers participated in the original STRS survey.

Dr. Charles E. Dougan served on the first Strategic Highway Research Program Advisory Committee on Snow and Ice Study. Dr. Dougan also served on the Strategic Highway Research Program Long-Term Pavement-Performance Advisory Committee and the post-SHRP LTPP Advisory Committee. Dr. Dougan was selected as the State of Connecticut SHRP Coordinator from the beginning of the program until his retirement in 1997. Dr. Dougan was also active as the Chair of the LTPP Subcommittee on Program Improvement. Dr. Dougan was recognized as a program "Champion" for his many fruitful efforts and active involvement with SHRP.

Image 2: Dr. Dougan active at SHRP Snow and Ice Control Advisory Committee Meeting, 1985. (Third back; far left row)

Dr. Jack E. Stephens from the University of Connecticut served on the Strategic Highway Research Program Advisory Committee on Asphalt. Mr. Donald A. Larsen served the TRB Expert Task Group on Long-Term Pavement Performance, Automated Distress Identification from January 1996 to September 15, 1997. Mr. Keith R. Lane served as the Connecticut LTPP Coordinator since 1997 and on the Technical Working

Group (TWG) for Asphalt and on the AASHTO Subcommittee of Materials, which worked a great deal with the SHRP products. Mr. James M. Sime has served as the SHRP Coordinator for Connecticut since 1997. Ms. Colleen A. Kissane has served on the TRB ETG on LTPP Distress and Profile Data Collection and Analysis from August 1998 to present. Ms. Anne-Marie H. McDonnell has served on the TRB ETG on Traffic Data and Analysis from 1996 to present, as liaison to the ETG on Data Analysis from 1996-1998, and as a participant in the Data Analysis Workshops in 1997, 1998 and 1999.

National involvement by State personnel has been mutually beneficial. It is important that program decision makers be apprised of regional perspectives and issues. The best way to do this is to have direct representation. Conversely, the State of Connecticut can be assured that their needs will be voiced and, therefore, have a greater likelihood of being addressed. Active participation has also allowed the added benefit of allowing State representatives to interact with other professionals from across the country, greatly improving understanding and communication, as well as keeping the state current on issues and priorities as events unfolded in the evolving transportation industry.

Field Trials

ConnDOT volunteered to be part of National Trials for both the Work Zone Safety Devices and the Snow and Ice Technology Trials. In the case of the work zone safety devices, the trial did not come to fruition, due to administrative and scheduling issues. If the relatively inexpensive devices were provided free of charge (and therefore reduced paperwork) to the state, this trial would have proceeded. In the case of the snow and ice technical trial, Connecticut was designated as a program alternate and never called upon to participate further.

Demonstrations

A few demonstrations were held to introduce ConnDOT personnel to various products. One such demonstration was provided on September 13, 1995 by Minnesota Department of Transportation (MnDOT) personnel working with FHWA on the Remotely Driven Vehicle. The remotely driven vehicle Demonstration is shown in Image 2. Many of ConnDOT employees found the device to be interesting, but found the system expensive and with limited application to their work. It was suggested by a ConnDOT employee that this device might have applicability for hazardous waste spill situations. This suggestion was forwarded to the demonstration personnel. Image 3 shows the flashing stop/slow paddle during the same demonstration by MnDOT. Questions regarding cost, transport, and maintenance were generated by ConnDOT personnel regarding this product.

Image 3: Demonstration of Remotely Driven Vehicle, ConnDOT 1995

Image 4: Demonstration of the Flashing Stop/Slow Paddle, ConnDOT 1995

In addition, several products were demonstrated at the state by vendors and distributors. This was the case of intrusion alarm system demonstrations. Some ConnDOT personnel were interested in these devices, but none were ever purchased.

Demonstrations of SHRP equipment were routinely provided at the Transportation Research Board (TRB) Meetings. These forums provided opportunities for ConnDOT employees attending to be introduced to the program products and updated information and other states' experiences. The SHRP Asphalt Equipment Demonstration for the Northeast States Asphalt User-Producers Group was hosted by ConnDOT, April 6-7, 1992.

SHRP Products were routinely discussed at National Forums, such as AASHTO. These forums were an important aspect of implementation. Peer-to-peer recommendations, expressed within the specific program discipline areas and transportation official's community can be influential. These forums were particularly useful to introduce the program and products to upper-level decision-making employees.

ConnDOT staff traveled to see demonstrations when applicable, as was arranged on March 11, 1993 to gain information regarding the SHRP Product 3023, Roadway Weather Information System (RWIS) as installed in New Jersey.

A Demonstration of the Long-Term Pavement-Performance (LTPP) DataPave Demonstration Workshop was provided in May 1998 at a computer laboratory at the University of Connecticut. Representatives from various units within the Department, neighboring states, and academia were invited.

Field tests and measurements conducted as part of the Long Term Pavement Performance (LTPP) program effort at the state test sites allowed for demonstrations of equipment that would not otherwise have been possible. Instrumentation included: falling-weight deflectometers, Georgia Profiler, Dipstick software, PASCO filming, and profilers and seasonal monitoring equipment. Although demonstrations were not officially part of the program, the Regional Contractor administrating field work was always willing to speak with State personnel.

Overall, these demonstrations provided both ConnDOT employees and University of Connecticut students with familiarization and training. In addition, by nature of these routine state visits, newer technology was quicker to be introduced, understood, and accepted into practice.

Workshops

Many workshops were offered by FHWA to promote new technologies developed under SHRP. A listing of the workshops and demonstrations that ConnDOT personnel participated in is given in Table 1.

The FHWA Anti-Icing Outreach Program was held on April 25, 1996 at the ConnDOT Training Division. FHWA sponsored NY State employee and program champion, Mr. Duane “Dewey” Amsler to come to Connecticut in an effort to discuss and share information on snow and ice operations between the states. Specifically, to share experiences in the use of innovations in anti-icing, including truck mounted roadway sensors and technology used in Colorado, Washington, New York and Oregon.

Table 1: SHRP Workshop/Demonstration Participation by ConnDOT

Workshop	Date	Participant(s) /Affiliation
Demonstration of Product 3023-RWIS Roadway Weather Information System	3/11/1993	Louis Malerba - ConnDOT Maintenance Patrick Rodgers - ConnDOT Maintenance Thomas Daly - ConnDOT Maintenance Anne-Marie McDonnell - ConnDOT Research
National Anti-Icing Technology Meeting	6/9-10,1993	Tom Daly - ConnDOT Maintenance
SHRP Binder Equipment Training	7/19-23/93	Joseph Varhue - ConnDOT Materials
Training: SHRP Asphalt Mixture Design	4/25-29/94	Jon Whitbeck - ConnDOT Materials Nelio Rodrigues - ConnDOT Materials
Teleconference, "Improving the Performance Durability and Safety of Local Roads: Innovations in Materials, Equipment and Procedures from SHRP"	11/15/1994	Representatives from Local Roads through the Technology Transfer Center/ UCONN Anne-Marie McDonnell - ConnDOT Research
Product Evaluation No. 28 :Anti-Icing Technology	10/1/1995	Vincent Guntner - ConnDOT Maintenance
SHRP Superpave Workshop	12/13/1995	75 people from ConnDOT & Contractors
Improving Pavement with LTPP Products for Today and Tomorrow	3/24-28/96	Charles Dougan - ConnDOT Res & Materials Anne-Marie McDonnell - ConnDOT Research
FHWA Anti-Icing Outreach Program	4/25/96	Duane “Dewey” Amsler – NY State
FHWA New England Anti-Icing Technology Workshop	10/1996	Over 75 people – ConnDOT and New England
FHWA Region 1 Showcase Workshop on Concrete Durability	11/12&13/96	Steve Gage - ConnDOT Materials Testing
Methodology for Design and Treatment of Concrete Bridge Components Subject to Bar Corrosion	12/1/1997	Eric Lohrey - ConnDOT Research Ned Statchen - ConnDOT Engineering
Presentation "Norcure Electrochemical Chloride Extraction (ECE)” by vendor Vector Construction Group	12/8/1997	ConnDOT Personnel from Bridge; Maintenance, Research
High Performance Concrete Bridge Showcase	9/22-23/97	Steve Gage - ConnDOT Materials Testing
DataPave Demonstration Workshop	8/6/1998	ConnDOT Materials & Research, Construction and Pavement Management
Pavement Maintenance Effectiveness		Not recorded
NECEPT “Direct Tension Equipment SHRP Binder Testing”	4/2002	Joseph Varhue - ConnDOT Materials

ConnDOT sponsored the FHWA New England two-day workshop on “Anti-Icing Technology” in October 1996. More than sixty people participated from the State of Connecticut, and representatives from the States of New York, FHWA, New Hampshire, Massachusetts, Rhode Island and several Connecticut town governments. The agenda included: WELS Forecast Model, RWIS in Nevada, Anti-Icing, Anti-Icing in Oregon, Disbonding, Handbook of Deicer Test Methods, Snow Drift Control, Snowplow Cutting Edge, and Snowplow Scoop design.

Presentations

Superpave Presentations/Workshops at ConnDOT

In 1998 the Division of Research participated in the annual Office of Construction training sessions for each of the four districts. Included in this were presentations on SHRP Products and Technologies. In many cases this was the first introduction of SHRP and Superpave Technologies for many of these personnel.

Presentations were given at the University of Connecticut as part of the pavement technology classes in their undergraduate curriculum.

The SHRP Product (5016) “Distress Identification Manual SHRP-P-338” /5/ was emphasized at the training for the ConnDOT (PAT) Paving Advanced Technology Team in 1995. Images from the slides and SHRP distress manuals, provided by SHRP, were utilized in presentations to the members of the team. The SHRP Distress Identification Manual allowed for training of personnel that helped them become consistent, repeatable and accurate in their distress identification.

