Rehabilitation of Asphalt Concrete Pavements: Initial Evaluation of the SPS-5 Experiment—Final Report

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LTPP

FOREWORD

This report documents a detailed review of the Long Term Pavement Performance (LTPP) Special Pavements Study—5 (SPS-5) experiment. The purpose of the review was to determine the adequacy of the data provided by the experiment. The SPS-5 experiment, entitled *Rehabilitation of Asphalt Concrete Pavements*, is one of the key experiments of the LTPP program. Its goal is to develop improved methodologies and strategies for the rehabilitation of flexible pavements. The review concentrated on the core experimental test sections, with secondary emphasis on the supplemental test sections that were built by individual agencies for each SPS-5 project.

As a result of this work, the data availability and completeness for the SPS-5 experiment were found to be good overall with two exceptions. The two critical elements or parameters found to have significant deficiencies were the traffic and materials test data. These data deficiencies need to be addressed before a comprehensive analysis of the SPS-5 experiment is conducted. The majority of the SPS-5 data that were collected were at level E.

This report will be of interest to highway agency engineers involved in the collection, processing, and analysis of data that shed light on ways to improve on the design procedures and standards for rehabilitating hot mix asphalt-surfaced pavements.

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Research and Development

NOTICE

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16. Abstract

The SPS-5 experiment, entitled *Rehabilitation of Asphalt Concrete Pavements*, is one of the key experiments of the LTPP program. The objective of this experiment is to determine the relative influence and long-term effectiveness of different rehabilitation techniques (including overlay thickness, material, and surface preparation) and site conditions (traffic, pre-existing pavement condition, and climatic factors) on performance. This report documents the first comprehensive review and evaluation of data completeness and availability from the SPS-5 experiment. Eighteen SPS-5 projects have been identified. At each site there are nine core test sections. Some SPS-5 projects also have various supplemental sections. 210 test sections are included in the SPS-5 experiment.

The data availability and completeness were good overall for the SPS-5 experiment with two exceptions: traffic and materials test data. These data deficiencies need to be addressed before a comprehensive analysis of the SPS-5 experiment is conducted. Both of these data elements must be collected in order for the SPS-5 experiment to meet the expectations for calibrating and validating mechanistic models. The majority of the SPS-5 data that were collected were at level E.

Required experiment design factors were compared with the actual experiment design for the large majority of the design factors and can be characterized as good to excellent when comparing designed versus constructed. One project had yet to be constructed and materials testing and data processing still needed to be completed.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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ABBREVIATIONS

AC	asphalt concrete
ANOVA	analysis of variance
AGG	aggregate bases (identical to dense graded aggregate base materials)
ATB	asphalt-treated base mixtures
AVC	automatic vehicle classification (or automated vehicle classifiers)
AWS	automated weather station
COV	coefficient of variance
CTB	cement-treated base
DGAB	dense-graded aggregate base
DOT	Department of Transportation
ESAL	equivalent single axle load
FHWA	Federal Highway Administration
FWD	falling weight deflectometer
GPS	General Pavement Studies
HMA	hot mix asphalt
IMS	Information Management System
IRI	International Roughness Index
LTB	lime-treated base
LTS	lime-treated subgrade
LTPP	Long-Term Pavement Performance
NAA	National Aggregate Association
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
OGFC	open graded friction course
p	probability value
PFC	porous friction course
QC/QA	quality control/quality assurance
RAP	Recycled Asphalt Pavement
RCO	Regional Coordination Office
RIMS	Regional Information Management System
SAMI	stress absorbing membrane interlayer
SHA	State Highway Authority
SHRP	Strategic Highway Research Program
SPS	Special Pavement Studies
WIM	weigh in motion

SPS-5 Project Name Abbreviations

AB—Alberta, Canada
AL—Alabama
AZ—Arizona
CA—California
CO—Colorado
FL—Florida
GA—Georgia
MB—Manitoba, Canada
MD—Maryland
ME—Maine
MN—Minnesota
MO—Missouri
MS—Mississippi
MT—Montana
NJ—New Jersey
NM—New Mexico
OK—Oklahoma
TX—Texas

1. INTRODUCTION

One objective of the Long-Term Pavement Performance (LTPP) studies is to develop improved methodologies and strategies for rehabilitating flexible pavements. Those factors that can affect the performance of overlaid flexible pavements include, as a minimum, surface preparation, overlay thickness, overlay material, environment, and condition of the original pavement. The LTPP program incorporated all of these factors into a single experiment to study the rehabilitation of flexible pavements—the Specific Pavement Studies (SPS) 5, entitled *Rehabilitation of Asphalt Concrete (AC) Pavements*.

This controlled field experiment focuses on the study of the specific features noted above for the rehabilitation of hot mix asphalt (HMA) flexible pavements. It is expected that the successful completion of this experiment will lead to improvements in design procedures and standards for overlaying HMA-surfaced pavements. These improvements should contribute to achieving the overall goals of the LTPP program—increased pavement life and better utilization of resources.

Investigating the effects of the specific experimental design features and site conditions (surface preparation, overlay thickness, overlay material, environment, and original pavement condition), as well as their interactions on pavement performance makes it possible to evaluate existing rehabilitation design methods and predict performance of overlaid flexible pavements. It also makes it possible to develop new and improved HMA overlay design equations and to calibrate mechanistic-empirical models.

BACKGROUND

The SPS-5 experimental plans were originally designed to incorporate project sites built in all four LTPP climatic regions on fine-grained subgrade soils. The Strategic Highway Research Program (SHRP), Federal Highway Administration (FHWA), and U.S. State and Canadian Province highway agencies made a major effort to identify appropriate SPS-5 sites and to construct all test sections according to the original experimental design.

A wide range of specific data was collected during and after construction of the HMA overlays. An effort was made to collect field data (profile, cracking, and materials data) before the construction of the HMA overlays in order to quantify the surface condition of the HMA pavement before rehabilitation.

The original expectations for the LTPP program are summarized in the SHRP-P-395 report.[(1)] Originally, the following objectives were established:

- Evaluate existing design methods.
- Develop improved strategies and design procedures for rehabilitating existing pavements.
- Develop improved design equations for new and reconstructed pavements.
- Determine the effects on pavement distress and performance from traffic loading, environment, materials properties and variability, construction quality, and maintenance levels.
- Determine specific design procedures to improve pavement performance.
- Establish a database to support these objectives and future pavement engineering needs.

The experimental designs for LTPP were developed to achieve these objectives. The following products were identified for the LTPP program:

- **General Products**: Evaluation of existing design methods and performance equations, new and improved design equations, and calibration of mechanistic models.
- **Specific Products**: Effects of the specific experimental design features, subgrade soil, traffic and climate, and their interactions (i.e., permeable drainage layers, widened slabs, AC overlay thickness, pre-overlay repair, and many others).
- **Other Products**: Test methods developed specifically for SPS test sections; correlations between materials and technology transfer.

Two objectives of the SPS-5 (rehabilitated flexible pavement) and SPS-6 (rehabilitated rigid pavement) experiments are stated in the same report:

- "The SPS will develop a comprehensive database with information on construction, materials, traffic, environment, performance and other features pertaining to the test sections.
- The primary objective of the experiments on rehabilitation of asphalt concrete and jointed portland cement concrete pavements is to develop conclusions concerning the effectiveness of different rehabilitation techniques and strategies and their contribution to pavement performance and service life."[(1)]

The SPS-5 experiment was designed to evaluate some more common rehabilitation techniques currently used in North America. The experimental factors include the condition of the pavement before overlay (both structurally and functionally), the loading conditions to which the test sections are exposed (both environment and traffic), and the various treatment applications. Five products are expected from the SPS-5 experiment:[(2)]

1. Comparisons and development of empirical prediction models for performance of HMA pavements with different intensities of surface preparation, with thin and thick HMA overlays, and with virgin and recycled asphalt pavement (RAP) mixtures.
2. Evaluation and field verification of the *American Association of State Highway and Transportation Officials (AASHTO) Guide* design procedures for rehabilitation of existing HMA pavements with HMA overlays and other analytical overlay design procedures.[(3)]
3. Determination of appropriate timing to rehabilitate HMA pavements in relation to existing surface conditions and types of rehabilitation procedure.
4. Development of procedures to verify and update the pavement management and life cycle cost concepts in the *AASHTO Guide* using the performance prediction models developed for rehabilitated HMA pavements.
5. Development of a comprehensive database of the performance of rehabilitated HMA pavements for use by State and provincial engineers and other researchers.

The SPS-5 experiment also was designed to identify trends associated with various rehabilitation methodologies on pavement performance and life expectancy. In addition, it is expected to provide data to improve and/or validate current design procedures. With these improved methodologies and procedures, highway agencies should be able to determine more appropriate strategies to rehabilitate flexible pavements. However, the ability of the SPS-5 experiment to meet these expectations has been questioned.(4,5) Some concerns are:

- Lack of detailed expectations and objectives from the SPS-5 experiment.
- Ability of the SPS-5 experiment to meet expectations in terms of the quality and completeness of the data at present and in the future.
- Deviations between the design and construction features of the in-place project (i.e., layers built to a different thickness or lack of pavement layer compaction).
- Deficiencies in performance data on construction, materials, climate, traffic, and for current and future analysis needs.

The full extent of the deviations and deficiencies, and the potential impact of those deficiencies, are not yet quantified for the SPS-5 experiment. Issues of experimental design, construction quality, data quality, and data completeness (with respect to both current data-collection guidelines and anticipated pavement engineering needs) also need to be addressed.

The SPS-5 projects were constructed between 1989 and 1997. Therefore, at the time this review was performed in 1999-2000, the data were sparse in many of the above-listed areas. However, several of the SPS-5 sections had begun to exhibit distress; thus, it was possible to make preliminary evaluations.

As of 2000, the only in-depth assessment of the SPS-5 experiment was *Performance of Rehabilitated Asphalt Concrete Pavements in the LTPP Experiments—Data Collected Through February 1997* (using the LTPP data public release of February 1997). That study summarized early performance trends and observations of the 17 SPS-5 projects built as of 1996.(6) The study neither focused on nor addressed the completeness of the experimental data, nor did it evaluate the adequacy of the experiment to provide data necessary to ensure that the broader expectations of this experiment could be attained. Therefore, the effort described in this report was initiated to conduct a comprehensive review of all SPS-5 experimental sites to determine the adequacy and potential of data from this experiment to satisfy future pavement engineering needs.

This review compared the experiment sites, as they existed in 1999-2000, with the original expectations and measured the projects against new expectations for the 21st century. For example, there was a greater emphasis on mechanistic-based design in 2000 than existed a decade previously. This review provides a sound basis for:

- Planning remedial actions that may be warranted given various deficiencies in construction or data collection.
- Determining future monitoring and data collection activities.
- Planning future analysis of the collected or monitored data.

This evaluation of the SPS-5 experiment was conducted at the same time as and in cooperation with the evaluation of the SPS-1 (new flexible pavement), SPS-2 (new rigid pavement), and SPS-6 (rehabilitated rigid pavement).

STUDY OBJECTIVES

The primary objective of the SPS-5 experiment on rehabilitation of flexible pavements is to determine the relative influence and long-term effectiveness of factors that influence the performance of overlaid flexible pavements. The study described in this report was to conduct a detailed review and to determine the extent to which this experiment would provide the necessary data to ensure that the objectives and expectations are attained. This review concentrated on the core experimental test sections and on the supplementary test sections that were built by the individual agencies for each project. Five specific activities were completed for this review:

1. Evaluation of the set of core and supplemental test sections constructed within the SPS-5 experiment in relation to their ability to support the objective and characterize the overall "health" and analytical potential of the SPS-5 experiment. This included: (a) identifying areas of strength and weakness and developing a plan of recommended corrective measures as appropriate to strengthen the SPS-5 experiment to accomplish its objectives; and (b) developing analysis plans for both short-term and long-term goals. This objective was subdivided into two areas:

    - Evaluate the quality and completeness of the SPS-5 construction data (in relation to current data-collection requirements) and provide recommendations for the resolution and correction of anomalous or poor quality data.