The Division of Research hosted a Research Showcase in April 1999 for both ConnDOT and private sector employees. A presentation on SHRP was provided to further distribute information about activities related to SHRP in Connecticut. A program display was created that featured SHRP. This Showcase Display was also featured at the NASTO – North East Association of State Transportation Officials Conference held in 2000.

Overview of Product Use and Implementation by Functional Area

The list of SHRP products was reviewed and tables (located in Appendices B-E) were created to document the level of interest, applicability and use at the Connecticut Department of Transportation.

Asphalt

The Connecticut Department of Transportation has implemented SHRP Asphalt technology and is using the resulting Superpave™ (Superior Performing Asphalt Pavements) Binder and Mix Design Methodologies. Implementation of the new asphalt technologies has been a multi-year developmental process. This process has involved evaluations of the test methods, acquisition of equipment, training of personnel, communication and partnership with industry and field-testing and implementation. We have worked with the changing system, as AASHTO continues to adjust the specifications, as necessary. Field deployment is detailed in Table 2, "Superpave Paving Activities by Connecticut DOT." Connecticut DOT is phasing in the implementation with projects over 10,000 tons. Full deployment is planned for year 2005.

Table 2: Superpave Paving Activities and Deployment by Connecticut DOT

Year 1995

Project	Description	Tons (approx.)	Design
173-273 K	RT. 1 No. Branford	600	Designed by ConnDOT

Year 1996

Project	Description	Tons (approx.)	Design
173-286 I	RT 77 Guilford	5,000	Designed by ConnDOT
170-1646	RT 77/I-95 Commuter Lot	800	Designed by ConnDOT
	Total	*5,800*	

Year 1997

Project	Description	Tons (approx.)	Design
28-185	RT 2 Colchester	50,000	AASHTO MP-2/PP-28/SPS-9
172-292 I	RT 148 Killingworth	18,000	AASHTO MP-2/PP-28/SPS-9
	Total	*48,000*	

Year 1998

Project	Description	Tons (approx.)	Design
85-131	I-395 Montville	48,000	AASHTO MP-2/PP-28
144-171	RT 8 Trumbull	75,000	AASHTO MP-2/PP-28
	Total	*123,000*	

Table 2 (continued)

Year 1999

Project	Description	Tons (approx.)	Design
34-289	I-84 Danbury	72,000	AASHTO MP-2/PP-28
46-118	I-91 Enfield	126,000	AASHTO MP-2/PP-28
137-137	RT 2 North Stonington	32,000	AASHTO MP-2/PP-28
	Total	*230,000*	

Year 2000

Project	Description	Tons (approx.)	Design
82-266	RT 9 Middletown	48,000	AASHTO MP-2/PP-28
92-474	I-91 North Haven	46,000	AASHTO MP-2/PP-28
109-150	I-84/RT 72 Plainville	15,000	AASHTO MP-2/PP-28
	Total	*109,000*	

Year 2001

Project	Description	Tons (approx.)	Design
15-272	I-95 Bridgeport	68,000	AASHTO MP-2/PP-28
58-249	RT 12/184 Groton	20,000	AASHTO MP-2/PP-28
83-220	I-95 Milford	52,000	AASHTO MP-2/PP-28
88-153	RT 9 New Britain	18,000	AASHTO MP-2/PP-28
106-111	RT 1 Orange	15,000	AASHTO MP-2/PP-28
109-152	RT 72 Plainville	15,000	AASHTO MP-2/PP-28
164-224	I-91 Windsor	177,000	AASHTO MP-2/PP-28
165-303	Old Colony Road, Windsor Locks	14,000	AASHTO MP-2/PP-28

171-293 I	RT 140 E. Windsor/Ellington	8,200	AASHTO MP-2/PP-28
171-292 H	RT 5/15 Newington	8,200	AASHTO MP-2/PP-28
172-327 A	RT 2 Norwich	7,400	AASHTO MP-2/PP-28
172-327 J	RT 193 Thompson	11,000	AASHTO MP-2/PP-28
173-334 E1	RT 15 Milford	5,700	AASHTO MP-2/PP-28
173-334 E2	RT 15 Orange	12,000	AASHTO MP-2/PP-28
174-295 A, A1	RT 8 Harwinton/Torrington	35,000	AASHTO MP-2/PP-28
174-296 A, A1	RT 8 Thomaston, Litchfield, Harwinton	36,000	AASHTO MP-2/PP-28
174-295	RT 45 Warren, Cornwall	6,000	AASHTO MP-2/PP-28
	Total	*508,500*	

Evaluation and Testing Participation

The Connecticut Department of Transportation has been a participant in numerous test procedure reviews and evaluations of the SHRP asphalt equipment. In 1992 the Department submitted asphalt cement samples for the “Performance Graded Asphalt Binder Specifications,” at SHRP in Washington, D.C. Numerous reviews were conducted on the SHRP Products “Test Methods and Specifications,” at the request of the AASHTO Subcommittee on Materials. These included “the Extraction and Recovery of Asphalt Cement for Rheological Testing” in 1994 and AASHTO Provisional Standard PP2 in 1994. Personnel from the Division of Materials Testing voiced concern following these tests. Specifically, they questioned if the lab simulation of aging asphalt cement was representative of field conditions. ConnDOT was also a participant in the Binder Proficiency Round Robin Testing Administered by the CAP Lab, in cooperation with the Northeast Center of Excellence for Pavement Technology (NECEPT) at Penn State in July 1998.

Development of Testing Facilities

ConnDOT began to acquire the Superpave testing equipment in cooperation with FHWA, when it became available. Table 3 indicates the ConnDOT equipment and acquisition dates for the ConnDOT Materials Testing Laboratory in Rocky Hill, Connecticut. Preliminary testing on several of the pieces of equipment required hours of testing, repairs and modifications. The Dynamic Shear Rheometer (DSR), initially released in 1992 was particularly troublesome (See Image 5). ConnDOT employees worked with the manufacturer in attempts to correct the problems both physically and through improved software. In addition, the Bending Beam Rheometer and the Direct Tension Devices required extensive modifications and re-engineering in order to be useful.

Table 3: SuperPave Binder Equipment at ConnDOT

Equipment	Company	Date
1. *Dynamic Shear Rheometer (DSR)	Paar Physica	11/95
2. Bending Beam Rheometer (BBR)	ATS	2/96
3. Rotational Viscometer	Paar Physica	3/96 (replaced by item 8)
4. Viscometer Oven (PAV)	ATS	8/96
5. Direct Tension	Instran	9/99
6. Rolling Thin Film Oven (RTFO)	Cox	4/96
7. Various equipment used for SuperPave Binder testing	Various	1995-2001
8. Viscometer	Brookfield	98
9. Bending Beam Rheometer (BBR)	Cannon	4/01
*Returned DSR to Paar Physica for a small credit and purchased ATS Rheo Systems DSR 8/97.		

Image 5: Dynamic Shear Rheometer in Use at ConnDOT Laboratory

Connecticut Advanced Pavement Laboratory (CAP Lab)

The CAP Lab was created as a joint venture between the University of Connecticut, the Connecticut Department of Transportation, and the U.S. Department of Transportation, Federal Highway Administration. The CAP Lab's Mission includes, "to provide a regional center of excellence to address systems, methods, new materials, and training to solve pavement technology problems impacting the safe and efficient management, operation, preservation, and improvement of systems used in the transport of people, goods and services." /6/ CAP Lab is one of only three fully equipped SuperPave Labs at a University in the Northeast. As such, they are well positioned to provide technical support, training and testing. Through the CAP Lab, additional testing has been possible for ConnDOT, other New England State DOTs, and industry.

Training

Training has been and continues to be essential in the implementation of the SHRP test procedures and methodologies. To date, the training provided by CAP Lab has included demonstrations, workshops and full training courses.

As part of the Northeast Asphalt User-Producer group, ConnDOT hosted the Asphalt Equipment Demonstration for the Northeast states on April 6-7, 1992 and the Northeast Asphalt User/Producer Group TE-19 Workshop on Asphalt Binder Equipment and Specifications was held at the ConnDOT Materials Testing Laboratory on October 28-30, 1992 and again on November 4-6, 1992. Over sixty-five participants attended the program to gain detailed explanations and hands-on training on the new equipment. A copy of the videotaped binder workshop was submitted to the AASHTO Materials Reference Laboratory in Gaithersburg, Maryland. Additional testing was conducted after the demonstrations by ConnDOT staff using the loaned equipment to gain further experience. In addition, SHRP informational sessions were held at Northeast User-Producer Group Meetings from 1992 through to the present.

Materials Testing personnel from the State of Connecticut were trained at the Asphalt Institute Advanced Research Laboratory located in Lexington, Kentucky between 1992-1995. Employees attended both SuperPave binder and mix training sessions.

During the construction of the SPS-9A test site on Route 2, the FHWA’s Mobile Asphalt Laboratory was on-site to perform mix design verification and simulated quality assurance as part of FHWA Demonstration Project #90. The demonstration project provided an opportunity for both public and private sector employees from Connecticut and the Northeast to view and try the equipment. The tour, demonstration, and field tour were followed by a seminar with presentations to provide complete information for the participants.

ConnDOT is currently studying SuperPave under the LTPP SPS-9A experiment. Additional information is listed under the LTPP section of this report.

Participation in Additional Studies

ConnDOT is currently supporting additional studies in support of SuperPave under the New England Transportation Consortium (NETC). These are listed in Table 6, “Connecticut’s Involvement in SHRP-related Research Projects.”

Concrete and Structures

Concrete

In the areas of concrete, the greatest influence to the State of Connecticut will be if the SHRP products are accepted as AASHTO test methods. In accordance with FHWA guidelines, the Connecticut Department of Transportation’s policy is to utilize standard AASHTO test methods. At the time of this printing, the SHRP Products indicated in Appendix C are being balloted for an adoption into AASHTO Specifications. ConnDOT’s Materials Testing Division Engineers examined Product #2010, “Manual for ASR Detection.” Their opinion was that, when used in conjunction with a National Highway Institute (NHI) course, it will be useful to the states that have ASR (Alkali-Silica Reaction) problems. Product #2014, ”High Performance Concrete Specifications,” are being incorporated into some bridges. Product #2012, ”Flaw Detection by Impact-Echo Method,” has been used as a special provision on a few projects.