    - Evaluate the adequacy of existing data and current data-collection requirements in relation to anticipated analytical needs; identify areas where current requirements were excessive or deficient; and provide recommendations where adjustments (in quantity, quality, frequency, or data type) were warranted.

2. Identification of any confounding factors introduced into the SPS-5 experiment by construction deviations or other factors not accounted for in the original experimental design.
3. Consideration of both short-term and long-term horizons in the evaluation and preparation of recommendations for data analysis.
4. Evaluation of the opportunities for local, regional, or national analysis of the core and supplemental test sections.
5. Identification of specific objectives and expectations that should be pursued for the SPS-5 experiment, considering the original expectations and future needs. As appropriate, expectations at the local agency, the regional, and the national level were considered.

Specifically, this report focused on four areas of the SPS-5 experimental data:

1. Review of data quality.
2. Detailed discussions on the quantity and percentage of data that were at Level E (the highest quality data, which has passed specific checks) in the LTPP Information Management System (IMS) database.
3. Comparison of designed versus as-constructed section parameters, especially those used to design the experiment (i.e. experimental deviations and construction problems).

4. Preliminary evaluation of performance and identification of future analyses that can be performed on the data.

It should be understood that the LTPP database is dynamic– data are continually checked and entered. This review and detailed assessment of the experiment represents a “snapshot” of the database and the Level E data at a particular point in time.

SCOPE OF REPORT

The report is subdivided into six chapters including the introduction. The second chapter is an overview of the status, as of 2000, of the SPS-5 experiment in comparison to the original experiment designs. The third chapter looks at the project requirements for each SPS-5 project. The fourth chapter is an overall summary of each project detailing the construction difficulties, experimental deviations, and data completeness; in other words, it summarizes each SPS-5 project that had been built (as of 2000), notes the data that are available for each project, and identifies construction difficulties and any data deficiencies. The fifth chapter presents an analysis of the initial observations of the key distress and performance indicators completed on a project-by-project basis and across the entire experiment. Chapter six summarizes effects that data deficiencies may have on the results that can be obtained from this experiment.

More detailed information and data are provided in the appendices. Appendix A presents a summary of the construction and deviation reports, as well as other data elements that were available for each project. Appendix B presents a summary of the available construction data for each project.

2. GENERAL OVERVIEW OF EXPERIMENT

The first step in evaluating the SPS-5 experiment assessed how much of the experiment actually was constructed and what effect any missing sites might have on the experiment. This chapter discusses the original SPS-5 experiment design, the experimental sites constructed as of the time of this report, the effects of the missing experimental design cells, and the information available from the supplemental sites. The January, 2000, release of the IMS that contained only Level E data was used for the detailed review.

ORIGINAL SPS-5 EXPERIMENT DESIGN

The SPS-5 experiment examines the effects of climatic factors (wet versus dry and freeze versus no-freeze) and pavement condition (fair versus poor) on pavement sections incorporating different rehabilitation structural features. The features include:

- Amount and type of surface preparation before overlay.
- Type of material used for the overlay (recycled versus virgin asphalt mix).
- Variations in overlay thickness (51 or 127 mm).

The original SPS-5 experiment factorial is shown in table 1. A site is defined by the environmental conditions shown within the design. Nine combinations of rehabilitation factors are presented by the factorial. In table 1, *intensive* surface preparation denotes those test sections in which 51 mm of the surface was milled off and patching was performed as needed to rectify localized failures. *Minimum* surface preparation indicates that only patching was performed. The experimental plan specified that the recycled mixtures should contain 30 percent RAP and that the RAP incorporated into the mix should be the material that was milled from the intensive surface preparation test sections.(2) As part of the experiment design, one section was to have no treatment and serve as the control section for the project.

Two projects were required for each of the nine combinations of rehabilitation factors. Table 1 illustrates which State projects were nominated initially to fill specific design cells of the factorial. As shown, at least two projects were nominated for each cell with the exception of the dry-freeze-poor condition cell of the factorial. Some cells contain triplicate sections. As of August 1999, the SPS-5 experiment had 18 projects located throughout the United States and Canada. A map of the selected sections is shown in figure 1. These projects are well distributed across North America.

Table 1. Factorial used in SPS-5 experiment design.

Rehabilitation Procedures			Factors for Moisture, Temperature, and Pavement Condition															
			Wet								Dry							
			Freeze				No-Freeze				Freeze				No-Freeze			
Surface Prep	Overlay Material	Overlay Thickness, mm	Fair		Poor		Fair		Poor		Fair		Poor		Fair		Poor	
Routine Maintenance (Control)	N/A	0	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA
MINIMUM	Recycled AC	51	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA
		127	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA
	Virgin AC	51	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA
		127	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA
INTENSE	Recycled AC	51	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA
		127	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA
	Virgin AC	51	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA
		127	MD,MN	NJ	ME	MO	TX	GA	MS,FL	AL	CO,AB	MT	MB		NM	OK	AZ	CA

Figure 1. Map. Location of the SPS-5 projects.

Each test section has an identifying number that is common for all of the SPS-5 projects, and this test section number indicates the following characteristics:

- 501: Control—no treatment.
- 502: Thin overlay (51 mm)—recycled HMA mix.
- 503: Thick overlay (127 mm)—recycled HMA mix.
- 504: Thick overlay—virgin mix.
- 505: Thin overlay—virgin mix.
- 506: Thin overlay—virgin mix— with milling.
- 507: Thick overlay—virgin mix—with milling.
- 508: Thick overlay—recycled mix—with milling.
- 509: Thin overlay—recycled mix—with milling.

Requirements set for all test sections on each project are as follows:

- Length: 152.4 m—for performance monitoring with time.
- Subgrade: Fine-grained.
- Minimum estimated traffic loading: 85,000 equivalent single axle loads (ESALs) per year.

SUPPLEMENTAL SECTIONS

In addition to the nine core sections located at each project, the States were allowed to add supplemental sections that would be monitored by LTPP. These supplemental sections are usually a variation of the experiment and represent typical rehabilitation practices by the individual agency. Table 2 provides a list of the SPS-5 projects and the number of supplemental sections that were built at each. These supplemental sections represent a much more diverse range of overlay materials and rehabilitation strategies than were considered in the core experiment. The 48 supplemental sections are considered a valuable source of data for future pavement engineering needs.

CURRENT STATUS OF DESIGN FACTORIAL

The status, as of the year 2000, of the SPS-5 design factorial is provided in table 3. All projects have been located in the appropriate cells based on the actual environmental data, which will be discussed in detail in chapter 4. As shown, all of the cells have at least two projects, except for the wet-no-freeze, fair condition cell and the dry-freeze, poor condition cell. The distribution of these projects across North America represents the diverse environmental conditions required for this experiment. In summary, a total of 210 test sections (162 core test sections of the experiment plus 48 supplemental sections) had been built as part of the SPS-5 experiment.

Table 2. Supplemental sections constructed on SPS-5 projects.

STATE	SHRP ID	REHABILITATION
ALABAMA	0563	51 mm milling and inlay with virgin mix
	0564	51 mm milling and inlay with RAP mix
ARIZONA	0559	51 mm milling and inlay with RAP mix
	0560	51 mm milling and inlay with asphalt rubber asphalt concrete
CALIFORNIA	0559	Chip seal on 51 mm virgin mix
	0560	51 mm virgin mix on pavement-reinforcing fabric
	0651	51 mm rubberized mix on pavement-reinforcing fabric
	0562	51 mm rubberized mix
	0663	51 mm rubberized mix on stress absorbing membrane interlayer (SAMI)
	0564	51 mm virgin mix on SAMI
	0565	19 mm open-graded mix on SAMI on virgin mix
	0566	19 mm open-graded mix on 51 mm virgin mix
	0567	100 mm virgin mix
	0568	51 mm virgin mix on 100 mm virgin base mix
	0569	51 mm Stone Mastic Asphalt with Vestoplast®
	0570	51 mm modified stone mastic asphalt
	0571	51 mm dense graded overlay
COLORADO	0559	159 mm virgin mix
	0560	51 mm polymer modified mix on 108 mm virgin mix
FLORIDA	0561	89 mm RAP mix
	0562	89 mm virgin mix
	0563	Mill inlay with virgin mix
	0564	Mill inlay with RAP mix
	0565	Mill and inlay, overlay with 89 mm RAP mix
	0566	Mill and inlay, overlay with 89 mm virgin mix
GEORGIA	0560	Planned treatment
	0561	89 mm RAP mix
	0562	89 mm virgin mix
	0563	Mill 51 mm and inlay 51 mm virgin mix
	0564	Mill 51 mm and inlay 51 mm RAP mix
	0565	Mill 89 mm and inlay 89 mm RAP mix
	0566	Mill 89 mm and inlay 89 mm virgin mix
	0567	Second control section
MAINE	0559	32 mm virgin mix on 19 mm virgin shim layer
MARYLAND	0559	51 mm agency mix design
	0560	64 mm Arbocel® modified stone mastic asphalt
	0561	64 mm Vestoplast modified stone mastic asphalt
	0562	64 mm Styrelf® modified stone mastic asphalt
	0563	64 mm Styrelf and Arbocel modified stone mastic asphalt
MINNESOTA	0559	38 mm virgin mix
	0560	Milling of transverse cracks only and overlay with 38 mm virgin mix
	0561	Overlay with type 41 mix on type 31 mix
MISSISSIPPI	0560	76 mm virgin overlay with fabric underseal and slurry seal
MONTANA	0561	127 mm mill and inlay with Polybuilt® modified mix
	0560	51 mm mill and inlay with Kreton modified mix
NEW JERSEY	0559	Mill 51 mm and overlay with 51 mm RAP on 64 mm virgin mix
	0560	Mill 51 mm and overlay with 25 mm rubblized wearing course on 64 mm virgin mix
OKLAHOMA	0560	Mill and inlay, 89 mm virgin overlay

Note: Unmentioned states and provinces had no supplemental sections.

There is one major difference or deviation from the SPS-5 experimental plan. The subgrade soils for all SPS-5 projects were to be fine-grained soils. However, the soils for many of the projects are classified as coarse-grained soils. Table 3 identifies those projects that have fine-and/or coarse-grained soils. Only five of the SPS-5 projects have fine-grained soils: Maryland, Minnesota, Mississippi, Oklahoma, and Texas. The soils supporting the Missouri project were not yet classified. Four projects have soils that vary between fine- and coarse-grained: California, Colorado, Georgia, and Manitoba. The subgrade soils for the remaining eight projects are classified as coarse-grained. Although this is considered a significant deviation from the experimental plan, it is not believed to be detrimental to achieving the overall expectations for this experiment.

Table 3. Final factorial for the SPS-5 experiment design.

Pavement Condition	Soil Classification	Climate, Moisture-Temperature			
		Wet-Freeze	**Wet-No-Freeze**	**Dry-Freeze**	**Dry-No-Freeze**
Fair	Coarse/fine	GA (8) 6.2	–	CO (2) 7.9	
	Coarse	NJ (2) 7.0	–	AB (0) 8.9 MT (2) 8.0	NM (0) 2.9
	Fine	–	–	MN (3) 8.9	OK (1) 2.1 TX (0) 7.8
Poor	Coarse/fine	–	–	MB (0) 10.0	CA (13) 7.3
	Coarse	ME (1) 4.1	FL (6) 4.3 AL (2) 7.7	–	AZ (2) 9.2
	Fine	MD (5) 7.2 MO* (0) 0.0	MS (1) 8.9	–	–

Note: The numbers in parentheses indicate supplemental sections, which are followed by the age of the project as of January 2000.

*Missouri is located in the cell for which it was nominated because the data for determining the correct cell assignment were unavailable as of the time of this report.

3. PROJECT REQUIREMENTS

A set of requirements was placed on each SPS-5 project to be built as part of the LTPP program. These included limitations on the rehabilitation of the test sections and specifications covering the types of materials to be used, the materials tests to be conducted, and the monitoring to be conducted by the Regional Coordination Office (RCO) during the life of the project. Each of these requirements is described in this chapter.

CONSTRUCTION REQUIREMENTS

Each region received, construction requirements from the "Construction Guidelines" section of the *Specific Pavement Studies of Rehabilitation of Asphalt Concrete Pavements (SPS-5) Guide*.(2) These guidelines would ensure adequate attention to the details of construction operations.

The guidelines included several special considerations: The SPS-5 projects could not be built in areas where lanes were being widened. Seal coats and geotextiles were not allowed on these test sections. The projects could not include retrofitted edge drains, lane additions, or shoulder construction. Surface friction courses could be used if required by the agency, but they were restricted to 19 mm and were not considered part of the HMA overlay thickness. If the HMA surface of the control section was stripping, a seal coat could be placed on its surface if that represented a standard agency practice.

Control Section

The control section on each project was to have only a limited amount of activity. A control section provides an indication of the performance of the pavement if no rehabilitation has been done. Therefore, it was important for construction activity on the control section to be limited to a minimum. Repairs on these sections were limited to those maintenance activities needed to sustain safety and functionality. The application of a seal coat or chip seal was to be delayed at least one year after construction of the other test sections.

Levels of Surface Preparation

The factorial had two levels of pavement preparation: minimal and intensive.

Minimal surface preparation was used on test sections 02 through 05, and included patching and placing a level-up course for ruts deeper than 13 mm. Patches were to be used in areas with localized failures. These areas included severe fatigue cracks, potholes, deep depressions, and cracks greater than 19 mm wide. The area to be patched was to be cleaned of loose material and a tack coat used to ensure a good bond of the patch material. The patch material was to be a dense-graded HMA. A level-up layer of a fine-graded HMA mixture could be placed only when the ruts were greater than 13 mm deep, and placement was confined to wheel paths.

If the original pavement included a porous friction course (PFC), this material could be milled off. The PFC was removed only if the prior experience of the State highway agency (SHA) indicated that this material would adversely affect the performance of the overlay. Milling of the PFC was not to extend into the surface course of the flexible pavement.

Intensive surface preparation was used on sections 06 through 09. As stated in chapter 2, this level of preparation included milling, patching of distressed areas and potholes, and crack sealing. No seal coats or geotextiles were to be placed on these test sections. Milling was required on all of these test sections to a depth of 38 to 51 mm to remove oxidized or stripped material. The milled surface was cleaned with a power broom and then the milled material was replaced with an equal thickness of the HMA overlay mixture, excluding any PFC material that was removed.

HMA Mixture Designs and Materials

HMA mixture designs for both the recycled and virgin mixtures were to meet the following requirements:

- If a Marshall mix design was used:

Compaction	75 blows
Stability (minimum)	8000 newtons
Flow	8 mm–14 mm
Design air voids	3 to 5 percent

- If a Hveem mix design was used:

Stability value (minimum)	37 newtons
Swell (maximum)	8 mm
Design air voids	3 to 5 percent

- All new aggregates were to have 60 percent of the material retained on the No. 4 sieve with two fractured faces. The aggregate blend should be a dense-graded gradation.
- Experimental modifiers and additives were not allowed.
- The recycled mix should include 30 percent RAP. The RAP should not be from a mix with a history of stripping or high abrasion.
- The reclaimed coarse aggregate should have 100 percent passing the 38-mm sieve and a maximum of 25 percent passing the 9.5-mm sieve.
- Lift thickness was to be no more than 76 mm.
- Longitudinal joints were to be located within 0.3 m of the center of the lane or within 0.3 m of the center of two adjacent lanes.
- Transverse joints were to be located outside of the test sections.

MATERIALS SAMPLING AND TESTING

Materials sampling and testing were required for each material placed and on the existing pavement before placement of the overlay to evaluate differences between the test sections and projects within the SPS-5 experiment. The material properties being measured are those commonly used for design and those needed to assess the response characteristics of HMA mixtures.

A general sampling and testing plan was created for use as a guideline.(1) This guideline was used to develop a sampling and testing plan specific to each project. Because each owner agency was allowed to add supplemental test sections, the number of tests varies for each project (test numbers increase with an increase in test sections). These plans were created before the construction of each individual project. The plans provided the location of each sample to be taken, where each sample should be sent, and specified the tests to be performed on each sample.

Samples taken from the project include:

- Bulk samples from the upper 305 mm of the subgrade.
- Thin-walled tube samples of the subgrade to 1.2 m from the top of the subgrade.
- Jar samples of the subgrade.
- Bulk samples of any unbound base layer.
- Jar samples of any unbound base layer.
- Cores of any bound base layer.
- Cores of the asphalt surface and binder.
- Bulk samples of the asphalt mixes used in the overlay.
- Bulk samples of the asphalt cement used in all mixes.
- Cores of the overlay materials being placed.

In addition to each of these samples, bulk samples were to be taken of the asphalt cement, aggregates, and uncompacted asphalt concrete mixes to be stored long term. Auger probes were to be performed in the shoulder of each test section to a depth of 6 m. This allowed determination of the depth to a rigid layer. Finally, as part of the field activities during the construction of the project, nuclear density and moisture testing was conducted on top of the bulk sampling areas for the subgrade, and on the top of each layer in each test section.

The testing of these samples was split between the FHWA and the owner agency. The FHWA was responsible for the resilient modulus tests, creep compliance tests, and associated tests (tests for which results are required before running the resilient modulus tests). For instance, the protocol for determining the resilient modulus on unbound materials was dependent upon the material classification. Therefore, the FHWA laboratory determined the classification of the material before running the resilient modulus test. The owner agencies were responsible for all other laboratory material tests. Tables 4 and 5 illustrate the tests that were to be performed and the minimum number required.

Table 4. Required testing for the SPS-5 experiment, preconstruction.

	Material Type and Properties	SHRP Protocol	No. of Tests per Layer
I.	ASPHALTIC CONCRETE		
	A. ASPHALTIC CONCRETE		
	Core examination/thickness	P01	26
	Bulk specific gravity	P02	9
	Maximum specific gravity	P03	3
	Asphalt content (extraction)	P04	3
	Creep compliance	P05	6
	Resilient modulus	P06	6
	Tensile strength	P07	9
	Field moisture damage	P08	3
	B. EXTRACTED AGGREGATE		
	Type and classification		
	Coarse aggregate	P13	3
	Fine aggregate	P13	3
	Gradation of aggregate	P14	3
	NAA test for fine aggregate particle shape	P14A	3
	C. ASPHALT CEMENT		
	Abson recovery	P21	3
	Penetration at 25 ºC and 46 ºC	P22	3
	Specific gravity (16 ºC)	P22	3
	Viscosity at 25 ºC	P24	3
	Viscosity at 60 ºC, 135 ºC	P25	3
II.	BOUND (TREATED) BASE AND SUBBASE		
	Type and classification of material and treatment	P31	3
	Pozzolanic/cementitious: compressive strength	P32	3
	Asphalt treated: dynamic modulus (25 ºC)	P33	3
	HMA: resilient modulus	P07	3
III.	UNBOUND GRANULAR BASE AND SUBBASE		
	Particle size analysis	P41	3
	Sieve analysis (washed)	P41	3
	Atterberg limits	P43	3
	Moisture-density relations	P44	3
	Resilient modulus	P46	3
	Classification	P47	3
	Permeability	P48	3
	Natural moisture content	P49	3
IV.	SUBGRADE		
	Sieve analysis	P51	3
	Hydrometer to 0.001 mm	P42	3
	Atterberg limits	P43	3
	Classification	P44	3
	Moisture-density relations	P46	3
	Resilient modulus	P47	3
	Unit weight	P48	3
	Natural moisture content depth to rigid layer	P49	3

Table 5. Required testing for the SPS-5 experiment, postconstruction.

Material Type and Properties	SHRP Protocol	No. of Tests per Layer
A. ASPHALTIC CONCRETE		
Core examination/thickness	P01	40
Bulk specific gravity	P02	40
Maximum specific gravity	P03	6
Asphalt content (extraction)	P04	6
Moisture susceptibility	P05	6
Creep compliance	P06	2
Resilient modulus	P07	6
Tensile strength	P08	18
B. EXTRACTED AGGREGATE		
Bulk specific gravity		
Coarse aggregate	P11	6
Fine aggregate	P12	6
Type and classification		
Coarse aggregate	P13	6
Fine aggregate	P13	6
Gradation of aggregate	P14	6
NAA test for fine aggregate particle shape	P14A	6
C. ASPHALT CEMENT		
Abson recovery	P21	6
Penetration at 25 ºC and 46 ºC	P22	6
Specific gravity (16 ºC)	P23	6
Viscosity at 25 ºC	P24	6
Viscosity at 60 ºC, 135 ºC	P25	6

MONITORING REQUIREMENTS

Performance Data

The several different types of performance data used to monitor the SPS-5 projects are:

- Manual and photographic distress surveys. The photographic distress surveys are performed by PASCO, while the manual distress surveys are performed by RCO personnel.
- Deflection basin measurements are collected by the RCOs using a Dynatest® falling weight deflectometer (FWD).
- Transverse profile measurements can be taken at the same time as the distress surveys. As part of a manual distress survey, the surveyor takes transverse profile measurements using a FACE Company Dipstick®, while the PASCO units take the transverse profiles in addition to the photographic distress surveys.
- Longitudinal profile measurements are collected by the RCOs with a GM Profilometer.
- Friction measurements are collected by each individual agency responsible for constructing the project.

Initial monitoring of these performance indicators was to be performed on the test sections 6 months before construction was initiated and within 6 months after construction was completed.

Long-term monitoring was to be performed every other year, but could be postponed for up to one year. The RCOs are responsible for maintaining the data-collection schedule. However, there can be numerous reasons why a RCO was unable to satisfy the monitoring frequency requirements in place when a project was built; some are:

- Egress restrictions imposed by the contractor until that project was accepted by or turned back over to the owner agency.
- Weather conditions, especially on projects built in the northern part of North America and completed during the fall months.
- Equipment breakdowns or maintenance requirements.
- Scheduling difficulties.

As of January 1, 1999, friction measurements were no longer required on any test section. All data collected are submitted and stored in the IMS.

Traffic Data

Traffic data are to be collected on each of the projects. The requirement as of the time of this report stated that automatic vehicle classification (AVC) data are to be collected continuously on SPS-5 test sections. The term “continuous data” is defined as the “use of a device that is intended to operate throughout the year and to which the SHA or Canadian Province commits the resources necessary to both monitor the quality of the data being produced and to fix problems quickly upon determination that the equipment is not functioning correctly.”(7) This level of data collection is necessary to provide accurate traffic loading measurements. In addition to continuous AVC data, weigh-in-motion (WIM) data are to be collected a minimum of 2 days per year.

Climatic Data

Climatic data are obtained from the National Oceanic and Atmospheric Administration (NOAA). These data are collected from four to five NOAA weather stations surrounding the project. The data are then averaged using a weighting procedure. This procedure gives weights based on the distance of the weather station from the project. The closer the weather station is to the project, the larger the weight used in the averaging. The data collected from NOAA include information about the temperature, rainfall, wind, and solar radiation.

Each SPS-5 project was to meet these monitoring minimum requirements. Any deviation from these requirements could affect the results that can be obtained from data analysis. The next chapter examines how each project has deviated from these requirements and how these deviations can be expected to affect results obtained from this experiment.

4. EXPERIMENT ASSESSMENT—DATA AVAILABILITY AND COMPLETENESS

This chapter presents a summary of the SPS-5 experimental data in the IMS based on the LTPP data-collection guidelines at the time of the data extraction—January 2000. Appendix A provides a brief discussion and summary of each SPS-5 project, including a review of construction difficulties and deviations from the experimental plan. The construction and deviation reports provide detailed information about the location and construction of each project. These reports were prepared by the RCOs upon completion of the project.