Structures

Participation in SHRP C-102-F, Cathodic Protection

The State of Connecticut was a participant in the SHRP C-102F Study, “Field Activities and Data Collection from Existing Cathodic Protection (CP) Installations.” The study involved the evaluation of the system installed on Bridge No.1242, located on Route 229 over I-84 in Southington, CT (See Image 5). This structure has a titanium mesh anode system with an overlay and null probes. It is one of the twenty-four existing cathodic protection installations, which were studied across the United States and Canada to gather information and ultimately to produce the Cathodic Protection Manuals for both maintaining and designing systems. As a participant in the study, engineers from ConnDOT provided the FHWA contractor with existing research documentation from inspection reports, rectifier output and depolarization test measurements. In addition ConnDOT hosted both an office visit and field site visit for the SHRP C-102F Task 2B Research

Team on June 22 through 25, 1992. The field visit included a detailed study of the system, which required traffic control for deck inspection, coring and patching operations, as well as providing the portable test equipment used by the state to monitor and maintain the cathodic protection system. Rectifier operational parameter measurements, potential polarization decay testing and “E log I” testing were conducted by the contractor during the field site visit. An additional follow-up field visit and testing was conducted on Bridge No. 1242 in 1995.

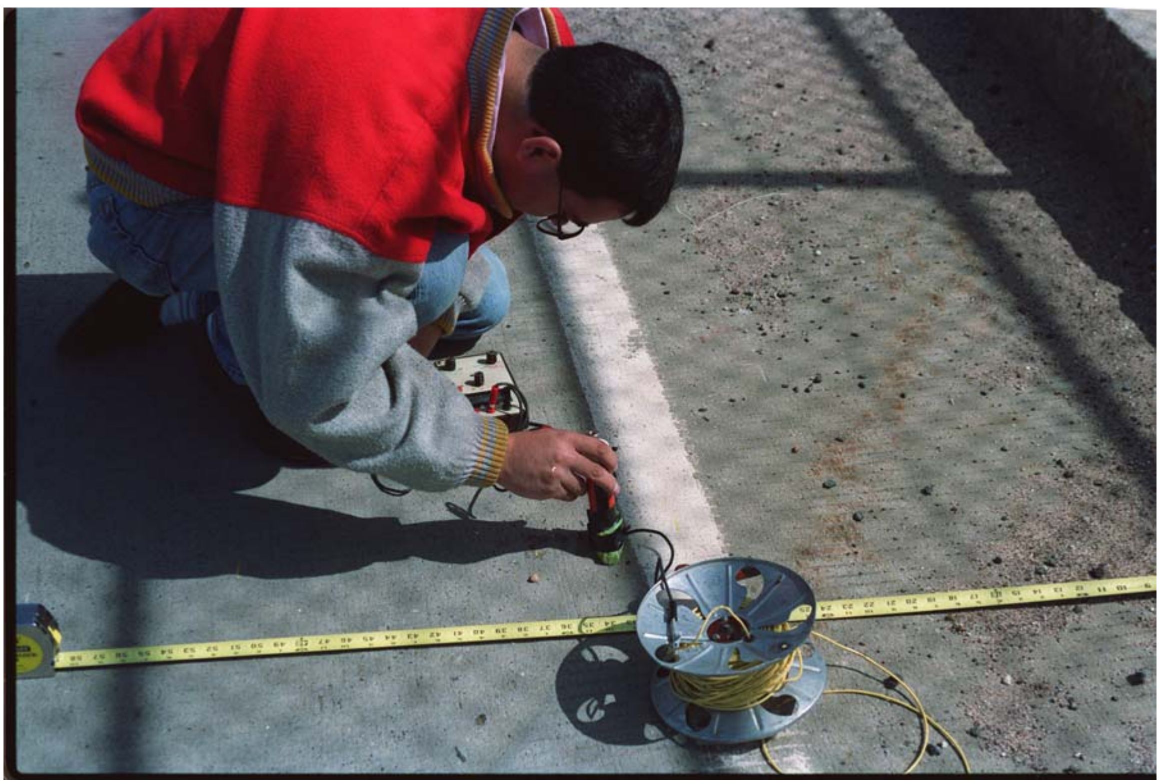

Image 6: Evaluation of Cathodic Protection on Bridge 1242 in Southington, Connecticut

The Connecticut Department of Transportation was also a participant in the FHWA research program entitled, “Concrete Bridge Rehabilitation and Protection,” and the Tasks included in the SHRP C-

102-C Project. Under this task an evaluation was conducted of the Elgard titanium mesh anode cathodic protection system with Null Probes (NP) installed on the Wawecus Hill Road Bridge over I-395 in Norwich, Connecticut. The field evaluation was conducted at this structure in July 1995.

The Connecticut Department of Transportation expended considerable effort seeking test sites and submitting detailed information to SHRP for two structural research projects. These included: SHRP 103, “Concrete Bridge Protection and Rehabilitation: Chemical and Physical Techniques” (1991); and, SHRP 101, “Assessment of Physical Conditions of Concrete Bridge Components” Subtask C-1.

Highway Operations

Roadway Weather Information Systems (RWIS)

In the area of highway operations, one of the most important results from SHRP was a resurgence of National attention on anti-icing technology. In Connecticut this focus at National forums encouraged the installation and use of technologies, such as the Roadway Weather Information Systems (RWIS) to allow for early warning of changing road surface and weather conditions. To date, nine RWIS sites are operational Statewide and more are proposed.

Opposing Traffic Lane Divider

The opposing traffic lane divider has been used successfully on many full-depth reconstruction projects in Connecticut. A special provision was developed for its use in Connecticut and is provided in Appendix A. Issues identified and considered by engineers when considering adoption of this product included: durability, cost, and availability on the job. A preliminary cost assessment between this SHRP product and traditional barrels indicated that the cost difference was minimal. This product is an example of a device that gained implementation by the department through information distributed by a vendor. An image of the device is shown in Image 6. Engineers from the ConnDOT Division of Traffic Engineering specify the use of this product on a project-by-project basis.

Image 7: Opposing Traffic Lane Divider

The automated pothole patcher technology developed through the SHRP IDEA Program was embraced. Seven automated machines are in use Statewide, one of which is the robotic type. The automated pothole patcher is shown in use in Connecticut in Images 7 and 8.

Image **8**: Automated Pothole Patcher in Action

Image 9: Automated Pothole Patcher in Use in Connecticut

An adaptation of the portable all-terrain sign and stand is commonly used in Connecticut. This technology was marketed and implemented to sections of the Department through vendor efforts.

The multi-directional barricade signs, as shown in Image 1, were bought in June 1998 for the Office of Maintenance to conduct field evaluations. Interest in this product and in the other highway signing was generated as a result of the need to comply with new national safety criteria, as recommended in NCHRP Report 350 in 1993 /16/.

In addition, the pavement repair manuals have been useful to Connecticut. Use of SHRP highway operations products are listed in Appendix D.

Long-Term Pavement Performance Products

The long-term pavement-performance program established the baseline for pavement monitoring at the national level. This project was similar to the project conducted by Mr. Donald A. Larsen of ConnDOT from 1986 to 1996 entitled, “Connecticut Long-Term Pavement Performance Study.” /10/ One of the most valuable products of LTPP was the standardization of the data collection terminology and protocols. As stated, the SHRP Report SHRP-P-338, “Distress Identification Manual for the Long-Term Pavement Performance Project,” has been used and recognized by ConnDOT as a valuable tool both as a training manual and as a definitive reference. Other products of LTPP, such as the pavement-surface profile dipstick software Product #5015, were examined but did not lend themselves to application for ConnDOT needs.

The profile measurements conducted by LTPP at the state level did provide an excellent opportunity to conduct comparison testing with state profile equipment. Comparisons were conducted for several years that showed good correlations.

The work conducted by LTPP in the study and the use of Falling Weight Deflectometer (FWD) testing represent significant improvements to both the methods and acceptance of this technology. Because of these improvements by LTPP, ConnDOT is more receptive to potential use of this technology.

The Resilient Modulus (M_R) Testing through LTPP facilitated the widespread use and acceptance of the unbound testing. It is anticipated that the LTPP test results will be utilized as a reference in the future.

DataPave is a software product from the LTPP effort that provides access to a database containing most of the key elements of the LTPP data collection. ConnDOT served as a Beta tester of the DataPave program. DataPave has been used primarily to retrieve data on study sites in Connecticut and as a reference of expected data ranges. DataPave is considered a valuable product for future needs.

The application of LTPP products in Connecticut is listed in Appendix E.

Connecticut's Efforts with LTPP

GPS General Pavement Studies

The Connecticut Department of Transportation conducted an exhaustive search for long-term monitoring test sites resulting in the nomination of 26 test sites for participation in the General Pavement Studies (GPS) in 1987. From these, four test sites were selected that met the stringent program requirements. These GPS test site locations and experiment information are listed in Table 4.