The IMS is a very dynamic database that is continually updated and revised as new data are entered and checked for anomalies. Figure 2 is a generalized flowchart showing the movement of data and the data quality checks through LTPP. This flowchart is useful for understanding why some key data collected for a specific test section do not appear as Level E data in the LTPP database.

LTPP DATA QUALITY CONTROL CHECKS

The quality of the data is the most important factor in any analysis. From the outset of the LTPP program, data quality has been considered of paramount concern. Procedures for collecting and processing data were defined and modified as necessary to ensure consistency across various reporting contractors, laboratories, equipment operators, or others. Although these procedures formed the foundation of quality control/quality assurance (QC/QA) and data integrity, many more components of a QC/QA plan were necessary to ensure that the data sent to researchers were as error free as practical.

LTPP has developed and implemented an extensive quality control (QC) program that classifies each data element into categories depending upon the location of the data in this QC process. Several activities comprise the overall QC/QA plan used on the LTPP data.

- **Collect data:** Procedures for collecting data are documented for each IMS module. These procedures ensure that data are collected in similar format, amounts, conditions, etc.

- **Review data:** Regional engineers review all data input into the regional IMS (RIMS) to check for possible errors: keystroke input, field operations, procedures, equipment operations, etc. The regional review is intended to catch obvious data-collection errors. In addition, some data are preprocessed before they are entered into the IMS. For example, PROFCAL™ software is used on SHRP profilometers to provide a system check by comparing measurements taken at different speeds. PROFSCAN™ is a field quality-assurance tool that allows an operator to identify invalid data while still in the field, thus saving costly revisits to the site.

- **Load data in IMS:** Some checks are programmed in the IMS to identify errors as data are entered. The IMS contains mandatory, logic, range, data verification, and other miscellaneous checks that are invoked during input.

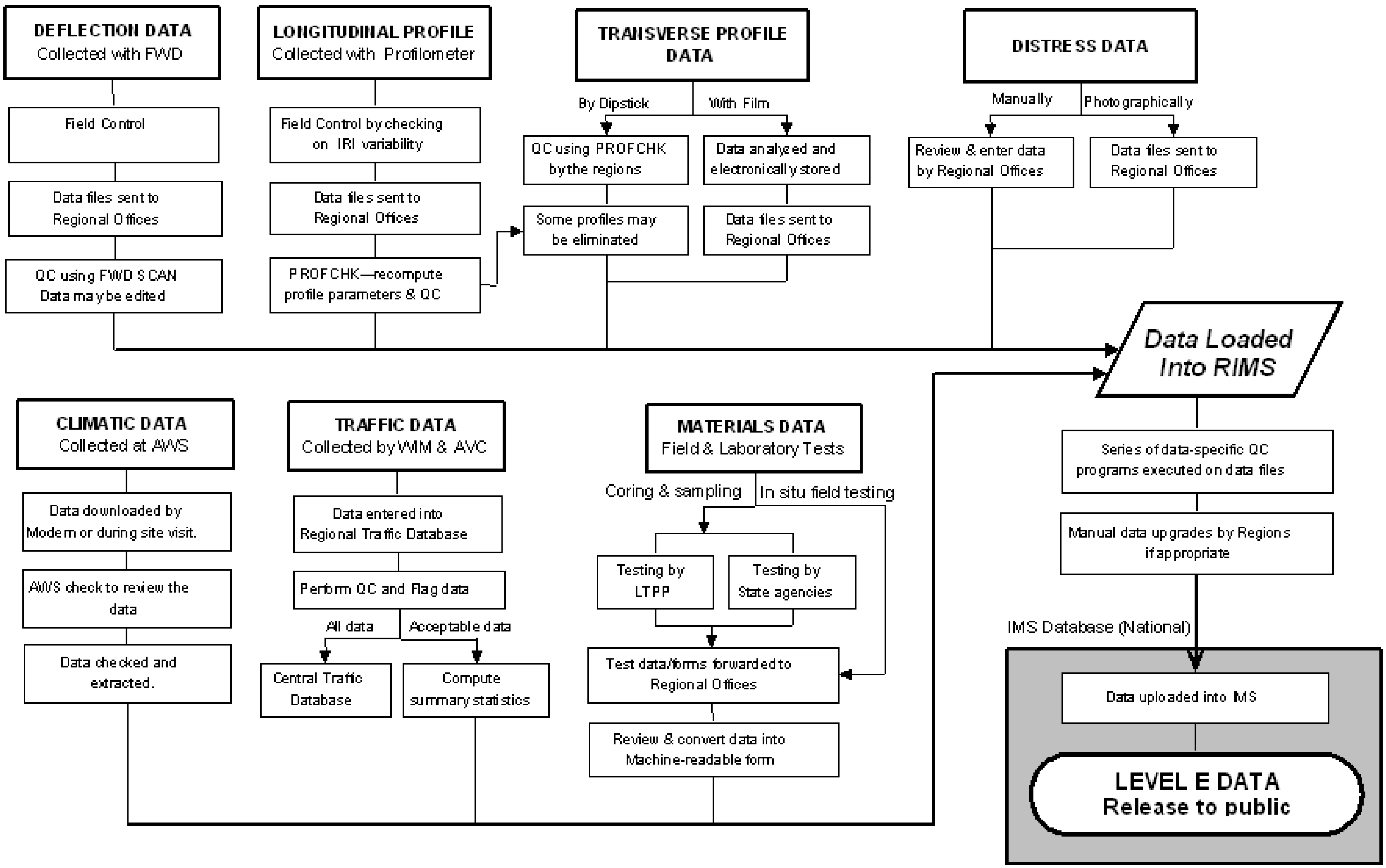


Figure 2. Chart. LTPP data collection and data movement flowchart.

- **QC/QA:** Once data are input into the IMS and reviewed by regional engineers, formal QC/QA software programs are run on the data.

    - **Level A—**Random checks of data are performed to ensure correct RIMS to IMS data transfer.
    - **Level B—**A set of dependency checks is performed to ensure that basic essential section information has been recorded in the IMS. In addition, experiment types are verified based on inventory data. These checks are currently being incorporated into the Level E checks for all modules.
    - **Level C—**A minimum data search is performed for critical elements, e.g., verification that inventory data contain the coordinates of the section; that friction data contain the skid number; and that rehabilitation data have a code entered to identify each work type activity.
    - **Level D—**Expanded range checks are applied to certain fields to identify data element values that fall outside an expected range. These checks are more stringent than the input range checks reviewed by the regional engineers.
    - **Level E—**Intra-modular checks are employed to verify the consistency of data within a data module, e.g., if an overlay is identified in the inventory layer structure, the data of the overlay should be recorded in the inventory table listing major improvements to the pavement structure.

When the QC/QA programs are completed, the RCOs review the output and resolve any data errors. Often, the data entered are legitimate and accurate, but do not pass a QC/QA check. If this occurs, the RCO can document that the data have been confirmed using a comments table in the IMS and can manually upgrade the record to Level E.

Figure 2 shows the movement of data elements and quality checks completed on the data before it is released to the public. Only a fraction of the data fields are checked. A value of *A* is assigned automatically to a record on entry in the database. A value of *B* indicates the QC process was executed but a Level C check failed. Any record for which correct section information is stored in the database is available after the QC is completed. A record of the QC processing is included with the record. Because the checks are run in sequence A-E, the last successful check is identified on the record as the record status variable. A value of B or C indicates that a necessary data element was not available when the QC was processed and does not necessarily imply that the higher level QC was unsuccessful.

There are several reasons that some data may be unavailable from the publicly released IMS database; for example:

- Data are not yet collected.
- Data are under regional review.
- Data have failed one of the quality checks and are to be reviewed.
- Data have failed one of the quality checks and were identified as anomalies.
- Data are not yet quality checked.

Therefore, the missing data identified in this report do not necessarily mean that the data were not collected or submitted by the owner agencies. There are several places where data may be delayed and not reach Level E. The results in this report are based only upon Level E because it was impossible to know the specific reasons the data did not pass all of the QC checks. Many reasons that prevent data from reaching Level E status are not the result of poor quality or unreliable data. The LTPP program is embarking on a system-wide effort to resolve all unavailable data so that future researchers can access them.

DATA ELEMENT CATEGORIES

All data elements included in the SPS-5 experiment were reviewed for their availability and completeness in the LTPP database (see table 6). Although each element is important for different reasons, the data were subdivided into three categories for the review process: essential, explanatory, and informational.

- **Essential—**Data elements that are directly needed to accomplish the experimental objectives and expectations. Without these data elements, the experiment will not accomplish its intended function.
- **Explanatory—**Data elements that are not necessary to achieve experimental expectations, but are needed to explain differences or anomalies in performance observations.
- **Informational—**Data elements that are not needed or required to achieve the experimental objectives; they only provide information that may be needed for future and more generalized studies.

Although the review of the SPS-5 experiment included all data elements, the detailed review concentrated on the elements identified as essential and explanatory because they are considered necessary to achieve the overall objectives of the experiment. Table 6 notes those data elements within each of the three different categories.

The key data elements that were evaluated and assessed for determining the quality level and completeness for each project were subdivided into the following types of data, which are discussed in this chapter:

- General information.
- Pavement structure.
- Construction data.
- Monitoring data.
- Materials data.
- Traffic data.
- Climatic data.

Table 6. Summary of SPS-5 data elements and their importance to experimental expectations.

Module ID	Data Element	*Data Avail., %	Data Importance		
			Essential	Explanatory	Informational
Climatic (CLM)	Maximum avg annual humidity	44.4	X		X
	Minimum avg annual humidity	44.4			X
	Annual Precipitation	94.4	X		
	Number of days with Intense Precipitation	94.4			X
	Number of days with Precipitation	94.4			X
	Annual Snowfall	94.4			X
	Number of days with Snowfall	94.4			X
	Mean Annual Temp	94.4			X
	Avg Max Annual Temp	94.4			X
	Avg Min Annual Temp	94.4			X
	Max Annual Temp	94.4			X
	Min Annual Temp	94.4			X
	Days > 32C	94.4			X
	Days < 0C	94.4			X
	Freeze Index	94.4	X		
	Annual No of Freeze Thaw Cycles	94.4			X
	Mean wind speed	27.8			X
Inventory (INV) - Original Pavement	Construction Date	94.4		X	
	Date Open to Traffic	94.4	X		
	Type of Aggregate Used in AC	61.1			X
	Aggregate Durability	16.7			X
	Pavement Type	94.4	X		
	Lane Width	94.4			X
	Subdrainage type	94.4	X		
	Gradation of AC	50.0			X
	Gradation of Unbound Base	61.1			X
	Gradation of Subgrade	44.4			X
	Functional Class	94.4			X
	Location	83.3			X
	Elevation	94.4			X
	Layer Thickness	94.4	X		
	Asphalt Modifier	0.0			X
	Aggregate in AC Specific Gravity	16.7			X
	Asphalt Viscosity	38.9			X
	Compaction Type	11.1			X
	Laydown Temp	38.9			X
	AC Bulk Specific Gravity	33.3			X
	AC Max Specific Gravity	38.9			X
	Asphalt Content	72.2			X
	Air Voids	61.1		X	
	VMA	27.8		X	
	Marshall Stability	27.8			X
	Marshall Flow	22.2			X
	Hveem Stability	22.2			X
	Hveem Cohesiometer	5.6			X
	Asphalt Plant Type	50.0			X
	Antistrip Agent	27.8			X
	Moisture Susceptibility	5.6		X	

* Data Availability—percentage of SPS-5 required tests for which data generally are available in the database.

Table 6. Summary of SPS-5 data elements and their importance to experimental expectations (continued).