Table 4: GPS Test Site Location Information in Connecticut

SHRP ID	Experiment No.	Highway/ Direction	Town	Log Mileage	Location
095001	GPS 5/ GPS 7B	I-84 Westbound	Vernon	76.62 – 76.39	0.7 Mi West of Route 31, Exit 67
094008	GPS 4	I-84 Westbound	Manchester	69.52 – 69.29	0.7 Mi West of Exits 62 & 60
094020	GPS 4/ GPS 7B	CT Route 2 Westbound	Glastonbury	7.44 – 7.22	~ 2 miles West of Exit 10, Route 83
091803	GPS 1	CT Route 117 Northbound	Groton	3.32 – 3.57	0.8 Mi North of Route 184

SPS Specific Pavement Studies

The Connecticut Department of Transportation expended considerable effort recruiting candidate sites for the Specific Pavement Studies (SPS). ConnDOT volunteered early to be a participant in the SPS 3 & 4 studies. The studies involved the application of surface maintenance treatments of slurry and chip seals. The candidate site was located on a high volume interstate facility. It was determined by the State that this location was too high a traffic volume to conduct these treatments. It was, therefore, eliminated from the experiment. Additional candidates were vehemently sought for other SPS sites. Work was conducted, including field marking and field testing. Many characteristics inherent to New England were not conducive to the test criteria, including roadway degree of curve, grade, curbing, drainage, traffic volumes, construction and age. Numerous locations and projects were nominated as candidates for SPS sites. The only SPS site approved in Connecticut was the SPS-9A, "Verification of SHRP Asphalt Specification and Mix Design," as part of CT Project 28-185 on CT Route 2 in 1997.

Work conducted under this CT Research Project (SPR Project 2219) from 1997 until 2003 included the construction of six 3.2 km monitoring sections, four SuperPave and two ConnDOT Class 1, each 62.5 mm overlays. Three of the sections are supplemental to the FHWA required SPS-9 sections. These supplemental sections utilize twenty percent Recycled Asphalt Pavement (RAP) obtained from milling the existing surface layer. The construction phase of the SPS-9A project is documented in detail. /9/ The SPS-9A test site location information is listed in Table 5. The final report is available by request. It is entitled, "Demonstration and Evaluation of SUPERPAVE Technologies: Final Evaluation Report for CT Route 2"; CT Report Number 2219-F-02-7, by Donald A. Larsen, October 2003.

Table 5: SPS-9A Test Site Location Information in Connecticut

SHRP ID	AC Grade	CT Route 2 / Direction	Town	Log Mileage
090901	AC-20	Eastbound	Colchester	26.76 – 26.95
090902	PG 64-28	Eastbound	Lebanon	28.77 -28.96
090903	PG 64-22	Eastbound	Lebanon	29.83 – 30.02
090960	AC-20 (w/RAP)	Westbound	Lebanon	30.02 – 29.83
090961	PG 64-28 (w/RAP)	Westbound	Lebanon	28.53 – 28.34
090962	PG 64-22 (w/RAP)	Westbound	Colchester	27.40 – 27.21

Historical Materials Data

Historical materials information and test data were required for experiments involving existing pavement structures. This work for the GPS was conducted by ConnDOT Engineers who spent many hundreds of hours retrieving historical maps and paper-based materials data, records, and querying information from engineers who had first-hand knowledge from the original construction. In some cases the historical data no longer existed. In general it is ConnDOT policy to discard routine materials testing documents after seven years. The materials data were formatted according to SHRP protocols and submitted through the Regional Contractor.

Materials Data/Coring

Field-testing of the test sites were conducted after the sites were marked. Field-testing included excavation of both pavement and subbase materials and split-spoon sampling to confirm the in-place materials. The initial samples were sent for testing and storage at the National Materials Testing Library (MRL), under SHRP.

State Support

In support of the LTPP test program it was the responsibility of the State to conduct the traffic data collection, friction testing, signing and marking, upkeep of sites, and coordination of the traffic protection (shown in Image 9) for all tests performed periodically by the Regional Contractor requiring lane closure. In addition, after LTPP became part of FHWA in 1998, the states were responsible for some materials sampling and materials testing from rehabilitated sites. ConnDOT conducted friction testing at the test sites from 1988 until 1998, when it was no longer requested by the administrators of the FHWA LTPP program.

Image 10: ConnDOT Providing Lane Closure for LTPP FWD and Distress Survey Manchester, CT (Site 094008)

Traffic Data at SHRP LTPP Sites

The collection of continuous weigh-in-motion (WIM) traffic data at the test sites was identified as the desirable level of traffic data collection by SHRP-LTPP. Test site 094008 was designated as the Regional WIM monitoring site. It was recognized that the need to collect data corresponded with the need to evaluate the WIM equipment. At the time, 1987, low-cost piezoelectric WIM systems were new to the marketplace. ConnDOT established a Research Study, HPR-1411, “Evaluation of a Piezoelectric Weigh-In-Motion System,” with the objective “to evaluate the accuracy, reliability and survivability of piezoelectric systems placed in various types of Connecticut pavements under actual traffic conditions.” Results from this study identified needs for calibration of the WIM systems using trucks of known weight and of the systems' problematic dependency on temperature. Findings from this work were presented for the LTPP audience at the National Traffic Data Acquisition Conference (NATDAC) 1994. Experience presented at NATDAC '98 entitled, "Calibrating WIM Sites in Connecticut" was presented as part of a session entitled, "Lessons Learned from the LTPP Project." A presentation entitled, "Collecting Quality Traffic Data for LTPP – Overcoming the Challenges," was provided by ConnDOT personnel at "Improving Pavements with LTPP: Products for Today and Tomorrow" Conference in Irvine, March 1996. The work conducted was summarized in CT report, "Evaluation of a Piezoelectric Weigh-In-Motion System – Final Report," /14/ Additional findings from this work were shared through participation on the LTPP Expert Task Group on Traffic Data.

The need for improved traffic data collection options for the SPS 9A test site was the incentive for personnel from ConnDOT research to install and evaluate sensors under CT Project SPR-2306, which was partially funded by the FHWA-PTP (Priority Technologies Program) and entitled, "Installation and Evaluation of a Weigh-In-Motion System Utilizing Quartz-Piezoelectric Sensor Technology." Interim findings from this study located at the SPS-9 site on CT Route 2 in Lebanon, were published in the report, "Second Interim Report on the Installation and Evaluation of Weigh-In-Motion Utilizing Quartz-Piezo Sensor Technology." /11/ Information regarding this study was presented at NATMEC 1998, NATMEC 2000, the Northeast Regional LTPP Meeting 1999, NATMEC 2002 and the International Weigh-In-Motion (ICWIM3) Conference. A final report is expected to be available in 2004.

Image 11: Installation of Traffic Monitoring Equipment at CT SPS 9A Site, October 1997

Rehabilitation of Test Sites

Because LTPP is a twenty-year program and the General Pavement Study (GPS) Experiment is a study of existing pavements, most of the test sections have undergone rehabilitation treatments, as may be expected. Each of the rehabilitations was conducted in accordance with FHWA procedures and protocols. Profile, manual distress surveys and FWD testing are conducted both before and after the rehabilitation treatments. The appropriate materials sampling was conducted (either cores or bulk samples) and were either sent to the LTPP laboratory or tested in-house. Each step of the rehabilitation process was documented according to LTPP protocols for materials sampling and testing.

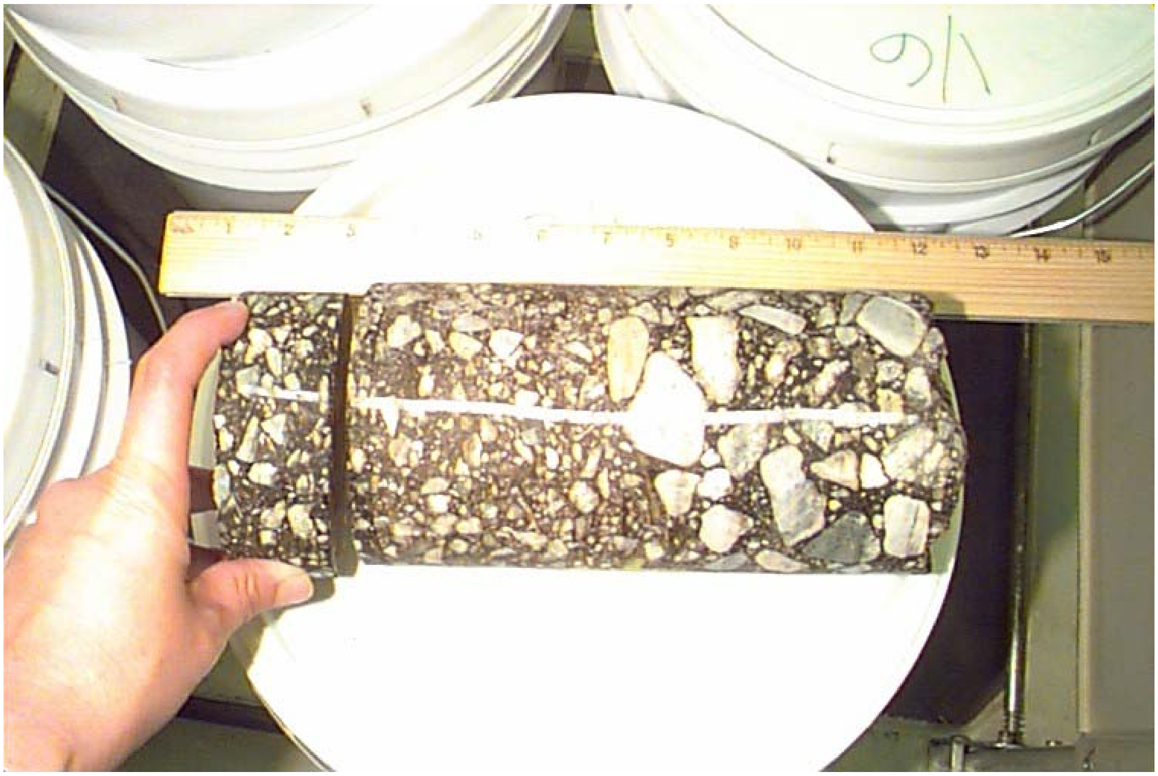

Image 12: Preparing Core Sample According to LTPP Protocols

When the test sites were established, the nearest weather stations and site locations were identified and established and documented by LTPP.