Module ID	Data Element	*Data Avail., %	Data Importance		
			Essential	Explanatory	Informational
Inventory (INV) - Original Pavement	Shoulder Type	94.4			X
	Stabilizing Agent for Base	33.3			X
	Stabilizing Agent for Subgrade	0.0			X
	Subgrade CBR	16.7			X
	Subgrade AASHTO Soil Class	55.6		X	
	Subgrade Resistance	0.0			X
	Subgrade Reaction Modulus	0.0			X
	Subgrade Atterberg Limits	33.3			X
	Subgrade Optimum Moisture	27.8			X
	Subgrade Max Density	22.2			X
	Subgrade In Situ Density	27.8			X
	Subgrade In Situ Moisture	33.3			X
	Soil Suction	0.0			X
	Expansion Index	0.0		X	
	Swell Pressure	0.0		X	
	Average Rate of Heave	0.0		X	
	Frost Susceptibility	11.1		X	
	Unbound Base AASHTO Soil Class	66.7			X
	Unbound Base Atterberg Limits	27.8			X
	Unbound Base Optimum Moisture	44.4			X
	Unbound Base Max Density	55.6			X
	Unbound Base In Situ Density	38.9			X
	Unbound Base In Situ Moisture	44.4			X
	Compressive Strength	0.0			X
	Unbound Base CBR	0.0			X
	Unbound Base Resistance	5.6			X
	Unbound Base Reaction Modulus	0.0			X
Maintenance (MNT)	Cracking sealing	16.7			X
	Patching	5.6			X
	Asphalt Seal	0.0			X
Monitoring (MON)	Deflections	94.4	X		
	Temperature at Testing	100.0	X		
	Backcalculated Modulus	--	X		
	Manual Distress	100.0	X		
	Photographic Distress	83.3	X		
	Friction	77.8			X
	Longitudinal Profile	94.4	X		
	Transverse Profile	94.4	X		
Construction	Primary Distress	16.7			X
	Secondary Distress	5.6			X
	No of Patches	16.7			X
	Area of Patches	16.7			X
	Type of Patching	16.7			X
	Air Temp	11.1			X
	Road Moisture	11.1			X
	Layer Thickness	94.4	X		
	Thickness from Rod & Level	61.1		X	
	Type of Milling Maching	83.3			X

* Data Availability—percentage of SPS-5 required tests for which data generally are available in the database.

Table 6. Summary of SPS-5 data elements and their importance to experimental expectations (continued).

Module ID	Data Element	*Data Avail., %	Data Importance		
			Essential	Explanatory	Informational
Construction	Cutting Head Width	83.3			X
	Depth of Milling	88.9		X	
	Overlay Surface Preparation	88.9		X	
	Type of Tack Coat	88.9			X
	Application Rate of Tack Coat	77.8			X
	Mix Plant Type	88.9			X
	Haul Distance	88.9			X
	Type of Paver	88.9			X
	Laydown Width	88.9			X
	Lift Thickness	83.3			X
	Compaction Type	83.3			X
	Laydown Temp	72.2			X
	Profile Index	16.7			X
	Rut Width prior to Level Up	5.6			X
	Rut Depth prior to Level Up	5.6			X
Rehabilitation (Overlay Data)	Type of Aggregate in AC	66.7			X
	Aggregate Durability	16.7			X
	Aggregate Gradation	77.8			X
	Lab Aged Cement Viscosity	22.2			X
	Design Air Voids	66.7		X	
	Design Asphalt Content	72.2		X	
	Design Marshall Stability	38.9			X
	Design Marshall Flow	27.8			X
	Design Hveem Stability	27.8			X
	Design Hveem Cohesiometer	5.6			X
	Asphalt Grade	77.8		X	
	Asphalt Viscosity	38.9			X
	Asphalt Modifier	11.1			X
	Gradation of Combined Aggregate (RAP & new)	77.8			X
	Recycling Agent	5.6			X
	Amount of New AC	66.7			X
	Combined Specific Gravity	38.9			X
	Combined Viscosity	16.7			X
	Processing of Old Pavement	55.6			X
	Gradation of Reclaimed Aggregate	55.6			X
	Specific Gravity of Reclaimed Aggregate	16.7			X
	Combined Lab Aged Cement Viscosity	0.0			X
	Grade of New Asphalt	77.8		X	
	Viscosity of New Asphalt	16.7			X
	Viscosity of Reclaimed Asphalt	5.6			X
	Gradation of New Aggregate	61.1			X
	Specific Gravity of New Aggregate	33.3			X
	Durability of New Aggregate	11.1			X
Traffic (TRF)	Estimated ESALs	5.6			X
	Estimated AADT	44.4			X
	W4 Tables	50.0	X		
	Monitored AVC	50.0	X		
	Monitored AADT	33.3		X	
	Monitored ESALs	0.0		X	

* Data Availability—percentage of SPS-5 required tests for which data generally are available in the database.

Table 6. Summary of SPS-5 data elements and their importance to experimental expectations (continued).

Module ID	Data Element	*Data Avail., %	Data Importance		
			Essential	Explanatory	Informational
Materials Testing (TST)	Core examination	83.3	X		
	Bulk Specific Gravity	66.7	X		
	Max Specific Gravity	66.7	X		
	Asphalt Content	61.1		X	
	Moisture Susceptibility	11.1		X	
	Asphalt Resilient Modulus	0.0		X	
	Ash Content of AC	55.6			X
	Penetration	66.7			X
	Asphalt Specific Gravity	66.7			X
	Viscosity	66.7		X	
	Aggregate Specific Gravity	44.4			X
	Aggregate Gradation	66.7		X	
	Fine Aggregate Particle Shape	27.8			X
	In Situ Density	88.9		X	
	Layer Thickness	77.8	X		
	Treated Base Type	22.2		X	
	Treated Base Compressive Strength	5.6			X
	Unbound Base Gradation	44.4	X		
	Unbound Base Classification	38.9	X		
	Unbound Compressive Strength of the Subgrade	0.0			X
	Unbound Base Permeability	11.1		X	
	Unbound Base Optimum Moisture	33.3		X	
	Unbound Base Max Density	33.3		X	
	Unbound Base Modulus	5.6		X	
	Unbound Base Moisture Content	33.3			X
	Subgrade Gradation	72.2	X		
	Subgrade Hydrometer Analysis	66.7	X		
	Subgrade Classification	77.8	X		
	Subgrade Permeability	0.0		X	
	Atterberg Limits	66.7	X		
	Subgrade Optimum Moisture	72.2			X
	Subgrade Max Density	72.2		X	
	Subgrade Modulus	72.2		X	
	Subgrade Moisture Content	72.2			X

* Data Availability—percentage of SPS-5 required tests for which data generally are available in the database.

GENERAL SITE INFORMATION DATA

This assessment includes the site identification and location, key equipment installed at the site, availability of the construction report, and important dates associated with each of the SPS-5 projects. The information for this review was obtained from the site construction report, deviation report, or the LTPP IMS tables entitled **EXPERIMENT_SECTION** and **INV_AGE**. All site-level records for the 18 SPS-5 projects are at level E, except for one. The Missouri project had very limited data in the database because at the time of this report it had only recently been constructed. Table 7 includes a summary of the site information and report availability for each project.

Table 7. SPS-5 project site information and report availability.

Project	Region	Age, Years	Pavement Condition Before Overlay	AVC Equipment Installed	Report Availability	
					Construction	Deviation
Maine	North Atlantic	4.1	√	–	√	√
Maryland		7.2	√	√(1)	√	√
New Jersey		7.0	√	√(1)	√	√
Minnesota	North Central	8.9	√	√(1)	√	√
Missouri		0.0	√	–	√(2)	–
Manitoba		10.0	√	√	√	√
Alabama	South	7.7	√	–	√	√
Florida		4.3	√	–	√	√
Georgia		6.2	√	–	√	√
Mississippi		8.9	√	√(1)	√	√
New Mexico		2.9	√	–	√	√
Oklahoma		2.1	√	–	√	√
Texas		7.8	√	√(1)	√	√
Arizona	West	9.2	√	√(1)	√	√
California		7.3	√	√(1)	√	√
Colorado		7.9	√	√(1)	√	√
Montana		8.0	√	√	√	√
Alberta		8.9	√	√(1)	√	√

Notes: 1. WIM equipment was installed at these sites.

2. The Missouri project was recently constructed. The construction report has been submitted to LTPP but was unavailable for the detailed review.

At the time of the preparation of this report, traffic monitoring equipment had been installed at 11 of the 18 SPS-5 sites, as shown in table 7. All 11 sites were 7 or more years old, while the 7 sites that did not have the equipment were less than 7 years old, except for the Alabama project. The seven sites without traffic monitoring equipment were considered significant to the experiment, especially when trying to validate the more sophisticated mechanistic-empirical design procedures. Specifically, reliable and site-specific traffic data were considered vital to NCHRP Project 1-37A, “Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures.”

The installation of automated weather station (AWS) equipment was not a requirement for the SPS-5 experiment.

All SPS-5 project sites were to have a fine-grained subgrade soil. However, both fine-grained and coarse-grained soils were included in the experiment. The effect of soil type has been included in the experiment by identifying the projects as “A” and “B” in the revised factorial shown in table 8. Four projects have both types of soils under specific test sections—California, Colorado, Georgia, and Manitoba, and are located in table 8 based on the predominant soil type at the site. Any data unavailable in the IMS will be presented in terms of this revised site factorial.

Table 8. Projects built for the SPS-5 experiment.

Pavement Surface Condition	Subgrade Soil Type	Climate, Moisture—Temperature			
		Wet-Freeze	Wet-No-Freeze	Dry-Freeze	Dry-No-Freeze
Fair	Fine grained	Site Cell 1.A: GA (8) 6.2	Site Cell 2.A:	Site Cell 3.A: CO (2) 7.9 MN (3) 8.9	Site Cell 4.A: OK (1) 2.1 TX (0) 7.8
	Coarse grained	Site Cell 1.B:	Site Cell 2.B:	Site Cell 3.B: AB (0) 8.9 MT (2) 8.0	Site Cell 4.B: NM (0) 2.9
Poor	Fine grained	Site Cell 5.A: MD (5) 7.2 MO* (0) 0.0	Site Cell 6.A: MS (1) 8.9	Site Cell 7.A: MB (0) 10.0	Site Cell 8.A:
	Coarse grained	Site Cell 5.B: ME (1) 4.1	Site Cell 6.B: FL (6) 4.3 AL (2) 7.7	Site Cell 7.B:	Site Cell 8.B: CA (13) 7.3 AZ (2) 9.2

Note: The values in parentheses are the number of supplemental sections for each project. The other value provided for each project is the age of that project in years, as of January 2000.

* The Missouri project is located in the cell for which it was nominated because the data for determining the correct cell assignment are unavailable at the time of data extraction.

As shown in table 8, no projects are located in site cell 2 (fair surface condition in a wet-no-freeze climate) and a replicate project is unavailable for site cell 7 (poor surface condition in a dry-freeze climate). Data for empty cells are not believed to be critical to the overall success of the SPS-5 experiment.

DESIGN VERSUS ACTUAL CONSTRUCTION REVIEW

Chapter 3 presented a summary of the construction and specification requirements for each SPS-5 project. The *Guidelines for Nomination and Evaluation of Candidate Projects*[8] and *Construction Guidelines*[9] also established specific site-selection criteria and key variable construction guidelines, which were developed to control the quality and integrity of the experimental data from the SPS-5 experiment and should be considered in the construction-adequacy evaluation and assessment.

One main objective of this study was to identify any confounding factors introduced into the SPS-5 experiment regarding construction deviations and/or other factors not accounted for in the original experiment design. It is extremely important to evaluate the types of variables that are considered key design factors in the SPS-5 experiment and to determine whether any deviation of the design parameters established for the design factorial would adversely affect the experiment expectations.

This part of chapter 4 evaluates the design versus actual construction of key variables identified in the experimental factorial and guidelines.

Climate

The SPS-5 experimental design called for each project to be located in one of four climatic zones: wet-freeze, wet-no-freeze, dry-freeze, and dry-no-freeze. The sites nominated in each zone were shown in table 1. The main purpose of this factor was to obtain SPS-5 projects in different climates, as well as a geographical distribution across the United States and Canada. Table 9 tabulates the average annual rainfall, mean annual air temperatures, and freeze index measured at each site.

The general climatic data include a site-specific statistical estimate, based on as many as five nearby weather stations, for each project. These estimates are called virtual weather stations. The IMS contains monthly and average annual summary statistics. Daily data for both the virtual and actual weather stations are stored offline. General environmental data available in the IMS are derived from weather data originally collected from the National Climatic Data Center (NCDC).

The SPS-5 project sites include a wide range of freeze index, temperature, and annual rainfall, as originally planned. The freeze index and average rainfall determine the climatic designation for each site. Those sites with an average annual rainfall greater than 1,000 mm are classified as wet and those with less than 1,000 mm as dry. Similarly, the sites with a freeze index greater than 60 °C-days are classified as a freezing climate and those with less than 60 °C-days are designated as a no-freeze climate.

The values used to determine the specific climatic cell assignment are arbitrary and are only used to ensure that the projects cover a diverse range of climates. An annual rainfall of 1,000 mm was used in some of the earlier LTPP studies for assigning a wet or dry climate to the site, while an annual rainfall of 508 mm is used in the latest version of DataPave®. A freezing index value of 60 °C-days was used to determine whether the site falls into a no-freeze or freeze cell, while a different value is used in DataPave.

Some did not meet the above definitions based on the climatic data that had been collected as of the time of this report. For example, Minnesota and Texas both have annual rainfalls less than 1,000 mm, but are in experimental cells designated as wet. Similarly, Georgia has a freeze index of 66 °C-days, but is in an experimental cell designated as no-freeze. These differences are not considered detrimental to the experimental plan because the SPS-5 sites have a diverse range of climatic conditions.

Table 9. Summary of key factor values for the SPS-5 projects.

Climate	Project ID	Predominant Type of Subgrade Soil	Average Annual Rainfall, mm	Mean Annual Air Temp, °C	Freeze Index, °C-days	Age, years	Traffic Data, number of days		Estimated KESALs per year
							AVC	WIM	
Wet-Freeze	MD	Silt	1096	13.0	76	7.2	218	155	X[1]
	MN	Sandy clay	637	3.6	861	8.9	717	702	57
	NJ	Clayey sand	1205	11.5	114	7.0	1,395	1,466	391
	ME	Poorly graded sand	1050	6.5	401	4.1	0	0	X[1]
	MO	–	–	–	–	0.0	0[2]	0[2]	X[1]
Wet-No-Freeze	TX	Clay	992	18.3	17	7.8	385	7	X[1]
	GA	Sandy silt	1428	13.1	66	6.2	0	0	X[1]
	MS	Clayey silt	1464	16.9	16	8.9	91	89	X[1]
	FL	Poorly graded sand	1488	23.6	0	4.3	0	0	X[1]
	AL	Clayey sand	1441	18.5	5	7.7	0	0	X[1]
Dry-Freeze	CO	Sandy clay	417	9.5	214	7.9	338	1,058	X[1]
	AB	Clayey gravel	524	2.0	787	8.9	0	0[3]	X[1]
	MT	Clayey gravel	426	8.4	257	8.0	930	0[3]	X[1]
	MB	Sandy silt	567	2.3	1047	10.0	0	0[3]	X[1]
Dry-No-Freeze	NM	Silty sand	325	15.1	6	2.9	0	0	X[1]
	OK	Clayey silt	844	16.0	46	2.0	0	0	X[1]
	AZ	Silty sand	232	21.3	0	9.2	409	290	587
	CA	Poorly graded sand	119	19.4	1	7.3	32	32	X[1]

Notes: 1. Traffic estimates exist, but the reliability of the number of ESALs per year is unknown and not included in the IMS.

2. The Missouri project was recently constructed.

3. Traffic monitoring equipment installed at site, but data are not included in the IMS at Level E.

Original Pavement Condition

Each of the SPS-5 projects has been categorized based on the condition of the original pavement; a designation of fair or poor was assigned by the owner agency nominating the SPS-5 project. These ratings were purely subjective and not based on the actual amount of distress on the project—they were only used to ensure a range of surface conditions of the original pavement before rehabilitation.

Actual pavement condition data were collected before the rehabilitation of the test sections by the RCOs. These data included deflections from FWD testing, longitudinal profile, pavement distress, and transverse profile. Table 10 summarizes the average International Roughness Index (IRI), rut depths, fatigue cracking, and transverse cracking on each SPS-5 project before overlay placement. The pavement condition and distress data along each of the test sections are available; however, not all data have passed the QC checks for a Level E data status.

Table 10. Summary of preconstruction pavement condition data.

Original Pavement Condition	State/Province	Average IRI, m/km	Average Rut Depth, mm	Average Fatigue Cracking, m^2	Average Transverse Cracking Length, m
Fair	Maryland	1.64	7	62.5	33.2
	Minnesota	2.70	—	0	128.8
	New Jersey	1.86	7	76.9	18.6
	Texas	1.46	10	—	—
	Georgia	1.03	—	2.5	0.8
	Colorado	1.88	15	11.8	20.3
	Alberta	1.83	—	1.3	0.7
	Montana	1.36	13	115.6	70.4
	New Mexico	2.36	—	4.9	32.1
	Oklahoma	1.88	—	0.2	24.1
Poor	Alabama	1.14	—	21.5	1.6
	Florida	1.16	—	183.1	34.5
	Maine	1.22	15	0.0	6.0
	Mississippi	2.19	19	1.9	59.9
	Missouri	—	—	—	—
	Arizona	1.84	—	74.4	277.2
	California	2.29	9	37.2	116.6
	Manitoba	—	—	7.7	4.7

Overall, the value of the individual performance indicators of the two pavement groups (fair and poor) appears to be minimal, but there is a large difference in the performance indicators between the projects included in the SPS-5 experiment, which satisfies the experiment design requirement.

Layer Thickness/Structure

The pavement structure data are divided into two elements, layer data and pavement design features. Important general design features such as drainage, lane width, and shoulder type are included in IMS tables **INV_GENERAL** and **INV_SHOULDER**. All key design-feature data were available for all SPS-5 projects with one exception—as of the time of this report, the data for the Missouri project had not yet been processed through the system. All available data were at level E.

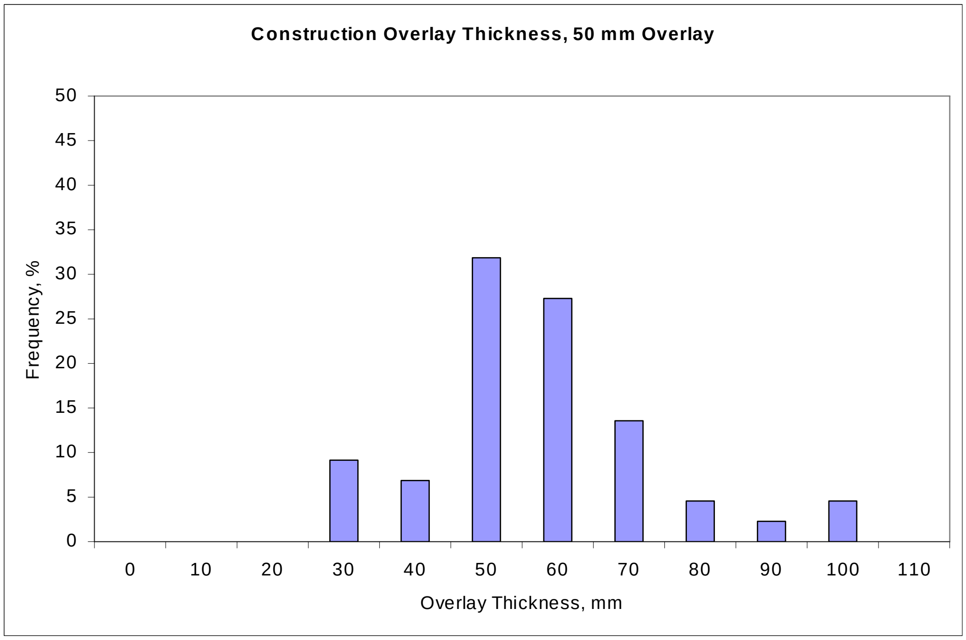
The postconstruction pavement layer data for the SPS-5 test sections are available from two different sources. IMS table **SPS5_LAYER_THICKNESS** contains data from the rod-and-level measurements that were performed to determine the depth of milling and the thicknesses of the overlay layers. Estimates of the thicknesses of the layers of the pavement structure after construction are stored in the IMS table **SPS5_LAYER**. Finally, the representative thicknesses are stored in IMS table **TST_L05B**. These thicknesses are determined by the RCO by reviewing data from the rod-and-level measurements, thicknesses from cores recovered on-site, and any other available data. While IMS table **SPS5_LAYER** only provides thicknesses for the post-construction layer structure, IMS table **TST_L05B** provides two sets of thicknesses—one for the preconstruction structure and one for the postconstruction structure.

All three of the above tables were examined to evaluate the thickness measurements and variation of the layer thickness data for each layer of overlay and existing pavement. The average thickness of each layer is provided in appendix B for all projects for which data were available. IMS table **TST_L05B** contains records for 14 of the 18 projects. Level E data for the Alabama, Missouri, New Mexico, and Oklahoma projects were unavailable. The Missouri, New Mexico, and Oklahoma projects were relatively new projects—the data had not passed all QC checks to achieve a Level E status at the time of data extraction for this study. The Alabama project was more than 7 years old.

IMS table **SPS5_LAYER** contains data for 16 of the SPS-5 projects; all available data were at level E. The Minnesota and Missouri projects did not have construction data in the database; and the Missouri project was new and very little data were available. The Minnesota project was more than 8 years old.

Histograms for the milling depth and the two overlay material thickness levels are shown in figures 3 through 5. These histograms review the distribution of layer thicknesses for all projects. Each shows the distribution of layer thicknesses from IMS table **TST_L05B** and from the construction data in IMS table **SPS5_LAYER_THICKNESS**. The distribution among the different methods is similar and the average values, taken from those thickness-determination methods, are approximately equal. These thickness variations represent typical construction practices and all data sets are distributed normally. The variations in layer thickness, which are greater than required by construction guidelines, are not believed to be detrimental to the experiment.

The experiment-wide average layer thicknesses were within the construction guidelines for each layer. The average thickness for some layers for some projects did not fall within the allowable deviation limits as shown in figures 3 and 4. All layers on all projects had at least one thickness measurement from the rod-and-level data that was outside allowable limits. It is believed that the construction guidelines called for an impractical tolerance.