Seasonal Monitoring Testing

The Groton test site (091803) was selected to be a seasonal monitoring test site as part of the LTPP Seasonal Monitoring Program (SMP). Initial installation of instrumentation and collection of samples was conducted on August 18, 1993. The installation consisted of the digging of a test pit downstream from the LTPP test area, soils sampling was conducted and instrumentation was installed which allowed for the monitoring of moisture levels using electrical resistivity probes down to 6.43 feet (1961 mm). In addition, a water monitoring well and weather station with tipping bucket were installed adjacent to the test pit area.

Under this program, testing consisted of downloading the continuously collected weather and moisture data, in conjunction with falling-weight (FWD) testing fourteen times a year. The monitoring test periods were October 15, 1993 to June 22, 1995 and from October 8, 1996 to October 16, 1997. The Northeast Regional Coordination Contractor's (ITX Stanley, AKA Stantec Consulting) LTPP Team conducted the testing and data collection and processing. They coordinated with personnel at ConnDOT who provided extended hours for lane closures each time FWD testing was necessary. The seasonal monitoring equipment at the Connecticut site operated without failure for the duration of the experiment. In addition, personnel from ConnDOT areas of maintenance, soils, materials and research provided services for the installation services, excavation and pavement repairs. Details from the installation were recorded in the FHWA-LTPP report, "LTPP Seasonal Monitoring Program – Site Installation and Initial Data Collection, Section 091803, Groton, Connecticut." /12/

Pilot Post-Seasonal Monitoring Data Collection Test Site

In 2000, site 091803 was scheduled for rehabilitation in the form of an overlay and, therefore, the end of the seasonal monitoring testing. After communication with FHWA-LTPP, it was determined that it would be worthwhile to conduct the first seasonal monitoring post-"forensic" test called "out-of-study" data collection prior to site rehabilitation. Therefore, excavation and testing of the site was conducted on May 2, 2000. Materials were sent to the LTPP laboratory to conduct the soils testing. Other materials testing were conducted by ConnDOT, including field nuclear gage testing. Soils sampling, lane closures and pavement repairs were all conducted by ConnDOT employees. The work was documented through photographs and videotape. See Images 12, 13, 14 and 15 from the Seasonal Monitoring Program Testing. Details from this work are published in the report, “LTPP Seasonal Monitoring Program Supplemental Data Collection Prior to Site Rehabilitation Section 091803, Groton Connecticut.” /13/ This served as the pilot for additional post-experiment testing of seasonal monitoring sites. Much of the organization and procedures, including the material sampling, labeling and testing established at the Connecticut site provided the basis for the program at other locations.

Image 13: Excavation by ConnDOT for Post Experimental Seasonal Monitoring Testing

Image 14: Post Seasonal Monitoring Testing, ConnDOT soils sampling (Site 091803)

Image 15: Post Seasonal Monitoring Testing – Image of Large Cobbles Detected

Image 16: Post Seasonal Monitoring Testing – Image of the Probes Prior to Removal

Availability of Resources

The success of any research program is dependent upon many factors, including the availability of resources, namely funding and personnel. In 1991 the Connecticut Department of Transportation experienced fiscal constraints that directly impacted our ability to commit to SHRP study participation. As a direct result, we did not participate in the following projects: SHRP-H-208, “Development of Anti-Icing Technology;” SHRP A-003A, “Performance-Related Testing and Measuring of Asphalt-Aggregate Interactions and Mixtures;” and, the field validation phase of SHRP C-101, “Assessment of Physical

Conditions of Concrete Bridge Components, Subtask C-1: Membrane Integrity and Effectiveness."

In 1988 the electrochemical chloride extraction (ECE) technology was another example of an opportunity the Department was unable to participate in due to fiscal constraints. Personnel from ConnDOT's Office of Bridge Maintenance identified a project and expressed a strong interest in utilizing ECE technology, but it was not pursued, due again to fiscal constraints.

Similarly in the early 1990's when ConnDOT experienced a downsizing of its workforce, a reduction of Departmental committees was advocated. Therefore, a Departmental SHRP Products Task Force, as recommended by the FHWA Implementation Plan, FHWA-SA-93-054, /8/ was not instituted.

SHRP Related Research

Connecticut has been a participating member in twenty-three other studies which were initiated independently, but as a result of the SHRP program's work. These include work done through the Connecticut State Planning and Research Program, Pooled Fund Studies, the Connecticut Cooperative Highway Research Program, and the New England Transportation Consortium. The benefits of the work fostered by the SHRP program should be considered when assessing the benefits of the program. In addition, the positive experiences gained through participation in SHRP programs extended the willingness of personnel to work with other States in other collaborative efforts, such as pooled fund studies. Table 6 lists research projects on which the Connecticut Department of Transportation was or is a participating member. The projects are listed according to research program.

Table 6: Connecticut's Involvement in SHRP Related Research Projects
Status March 2004

PROJECT TITLE	PROJECT NUMBER	STATUS
State Planning and Research		
LTPP (Long-Term Pavement Performance) Coordination in Connecticut	SPR-2108	Active
Demonstration and Evaluation of Superpave Technologies	SPR-2219	Completed
Implementation of Personal Digital Assistant (PDA) Devices for Superpave Field Data Collection	SPR-2228	Active
Development and Implementation of a Highway Construction Quality Assurance Program for the Connecticut Department of Transportation, Phase 1 – HMA Concrete Construction	SPR-2230	Active
Connecticut Advanced Pavement Laboratory (CAP Lab) at the University of Connecticut	SPR-2305	Active
Installation and Evaluation of Weigh-in-Motion (WIM) System Utilizing Quartz Piezo Sensor Technology	SPR-2306	Active
Pooled Fund Studies		
Validation of SHRP Asphalt and Asphalt Mixture Specifications Using Accelerated Loading	SPR-2(176) Awaiting call from Kevin Sheart, FHWA	Work completed – Final report pending
SHRP Implementation of Asphalt Test Equipment	HPR-0002(800)	Active

Table 6: Connecticut's Involvement in SHRP Related Research Projects (Continued)

New England Transportation Technical Certification Program (NETTCP) – Course Development	SPR-3(041)	Completed
Northeast Center for Excellence in Pavement Technology (NECEPT)	SPR-3(056)	Work completed – Final report pending
Dynamic Modulus (E*) in Hot Mix Asphalt Designs	SPR-3(084)	Completed
LTPP specific Pavements Study (SPS) Traffic Data Collection	TPF-5(004)	Active
Computer-Based, Self-Operating Training System on Anti-Icing/Road Weather Information Systems (AI/RWIS)	TPF-5(009)	Active
Full-Scale Accelerated Performance Testing for Superpave and Structural Validation	TPF-5(019)	Active
Coordination of Pavement Activities in the Northeast	TPF-5(062)	Active
Connecticut Cooperative Highway Research Program		
Development of a Test to Measure the Tendency for a Hot Mix to Segregate	JH 98-1	Completed
Determination of PG Binders to Use in Hot Mix Containing RAP	JH 99-1	Completed
New England Transportation Consortium		
Implementation of SuperPave	96-1	Completed
Evaluation of Permeability of SuperPave Mixes	00-2	Completed
Portable Falling Weight Deflectometer Study	00-4	Active
Development of a Testing Protocol for QC/QA of Hot Mix Asphalt (HMA)	01-2	Active
Design of SuperPave Hot Mix Asphalt for Low Volume Roads	01-3	Active
Establishing Subgrade Support Values for Typical Soils in New England	02-3	Active

Historical Perspective

Numerous developments have occurred in technology, transportation, and society since the inception of SHRP in the 1980’s. A brief review of some of the changes with computer technology, materials, communications and transportation is offered to better appreciate the programmatic choices and gauge the program’s influence. Dramatic changes occurred in the development and emergence of computer technology. Data processing capabilities and computer technology simply exploded. A couple of examples worth citing: In 1981 IBM introduced the personal computer (PC), priced at $2880 (US), equipped with 64 KB of RAM. The processing capabilities released in 1986 by Apple included up to 4 MB of RAM /19/. Although the computing capabilities were relatively expensive and limited at the time, SHRP and in particular LTPP correctly relied upon the forecasted future advances in technology to make analyses practical and concentrated on the gathering of data to support future work. By the end of the initial five-year experiment in 1992, the desktop computer had become commonplace and local area networks were emerging. These technologies aided in the first data analyses from the SHRP program, as well as in the improved processing abilities and reduced cost for numerous and varied field data collection systems.

Technological advancements to the areas of materials are notable. New materials continue to be developed today with the constant advent of new polymers, practices and applications. The evolution of traditional materials continued as well. At the end of SHRP, the market offered materials with improved functional capabilities, for example, higher strength. Advancements in materials were essential to the high-tech processing and communication development during this era.

Improvements to communications have enabled the transmittal of information quickly and easily. New communication technologies have enhanced not only the data collection and computational tools, but also the ability to administer the programs, exchange ideas and disseminate results. Improvements that have transpired since the inception of SHRP include: fiber optics which have enabled the transmittal of large amounts of data over longer distances; improved satellite technologies; wireless networks; and, of course, the revolutionary world wide web (www). A facsimile (fax) machine was not introduced into the State of Connecticut Research and Materials Testing Laboratory until the early 1990's and electronic mail (E-mail) was first available for ConnDOT Research Engineers as a tool in September 1995. When SHRP began, the typewriter was still used to produce correspondence, which was subsequently mailed via the postal system. This greatly influenced the time needed to coordinate activities.

The role of transportation in our society continues to evolve. Our highways carry more traffic and a greater percentage of trucks than any time in history. Since the beginning of SHRP, vehicle-miles have dramatically increased for all types of trucks and passenger cars. For example, according to the Bureau of Transportation Statistics, in 1980 there were 68,678 million vehicle-miles driven by combination trucks, in 2000 that number climbed to 135,208 million vehicle-miles, an increase of almost 200%. These types of increases in traffic and highway use only further substantiate the need and timeliness of SHRP and LTPP. A practical reality is that higher volumes of traffic have made the field environment increasingly dangerous to collect data. The use of non-intrusive technologies has become necessary for safety purposes. LTPP demonstrated a few of these technologies and enabled states to gain valuable experience in this now needed subject.

In many ways, the timing of SHRP paralleled a paradigm shift in our society. As a society, new technology has permeated many aspects of daily living at an exceptional rate. SHRP was designed specifically to make up for years of too little activity in targeted research areas of transportation, compared to other industries. Years of inactivity not only created a lack of innovation, but also influenced the practitioners' mode of thinking and common practice. Initially many practitioners routinely relied upon tradition or "that's the way we've always done it" approach. During the SHRP years, an inundation of new ideas and methods forced many practitioners to consider change. In some cases, innovation was not initially embraced due to skepticism of change. With time and the realization that change was all around them, many people became more receptive to the adoption of innovations.

The importance of how SHRP acted as a catalyst for innovation cannot be overstressed. History provides us with numerous examples, many rooted in government programs, when cascades of derivative products are realized over many years that have a greater impact than the initial vision encompassed. Back in 1890, a Census Department employee, Mr. Herman Hollerith, won a competition to find a better method to process census data. At the time, few could have envisioned the far reaching importance of his original work that would ultimately lead to the creation of the Tabulating Machine Company (1911), later to become the International business Machine (IBM Corporation, 1924) who developed the personal computer (PC). /19/ Perhaps SHRP has inspired a future Mr. Hollerith to incorporate innovation into practice, not to be measured by written implementation surveys or financial statements, but rather by time and history.

Lessons Learned

Product-Driven Research Program Considerations

Terminology

SHRP research was launched as "tightly focused on development of pragmatic products of immediate use to highway agencies." */18/* The term "product" was used in its most broad and literal sense: "A direct result; consequence" */2/* to describe the many outputs from research efforts. Outputs from the SHRP research work were commonly reports (which included findings), devices, computer programs and test methods. During the implementation and distribution of information we learned that the connotation of the term "products" was routinely limited to mean a tangible object or goods. A considerable amount of effort was necessary at the state level to clarify this point.

Similarly, during the introduction of products at the state level we also learned that the term "implementable" was problematic. The term "implementation" is defined as "to put into practical effect; carry out…" /2/ and similarly defined by SHRP in their Implementation Plan /8/ "bringing into practice and carrying out the means to bring into practice." The term "implementable" was commonly misinterpreted to mean "consumer ready" or "shrink-wrapped." Communication became required routinely to convey that the SHRP products were at different levels of readiness. In some cases the products had undergone extensive field testing and modifications. In other cases, however, the products were still being revised in response to the problems encountered by early adopters. Many practitioners did not consider products ready for implementation until they were accepted as standards by the appropriate organization or authorities, such as MUTCD or AASHTO. The process to create, review, approve and accept standards can be lengthy. The products need to be at an expected level of readiness in order to gain acceptance. This became a common impediment to broad acceptance and implementation.

The term “SuperPave,” that was used as the acronym for “Superior Performing Asphalt Pavements” /17/ was at times misleading. Some end-users developed expectations based on the interpretation of “super” meaning, “superhuman,” or “above or beyond the human or divine.” This example shows how the terminology itself may have established inflated expectations, as was often discussed among practitioners.

Tracking of Products

An important lesson learned was the value of consistent tracking and numbering of the research products. Early in the program, products were given different numbering schemes. As databases and web sites became more commonplace, improved methods of record keeping and communication evolved since the inception of SHRP. At ConnDOT a simple database was developed to log and track materials, as well as responses. Even today, as the products have become mainstreamed and are adopted by organizations such as AASHTO, there is often difficulty at the State level to determine the correlation between the original research and the results that have developed into standards and practices. Emphasis needs to be placed on keeping information up-to-date and determining the proper forums and permanent location(s) for the information. For a period of time, FHWA contracted to establish a SHRP Clearinghouse. Washington State DOT then used their Web Site to house the majority of the product information. Consideration is needed to determine how to keep or make information available when Web sites are no longer supported or updated.[1] The NCHRP website serves as a valuable resource, housing all the SHRP reports for on-line access. Research that was not completed or considered unsuccessful can also be of use and should also be made available, so that valuable time and money is not spent to repeat the same work.

Retrospect on a Product-Focused Program

The emphasis on product-driven research was both beneficial and detrimental to SHRP. Some people at the state level were pleased to see a catalog of products /17/. The pictures of well defined items led potential users to directly identify and rapidly assess the products. The immediate response was positive. This may have been because the pictures provided a visual confirmation to the recipients that they were achieving a return for their investment. On the other hand, the product-driven concentration of SHRP may have provided too rigid a focus for the measurement of its success. That is, if few products are implemented, the program itself appears less than successful. There are only several identifiable areas of SHRP product success in Connecticut. Though seemingly straightforward, tallying the number of products implemented at the state level does not take into account the more intangible effects of the program on the transportation community

[1] March 2004: The Washington State DOT (WSDOT) web site was reconstructed and the SHRP Clearinghouse information was eliminated. WSDOT personnel were contacted and it was determined that the data were not saved.

and society as a whole. Although it may never be packaged as a product or cataloged for inventory, much of the progress achieved from SHRP may be realized in the form of how we conduct work and on our perceptions of the key issues in this field.

Key Factors to Successful Product Implementation

Through the implementation efforts at the state, experience was gained regarding key factors that contributed to the successful implementation of products from SHRP research. These factors include if the product:

1. Had a previously recognized or perceived benefit
2. Cost was in an anticipated range
3. Had a proven record with other state agencies
4. Was developed to a stage that satisfied user expectations
5. Was accepted or recommended by a respected stakeholder or standard-setting organization
6. Was readily available for trials.

There were elements of the program that were beyond the technical specifications. One such element was the importance of key personnel at the State level for the implementation and adoption of products and to the overall program success.

Program Lessons

Over the course of SHRP it became evident that the design of SHRP emphasized key elements that fostered success. This program design contributed to its achievements at the state level too. At the state level, the elements of partnership, program credibility and allocation of resources greatly facilitated the multi-year effort. In retrospect SHRP was indeed required to be a partnership to integrate activities at many levels. It was essential that all parties were dedicated to their role, whether financial, participatory or decision-making, in order to have a chance to profit from the research. Many state highway employees were more receptive to the program after the experience of contributing directly to the program through the experiments. Stakeholder involvement in the national program was particularly vital. Our experience confirmed the importance of the SHRP state representative to be at an appropriate level within their organization, to have the authority to make decisions and opportunities to communicate with other agency decision makers, as designed in the initial program. In addition we learned how important it was that the stakeholders were personnel who shared the projects' interests and goals and kept technically and organizationally apprised to make the projects a priority.

Our experience also confirmed how important the allocation of resources at the state level was to properly support the needs of a "National" program. SHRP and LTPP efforts required substantial state support including: communication, responses to surveys (too numerous to count), field coordination (including lane closures), technical support, training, facility trials, and hosting demonstrations.

Adequate staffing needed to be available to properly complete work tasks. Continuance of personnel was important to the program. In Connecticut, we were fortunate to have maintained consistency through the same personnel over many years. Therefore, training and retraining was not as critical in the central organization (as was the case in other states). This was also true at the Regional Contractor, where continuation of key personnel was important to the SHRP and LTPP programs. For the length of LTPP however, a twenty-year program, support for a continued effort required great vigilance. For example, to address employee turnover issues at maintenance garages, which maintained the LTPP test sections proved to be necessary. For this reason, communication was essential, including periodic or fact-to-face meetings to increase awareness of the LTPP tests within the new personnel’s jurisdiction. Our experience showed that the time spent communicating the relevance of the test sections and the contribution of their work to the National program with the people involved with the field tasks (lane closures, patching, etc.) was well spent. The prospect of contributing to a long-term program of national benefit generated excellent contributions and long-term dedication by many personnel from ConnDOT’s highway maintenance garages.

The credibility of the program was indeed essential for both product adoption and continuance of the long-term elements of SHRP. The advocacy of the program at many national forums reached a wide audience. For example, AASHTO provided SHRP a unique forum to generate interest, as well as credibility. This was a needed compliment to the coordination efforts at the State level. On several occasions, ConnDOT senior-level executives expressed interest in the program based on information received at AASHTO forums.

Program Expectations and Assessment

As part of the implementation at the state, clear communication regarding the intent, purpose and expectations of each research topic was necessary. Based on early SHRP project catalogs and marketing, many end-users anticipated one-hundred percent success for the products of interest to them. This was an unrealistic expectation. As part of the local presentations on SHRP, it became necessary to explain that not only is there an expected return from research, but there is also an assumed risk involved. Communication included that there will be winners and losers from SHRP, and that hopefully the overall benefits will outweigh the costs and risk.

Nationally, it was anticipated SHRP would have an impact on the highway industry and practice. To determine whether the benefits of the program exceeded the cost, an assessment project was conducted under contract by FHWA in 1996 and 1997. Information was gathered on the use of SHRP products. Parts of the assessment project are summarized in FHWA publication, “Assessing the results of the Strategic Highway Research Program,” /7/ This program assessment shows that the economic benefits outweighed the initial investment with a substantial return. Of the research addressed in the FHWA report, ConnDOT has adopted several products including the SuperPave System and the Roadway Weather Information System (RWIS). The Department is still moving towards full adoption of these two products through an implementation process that will continue to take more years. Additional years of experience are necessary to determine the cost savings from the implementation of these products.

Future national-research efforts should include a formal mechanism to identify and evaluate new directions of innovation that emerge during the research itself. Depending on the significance of the trends discovered, this process may result in having specific program objectives periodically revisited to ensure that the program is effective as a whole.