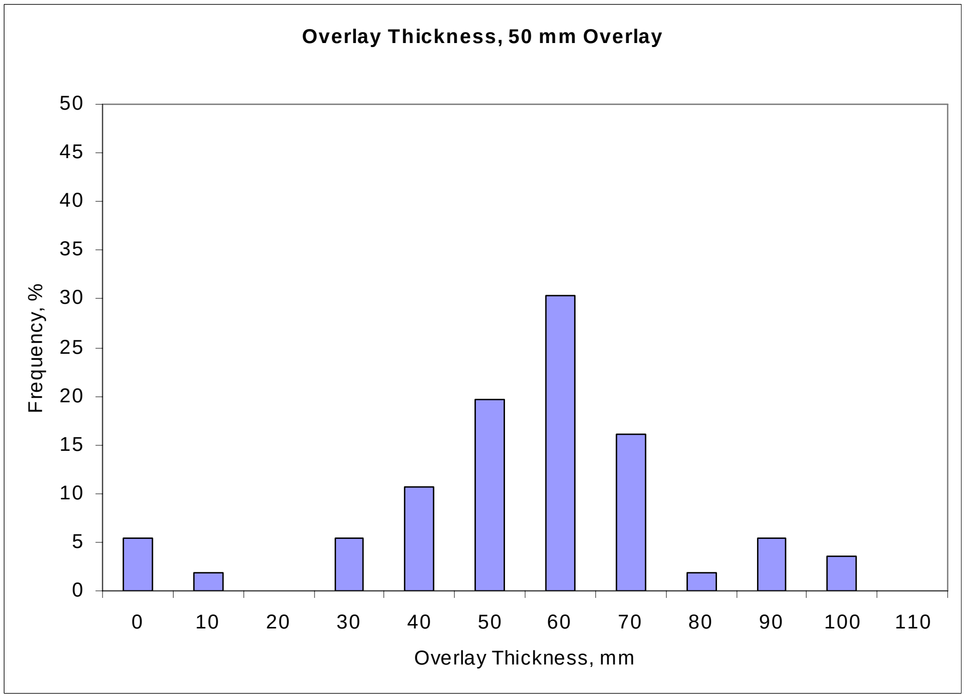
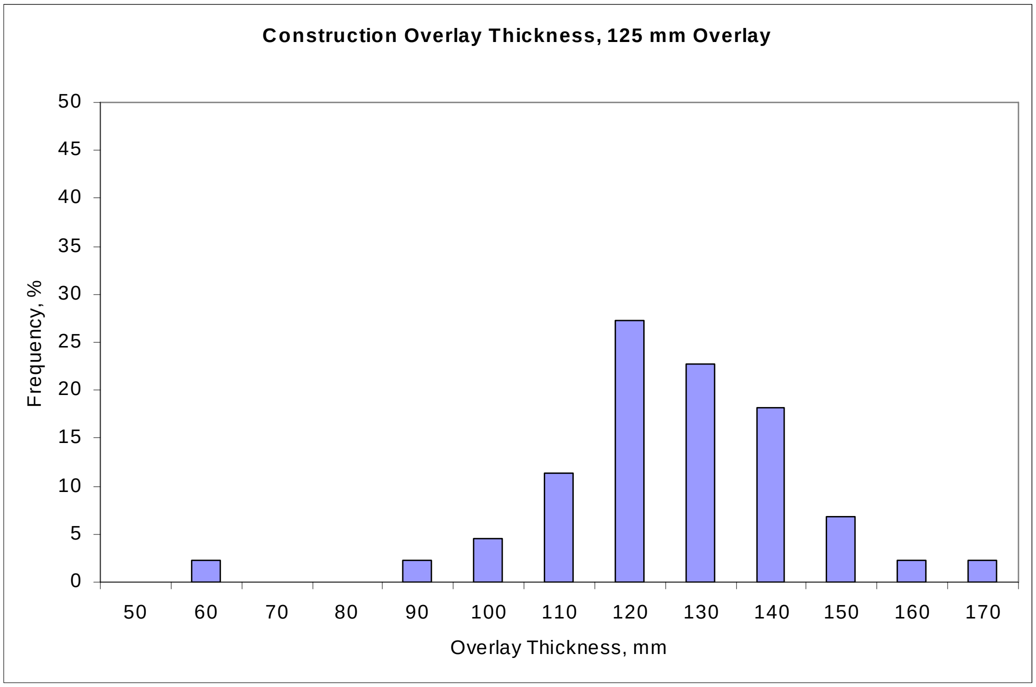


Figure 3. Histograms. Thicknesses for the thin overlay layer (50 mm) from IMS tables SPS5_LAYER_THICKNESS (construction data) and TST_L05B.



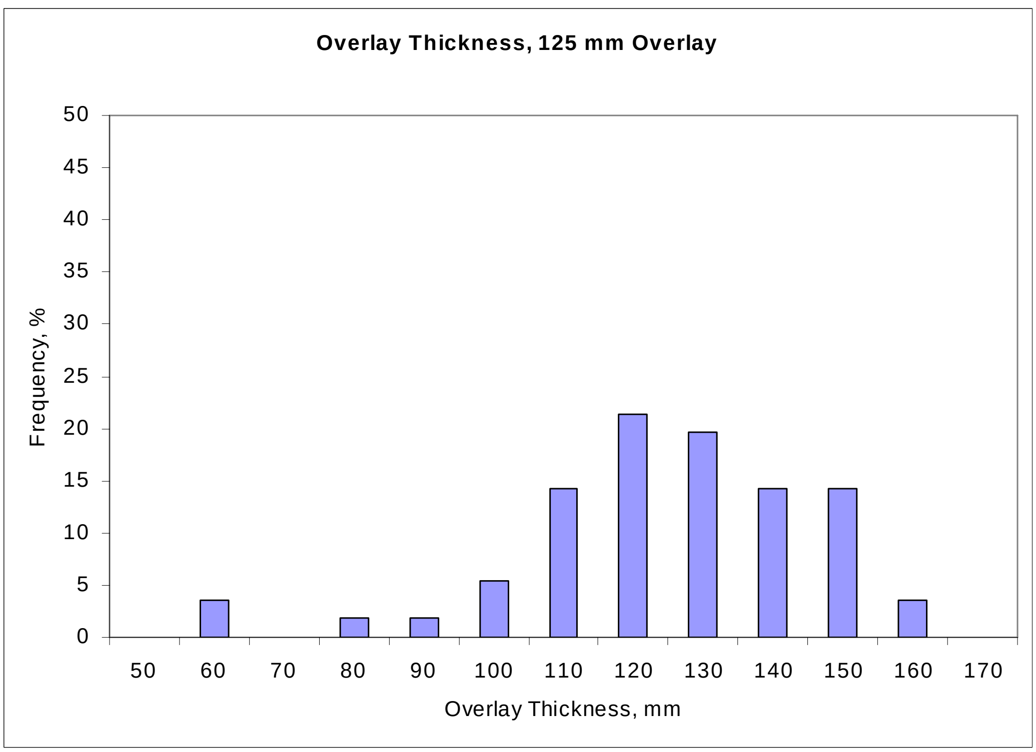
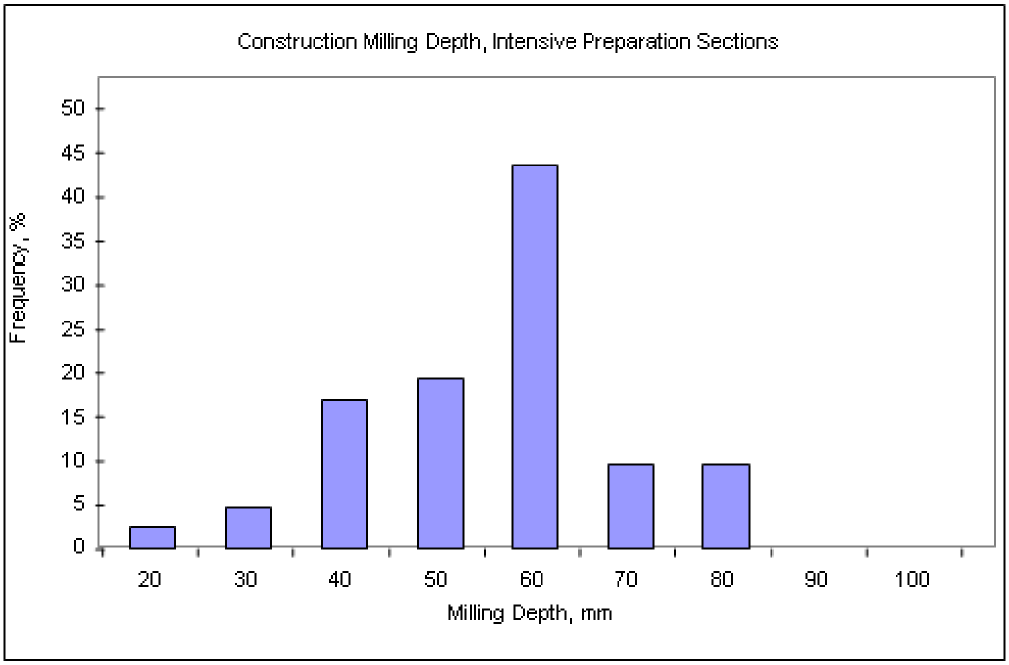


Figure 4. Histograms. Thicknesses for the thick overlay (125 mm) from IMS tables SPS5_LAYER_THICKNESS (construction data) and TST_L05B.



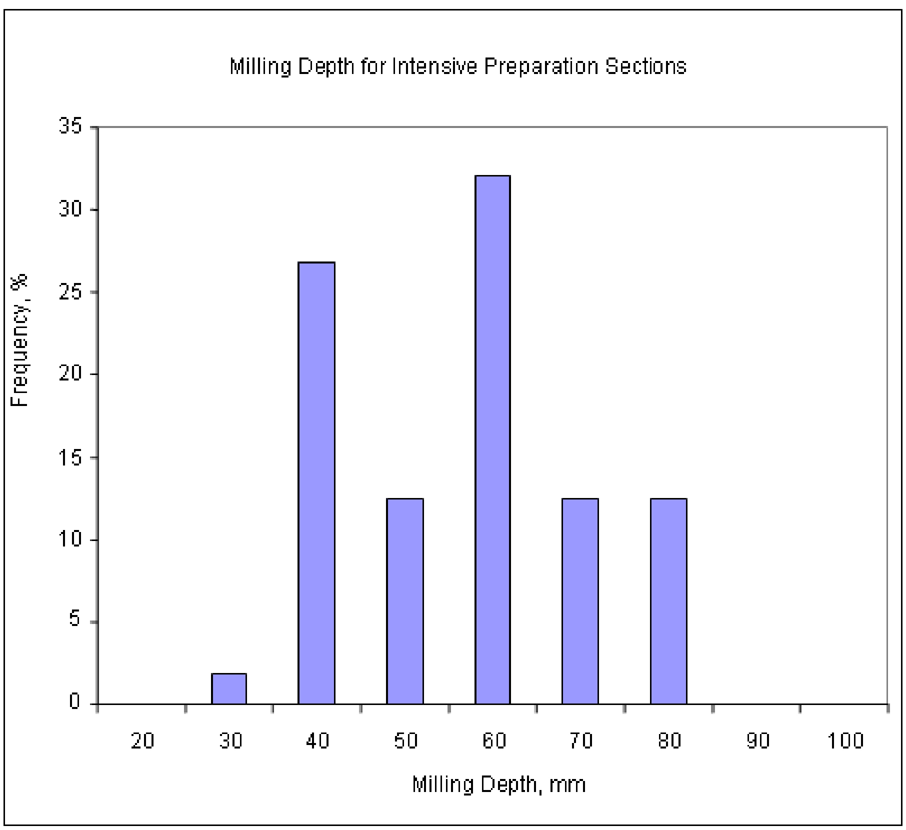


Figure 5. Histograms. Milling depth for sections with intensive surface preparation from IMS tables SPS5_LAYER_THICKNESS (construction data) and TST_L05B.

The pavement cross section and material types planned for each test section within the core experiment of each project generally were met and followed, based on construction guidelines.

Subgrade Soil

The SPS-5 experiment design called for all projects to have a fine-grained soil. However, 9 of the 18 projects have a coarse-grained soil, and 4 have both types of soils (refer to tables 3 and 9). The variation in soil classification at these four sites (California, Colorado, Georgia, and Manitoba), as well as at the other 14 sites, is considered typical and this deviation from the experimental requirement should have no detrimental impact on the SPS-5 experiment.

MATERIALS TESTING

Field and laboratory tests were conducted to establish the properties of each material included in the SPS-5 experiment. A round of testing was done on each project before construction of the overlay layers to establish the material characteristics of the existing pavement structure. A second round was done on the overlay mixtures to evaluate the material properties and variation of properties for the overlays. Many properties or material characteristics are those used in existing pavement design and analysis methods.

The material sampling and testing requirements are documented in the SPS-5 materials sampling and testing guidelines report.(2) This report contains the development of the SPS-5 sampling and testing plans, field material sampling and testing requirements, and laboratory materials testing requirements for each SPS-5 project site. A generalized version of these plans is provided in chapter 3; specific testing requirements for each material are in appendix A.