The SHRP experience also served as an excellent “primer-to-research” at the state level. The SHRP program was designed specifically to make up for years of too little activity in targeted research areas of transportation, compared to other industries. During the SHRP years, an inundation of new ideas and methods forced many practitioners to consider change.

Transportation Research

One of the most important lessons learned from SHRP was that it is possible to successfully conduct a large-scale concentrated National/International transportation research program. Conversely, at the State level the benefits of being a stakeholder in such an effort were demonstrated. SHRP will undoubtedly serve as the model for future programs. SHRP did not solve all of our complicated highway problems; it was not designed to be an all encompassing program. Sizable goals were however achieved. One of the most significant achievements of SHRP was creating a foundation for future work and progress. In fact, the original STRS program report recognized and recommended that, "other areas are clearly deserving of research." /3/ SHRP fostered communication between and within organizations that was and continues to be fruitful for other efforts. SHRP has undoubtedly activated the transportation community to seek innovations and improvements instead of accepted practice. And so, to revisit the SHRP program is to ask if the original program purpose achieved its goal "at closing specific technological gaps." /3/ SHRP has definitely made great strides in advancing the state-of-the-art in highway engineering practices at the State level. Moving forward, there are benefits in assessing the development of technological progress in the transportation field. This could be achieved by comparing the industry's performance in this regard, against appropriate benchmarks that characterize the advancement of science and technology as a whole.

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Rev. Date 11/99

Connecticut Special Provision

ITEM #0981101A – OPPOSING TRAFFIC LANE DIVIDER

Article 9.82.01 – Description:
This item shall include furnishing, installing, resetting, and removing Opposing Traffic Lane Dividers. Opposing Traffic Lane Dividers will be used to separate opposing traffic on two-lane two-way roadway. The legend on the Divider shall be two opposing arrows.

The Opposing Traffic Lane Divider shall meet the requirements of Federal Highway Administration's Strategic Highway Research Program (SHRP). The Opposing Traffic Lane Divider shall be 12 inch wide by 18 inch high sign panels mounted back to back on a flexible support post. The post shall be mounted to a base.

A series of these devices shall be placed on the center line of a temporary two-way operation. The support shall be designed to recover automatically to a vertical position if struck by a vehicle.

The opposing Traffic Lane Divider is covered in Section 6F-8.f. of the revised Part VI of the Manual on Uniform Traffic Control Devices.

Article 9.82.02 – Materials:

1) Panel – the vertical panel shall be constructed of a flexible material resistant to ultraviolet light, ozone and hydrocarbons. The surface shall be smooth and suitable for adherence of appropriate reflective sheeting. The reflective sheeting shall be Type III or Type VI reflective sheeting in accordance with Section M.18.09.01.

2) Support Post – The support post shall be made of a material resistant to ultraviolet light, ozone, and hydrocarbons. The post shall have sufficient stiffness to remain rigid in windy conditions. The support shall be designed to recover automatically to a vertical position or manually restored (when fastened to the roadbed), if struck by a vehicle.

3) Base – The base shall consist of a metal ballast plate fastened to a rubber base. For long-term use, the metal ballast plate can be fastened directly to the roadbed. When fastened to the roadbed, the post will need to be manually reset when hit. The base shall meet the requirements of the Federal Highway Administration's Strategic Highway Research Program (SHRP).

Article 9.82.03 – Construction Methods:
The Opposing Traffic Lane Dividers shall be spaced every 30 feet apart or a directed by the Engineer. The Contractor shall insure that the devices are kept clean and bright. Any devices that are missing, damaged, or defaced so that they are not effective, as determined by the Engineer and in accordance with the American Traffic Safety Services Association (ATSSA) guidelines contained in "Quality Standards for Work Zone Traffic Control Devices," shall be replaced by the Contractor at no cost to the State. When no longer required, they shall remain the property of the Contractor.

Article 9.82.04 – Method of Measurement:
This work will be measured for payment by the number of opposing traffic lane dividers furnished, installed and accepted on the project. Replacement devices shall not be measured for payment. Devices relocated to a different location in accordance with the Engineer shall not be measured.

Article 9.82.05 – Basis of Payment:
This work will be paid for at the contract unit price each for "Opposing Traffic Lane Divider" which price shall include all materials, equipment, tools, labor and work incidental to furnishing, installing, maintaining and removing the units.

SHRP ASPHALT PRODUCTS

SHRP No.	Product Name	Description	In Practice	Tried	Not Used
1001	Binder Specification		X		
1002	Bending Beam Rheometer	This test method and equipment is used in conjunction with the SHRP Binder Specification. Specifically, it is designed to determine an asphalt binder's resistance to low temperature cracking.	X		
1004	Asphalt Extraction & Recovery				X
1005	Low-Temperature Direct Tension Test	This equipment is used in conjunction with the SHRP Binder Specification. Specifically, it is designed to determine an asphalt's resistance to low temperature cracking. This test is a referee test to the Bending Beam Rheometer	X		
1006	High Temperature Viscosity Test	This test method and equipment is used in conjunction with the SHRP Binder Specification. Specifically, it is designed to measure the asphalt's handling characteristics during mixing and compaction.	X		
1007	Dynamic Shear Rheometer	This equipment is used in conjunction with the SHRP Binder Specification. Specifically, it is designed to determine an asphalt binder's resistance to rutting and fatigue.	X		
1009	Binder Chromatography				X
1010	Refiner's Guide				X
1011	Mix Specification		X		
1012	Superpave Mix Design System	This manual and computer program integrates SHRP's asphalt research and permits asphalt mix design using the performance-based binder and mix specifications.			X
1013	Net Adsorption Test				X
1014	Gyratory Compactor and Method	This equipment is used in conjunction with the SHRP SUPERPAVE System. Specifically, it is designed to better simulate field compaction and determine engineering properties and particle alignment of field and laboratory compacted specimens. It also provides real time determination of specific gravity and air void content during compaction.	X		

1015	Rolling Steel Wheel Compaction Method				X
1017	Shear Test and Device	This equipment is used in conjunction with the SHRP Superpave System. Specifically, it is designed to determine whether an asphalt mix will be prone to rutting or fatigue problems.			X
1019	Flexural Fatigue Life Test				X
1021	Thermal Stress Restrained Specimen Test				X
1022	Indirect Tensile Creep and Failure Test	This equipment is used in conjunction with the SHRP Superpave System. Specifically, it is designed to determine the indirect tensile creep and strength properties of asphalt mix samples.			X
1024	Environmental Conditioning System				X
1025	Short-Term Aging		X		
1026	Modified Rice Correction Test				X
1030	Long-Term Aging				X

1017] Consideration was given to each of the a.c. products. Those in practice represent the most practical applications both in terms of testing and cost at the State level.

SHRP CONCRETE AND STRUCTURES PRODUCTS

SHRP No.	AASHTO No.	Product Name	Description	In Practice	Tried	Not Used	Comments
2001	TP11	Corrosion Rate Method	This equipment measures the corrosion rate of reinforcing steel.			X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
2002	TP12	Aggregate Durability Test	This test method measures the susceptibility of aggregates to D-Cracking. It may be a substitute for the current test method for freeze-thaw resistance.			X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
2003		Concrete Removal Manual				X	
2004		Mitigation of D-Cracking				X	
2005		Handbook for Mix Design				X	
2006		Guide to Thermal Effects	Tables are used to assess whether conditions are appropriate for curing.			X	
2007	TP13	Permeability Laboratory Test				X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
2008		Fluorescent Microscopy Manual				X	
2009	TP14	Screening Reactive Aggregate Test	Rapid version of Mortar Bar Test, (AASHTO TP14) measures expansion.			X	
2010		Manual for ASR Detection				X	Useful to states with ASR problems.
2011		ASR Mitigation in Existing Concrete				X	
2012	TP15	Flaw Detection by Impact Echo Method			X		Used as a special provision.
2013	TP16	Chemical Test for ASR Detection				X	Useful to states with ASR problems.

2014		High-Performance Concrete Specifications		X			Being incorporated into some bridges.
2015	TP36	Radar Method for Asphalt Decks	This equipment consists of a van, 3 GPR units, computer hardware and software, distance and signal measuring units, and master control unit. By emitting and analyzing radar pulses, this unit can determine the condition of a concrete deck beneath asphalt overlays.			X	
2016	TP37	Membrane Integrity Survey Method	This modified, non-destructive test method uses ultrasonic pulse velocity as an indicator of membrane condition.			X	
2017		ASR-Safe Mix Designs				X	
2018	TP17	Modified Freeze and Thaw Test	This test method provides an alternative freeze-thaw test which simulates real conditions.	X			As ASTMC-666-97
2019	TP18	Soundness Test for Concrete				X	
2020		Air Entrainment Specifications				X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
2021	MP3	PCC Aggregate Specifications				X	
2022	PP27	Guide to Strength/Maturity	This is a guide for estimating the early-age strength of newly constructed concrete structures in the field.			X	
2023	TP19	Flexural Strength Test				X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
2024	TP20	Compressive Strength Test				X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.

SHRP CONCRETE AND STRUCTURES PRODUCTS

2025	TP21	Interfacial Bond Test				X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
2026	P22	Permeability Test-Electrical Resistance	Test method to determine concrete permeability.			X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
2027	TP23	Fresh Concrete Water Content Test	Rapid field test to determine water content in concrete using microwave drying.			X	
2028	TP24	Test for Consolidation	Field test to determine concrete consolidation.			X	
2029	TP35	Sealer Effectiveness Methods	There are two tests (Electrical Resistance Test and Water Absorption Test) to determine if a sealer has been properly applied, or if a previously applied sealer is no longer doing its job and needs to be reapplied.			X	
2030	TP25	Chloride Content Test	Field equipment used to determine chloride content in concrete.			X	In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
2031	TP26	Permeability Test Surface Air Flow Method	Can be used for field determination of concrete permeability.			X	
2032	PP23	Bridge Condition Evaluation Manual	This manual gives step-by-step guidance on methods to detect deterioration in reinforced and pre-stressed concrete structures.			X	
2033		Manual on Chloride Removal	This manual describes the non-destructive removal of chlorides from concrete.			X	
2034	MP5	Cathodic Protection Manual		X			CT first installed cathodic protection in 1985 and continued to do so. Study sites in CT included in study.

2035		Manual on Rapid Repair of Bridge Decks				X	
2036		Field Guide on Bridge Rehab and Protection				X	
2037		Manual for Selecting Bridge Rehab and Protection Options	This manual provides information on costs, service life and technical viability on a wide range of techniques for protecting or rehabilitating an existing concrete bridge. The manual covers both decks and substructure elements.			X	
2038		Computer Program for Bridge Rehab and Protection Options				X	
2039		HWYCON-Concrete Expert System			X		Very basic, may be useful as a teaching tool.
2040		Guidelines for Cathodic Protection	This guide presents time-dependent criteria that optimize Cathodic protection.	X			CT sites included in SHRP study.
4001		Measuring Air Entrainment					In accordance with FHWA Guidelines, we utilize standard AASHTO test methods.
4003		Monitoring Cathodic Protection		X			CT sites included in study.
4009		Repairing Marine Structures	This guide describes using passive, arc-sprayed zinc anodes to retard corrosion of reinforcing steel in reinforced concrete structures.			X	

SHRP HIGHWAY OPERATIONS PRODUCTS

SHRP No.	AASHTO No.	Product Name	Description	In Practice	Tried	Not Used	Comments
3001		Snow Fence Guide				X	
3003		Pavement Repair Materials Guidelines	This set of four field practice manuals describe how to use improved and innovative materials and cost-effective procedures for pavement surface repairs.	X			As a reference
3004		Robotic Crack Filling Vehicle	Equipment designed to clean and fill cracks automatically, thereby improving the crack sealing process and reducing worker exposure.			X	
3005		Robotic Pothole Patching Vehicle	Equipment designed to clean, dry, square, and fill potholes automatically.	X			7 Units In Use
3008		Ultrasonic Intrusion Alarm				X	Vendor Demonstrations;
3009		Queque-length Detector				X	
3010		Infrared Intrusion Alarm	These products provide audible alarms for the purpose of alerting highway workers of errant vehicles traveling through a coned off work zone. In addition, on product provides a visual alarm for workers wearing ear protection and also activates any radar detectors in approaching vehicles.			X	Vendor Demonstrations; Safety was interested in buying some- but never did.
3011		Opposing Traffic Lane Divider	Device helps motorists safely stay in designated travel lanes through work zones. The device consists of a W3-3 type two way traffic symbol mounted on a flexible post and affixed to the pavement between opposing flows. The device is proposed as an alternate to tubular markers.	X			ConnDOT Traffic used on full depth construcion projects as a Special Provision. Special Provision provided in Appendix A.

3012		Multi-Directional Barricade-Sign	This directional barricade sign is a plastic collapsible, three piece unit. The device has a (W1-11/12 type) arrow panel on top of a normal reflectorized barricade panel. The patented detent mechanism feature enables the SafetyCade to hold a rigid vertical position until impact. When it goes down, SafetyCade stays down, eliminating the danger of moving into other lanes of traffic.		X		ConnDOT Research purchased and Maintenance used one set for field trial purposes.
3013		Remotely Driven Vehicle	Dump truck modified to be operated remotely, which can serve as a shadow vehicle for construction or maintenance sites without exposing driver to traffic hazards.			X	Demonstration held ConnDOT 1995.
3014		Portable Crash Cushion	A cluster of sand-filled barrels for the protection of work crews designed for one person deployment in maintenance type lane closures. Transported and positioned by tilt-bed trailer equipped with powered winch.			X	
3015		Portable Rumble Strip	The portable rumble strip alerts drivers when they are approaching a highway work zone. As vehicles travel over the strip, an audible rumble and noticeable vibration in the steering wheel focus the driver's attention onto the driving task and makes them more receptive to traffic control.			X	ConnDOT Maintenance expressed interest; not used due to the poor performance of test models

3016		Flashing Stop/Slow Paddle	This product is similar to paddles commonly used by flaggers at work zones, but conspicuity is enhanced by two high intensity lamps mounted on the stop side of the paddle. When the flagger presses a button on the handle, the lights alternately flash ten times in a short sequence. Preliminary tests have demonstrated that this device got the driver's immediate attention and hastened braking action.			**X**	ConnDOT Research offered to purchase; offer declined by Maintenance
3017		Portable All-Terrain Sign Stand		**X**			Adapted product in-use
3018	TP49	Radar for Pavement Subsurface Condition	This equipment consists of trailer mounted radar and computer equipment. The unit emits and analyzes radar pulses, and determines subsurface conditions that lead to pavement distress.			**X**	
3019		Seismic Pavement Analyzer Method	The SPA uses five different seismic wave analyses techniques to measure localized pavement conditions. The purpose is to identify, measure, and diagnose early symptoms of conditions that could lead to pavement distress. This device is more appropriate to evaluating specific sections of pavement rather than entire road networks.			**X**	
3020	PP29	Handbook on Deicer Test Methods		**X**			As a reference
3021		Salt Spreader Truck Mounted Attenuator				**X**	
3022		Snowplow Cutting Edge				**X**	Maintenance expressed interest. Product not ready at the time.
3023		Guide for Road Weather Information Systems		**X**			Used to establish specfications, as reference manual and as state contact listing.

3024		Anti-Icing Operations Guide		X			Limited use as a reference.
3025		Snow Fence Engineering Design Manual	This design manual provides the designer with detailed instructions on how to design snow fences for high drift locations.			X	
3026		Snowplow Scoop				X	
3027		Snowplow Design Manual	This manual includes designs for new equipment to more effectively remove snow and ice.			X	
3030		Anti-Icing Equipment Evaluation		X			Limited use as a reference
3031		Anti-Icing Application Rates		X			Limited use as a reference
3032		Anti-Icing Chemical Evaluation		X			Limited use as a reference
3033		Manual on Rating Preventive Maintenance				X	
3034		Specifications for Preventative Maintenance	Regionally sensitive specifications for preventive maintenance treatments, such as crack, chip, joint, and slurry seals and undersealing.			X	Limited use for CT state routes
3035	TP28	Epoxy Core Test for Void Detection				X	
4006		Customized Weather Prediction System				X	Some interest expressed.

SHRP LONG-TERM PAVEMENT PERFORMANCE PRODUCTS

SHRP No.	AASHTO No.	Product Name	Description	In Practice	Tried	Not Used	Comments
4002		Capacitance Strip Weigh-In-Motion Sensor				X	
4008		Software for Measuring Pavement Layer Thickness				X	
5001		LTPP Information Management Systems				X	
5003	PP7	FWD Relative Calibration				X	
5004	PP8	FWD Reference Calibration				X	
5005	PP9	FWDREFCL Program for Calibration				X	
5006		FWDCAL Program for Calibration				X	
5007		FWDCHECK Program for Quality Assurance				X	
5008		FWDSCAN Program for Quality Assurance				X	
5009		Manual for FWD Testing				X	
5011		PROFCAL Program - Profile Quality Assurance			X		Compared results
5013		PROFSCAN Program - Profile Quality Assurance			X		
5014		Profile Measurement Manual	Manual used to measure pavement profiles in order to identify specific problems.		X		
5015		Dipstick Profile Software			X		

5016		Distress Identification Manual		X			Very good
5019		Resilient Modulus of Asphalt Pavement	This test method allows for the computation of fatigue life of a roadway.	X			
5020	TP46	Resilient Modulus of Soils and Aggregates	This test method standardizes the measure of resilient modulus of subgrade soils.	X			
5021		Guide to Field Material Sampling and Handling		X			
5022		Examining Asphalt Pavement Cores				X	
5023		Examining Concrete Pavement Cores				X	
5024		Fine Aggregate Particle Shape	This test method provides information on the particle shape characteristics of fine aggregate.			X	
5025	PP13	Laboratory Guide for Test Pavement Samples	This manual provides specific protocols for the handling and testing of pavement samples.			X	
5026		Visual Examination of Asphalt Stripping				X	
5028	PP15	Proficiency Testing for Modulus				X	
5029	PP16	Proficiency Tests for Concrete Cores				X	
5030	PP17	Proficiency Tests for Moisture Content				X	
5031		Modified Georgia Digital Faultmeter				X	Expressed interest
5032		Photographic Distress Surveys			X		Conducted comparisons to ConnDOT processes.
5034		Traffic Monitoring Data Reduction Software				X	Expressed Interest
5035		LTPP Traffic Monitoring Database				X	Contributed data
5037		FWD Calibration Stations				X	

5040		IMS Microcomputer Version				X	

SHRP AND LTPP RELATED WEB SITES AND LINKS

1. AASHTO – Innovative Highway Technologies
   Leadstates.tamu.edu

2. Canadian Strategic Highway Research Program
   www.cshrp.org/

3. Long Term Pavement Performance
   www.tfhrc.gov/pavements/ltpp/ltpp.htm
   LTPP North Atlantic Regional Office

4. LTPP Group- Pavement Technology
   www.fhwa.dot.gov/pavement/ltpphome.htm

5. LTPP Road Profile Data
   www.umtri.umich.edu/erd/roughness/ltpp_erd.html

6. SHRP Evaluation and Implementation Database
   www.ws.dot.wa.gov/fossc/OTA/SHRP/
   The Strategic Highway Research Program (SHRP) Database was created by Washington State Department of Transportation.

7. Southwest Central SuperPave Center – University of Texas at Austin
   www.utexas.edu/research/superpave/

8. Strategic Highway Research Program (SHRP) Publications
   www4.trb.org/trb/onlinepubs.nsf/web/shrp_publications

9. TRB Special Programs – SHRP Implementation
   www4.trb.org/trb/dive.nsf/web/shrp_implementation