Tables 11 through 13 summarize the available test data from selected tests for the subgrade soil, existing HMA layer, and HMA overlay for each SPS-5 project; table 14 provides a summary of the overall materials testing completed for the core test sections. As shown, a substantial amount of testing still needed to be completed, even for those tests identified as essential (see table 6). LTPP and the RCOs recognize the importance of the laboratory material tests and have taken action to obtain these data for all projects.

Table 11. Summary of preconstruction materials testing on the subgrade soils.

Project	Age, years	Subgrade Soil Testing			
		Gradation	Atterberg Limits	Moisture-Density Relations	Resilient Modulus
Manitoba	10.0	100	0	100	0
Arizona	9.2	100	100	100	0
Alberta	8.9	100	100	100	66
Mississippi	8.9	100	100	100	100
Minnesota	8.9	100	100	100	0
Montana	8.0	100	100	100	33
Colorado	7.9	100	100	100	100
Texas	7.8	100	100	100	100
Alabama	7.7	100	100	100	100
California	7.3	100	100	100	0
Maryland	7.2	0	0	0	0
New Jersey	7.0	66	100	0	66
Georgia	6.2	50	50	50	75
Florida	4.3	33	33	33	33
Maine	4.1	100	100	100	0
New Mexico	2.9	0	0	0	0
Oklahoma	2.1	0	0	0	0
Missouri	0.0	0	0	0	0

Table 12. Summary of preconstruction materials testing on the existing HMA layer.

Project	Age, years	Existing HMA Layer					
		Core Exam.	Spec. Grav. Bulk/Rice	Asphalt Content	Moisture Suscep.	Gradation	Asphalt Viscosity
Manitoba	10.0	0	0/0	0	0	0	0
Arizona	9.2	100	90/66	100	0	100	100
Alberta	8.9	100	100/1000	100	0	100	100
Mississippi	8.9	100	0/0	0	0	0	0
Minnesota	8.9	10	33/0	0	0	0	0
Montana	8.0	100	100/100	100	0	100	100
Colorado	7.9	100	85/66	100	0	66	66
Texas	7.8	100	100/100	100	0	100	100
Alabama	7.7	50	0/0	0	0	0	0
California	7.3	0	0/0	0	0	0	0
Maryland	7.2	100	100/100	100	0	100	100
New Jersey	7.0	100	100/0	0	0	0	0
Georgia	6.2	100	100/0	75	0	75	75
Florida	4.3	80	70/0	0	0	0	0
Maine	4.1	100	100/100	100	0	100	0
New Mexico	2.9	0	0/100	100	0	100	100
Oklahoma	2.1	0	0/100	100	0	100	100
Missouri	0.0	0	0/0	0	0	0	0

Table 13. Summary of postconstruction materials testing on the HMA overlay mixture.

Project	Age, years	HMA Overlay					
		Core Exam.	Spec. Grav. Bulk/Rice	Asphalt Content	Moist. S., Strength, Creep	Gradation	Asphalt Viscosity
Manitoba	10.0	100	0/0	0	0/0/0	0	0
Arizona	9.2	100	100/100	100	0/0/0	100	100
Alberta	8.9	100	100/100	100	0/0/0	100	100
Mississippi	8.9	75	0/0	0	0/0/0	0	0
Minnesota	8.9	10	10/0	0	0/0/0	0	0
Montana	8.0	100	75/100	100	0/0/0	100	100
Colorado	7.9	100	100/65	65	0/0/0	85	65
Texas	7.8	100	50/50	50	0/0/0	0	50
Alabama	7.7	0	0/0	0	0/0/0	0	0
California	7.3	0	0/0	0	0/0/0	0	0
Maryland	7.2	100	100/100	100	100/0/0	100	100
New Jersey	7.0	100	100/100	100	0/0/0	100	50
Georgia	6.2	100	100/0	0	0/0/0	0	0
Florida	4.3	100	100/100	100	100/0/0	100	100
Maine	4.1	100	100/50	100	100/0/0	100	100
New Mexico	2.9	0	0/0	0	0/0/0	0	0
Oklahoma	2.1	0	0/50		10/0/0/	0	0
Missouri	0.0	0	0/0	0	0/0/0	0	0

Table 14. Percentage of material testing completed by material type for the core test sections on each project.

Climate	Original Pavement Condition	State	Material			
			Surface	Base	Subgrade	Overlay
Wet-Freeze	Fair	MD	100	100	17	69
		MN	11	50	50	4
		NJ	62	33	39	72
	Poor	ME	84	57	86	61
		MO	0	0	0	0
Wet-No-Freeze	Fair	TX	98	100	100	40
		GA	82	0	71	52
	Poor	MS	46	0	100	17
		FL	55	44	44	83
		AL	26	78	100	0
Dry-Freeze	Fair	CO	82	100	94	79
		AB	95	100	89	78
		MT	98	67	67	24
	Poor	MB	4	67	67	24
Dry-No-Freeze	Fair	NM	36	0	0	0
		OK	34	0	0	2
	Poor	AZ	87	83	100	71
		CA	0	0	67	0

Note: More materials tests have been completed than summarized because some test results have not passed all QC checks to achieve a Level E data status in the IMS.

To evaluate the relative difference in construction of in-place properties, histograms of different material properties were prepared. Figures 6 and 7 show gradation test results for the percentage passing the number 4 and number 200 sieves for recycled and virgin overlay layers.

Figures 8 and 9 show the variation of air voids in both the virgin HMA and RAP overlay layers. These variations are substantial enough to cause a significant difference in performance. In fact, some air voids are greater than 10 percent, indicating inadequate compaction or other mixture problems. The differences in air voids need to be considered and accounted for in any analysis of performance data.

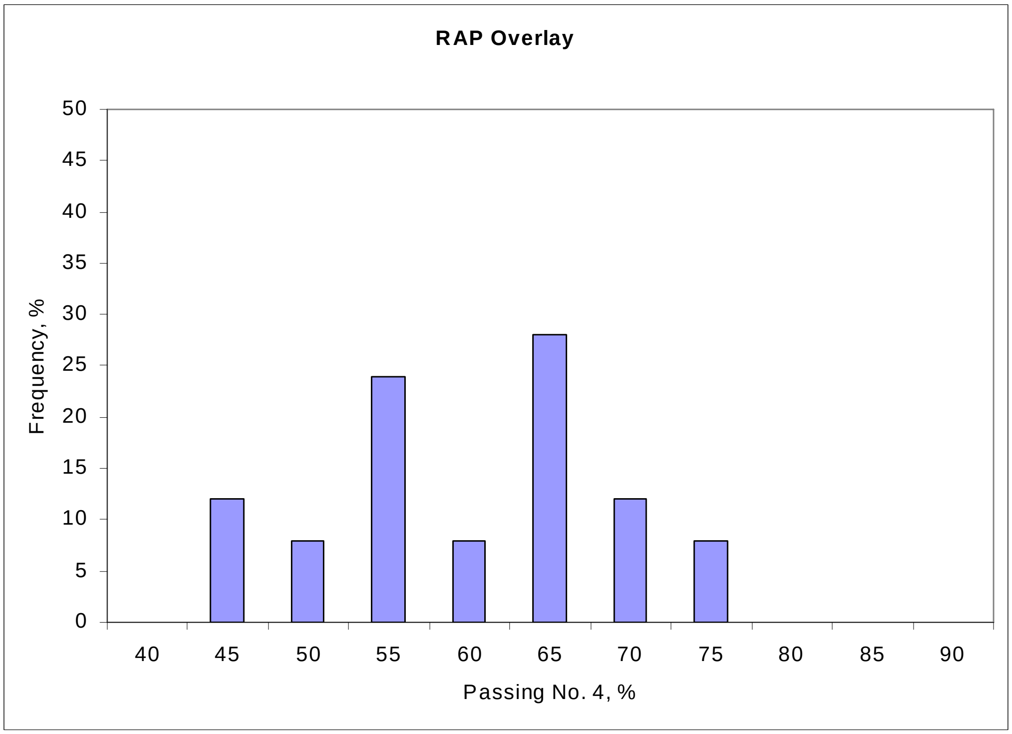
In summary, the between-project variation of different material properties can be large and will need to be considered as a secondary variable in completing a global analysis of SPS-5 results. The within-project variation, however, is much lower and typical of standard construction practices for a project.

TRAFFIC

Traffic data provide estimates of annual vehicle counts by vehicle classification and distribution of axle weights by axle type. Annual traffic summary statistics are stored in the IMS traffic module when available. These data are supposed to be provided for each year after the roadway was opened to traffic. For the SPS-5 experiment, traffic data are collected at the project site using a combination of permanent and portable equipment by the individual States agencies and/or Canadian provinces.

The SPS-5 experiment design calls for continuous AVC monitoring with WIM data collected at least 2 days of the year. IMS table **TRF_MONITOR_BASIC_INFO** was examined to identify the SPS-5 records with WIM, AVC data, and annual ESAL estimates. The availability of WIM and AVC was further classified as “at least 1-day” or “continuous.”

Continuous AVC and WIM monitoring were defined for two different conditions. In the past, LTPP has defined continuous AVC monitoring as more than 300 AVC monitoring days in a given year, and continuous WIM as more than 210 WIM monitoring days in a given year. However, based on variability measurements and the minimum number of sampling days recommended in NCHRP Project 1-37A for sampling truck traffic, continuous AVC and WIM monitoring were defined as of the time of this report as more than 45 monitoring days in a given season.



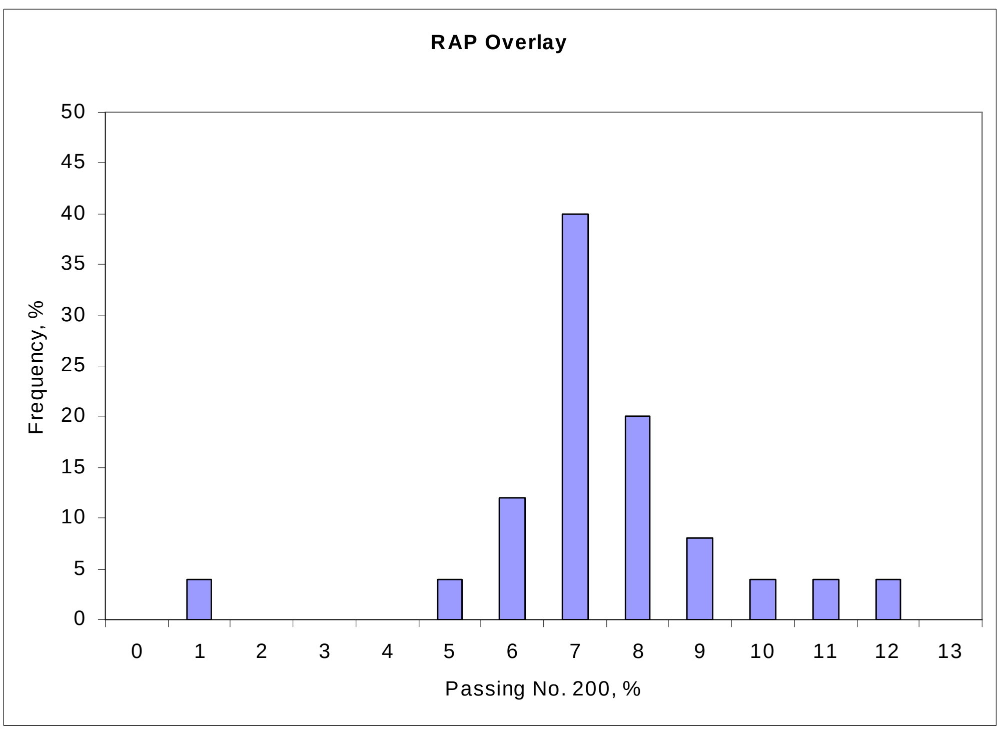
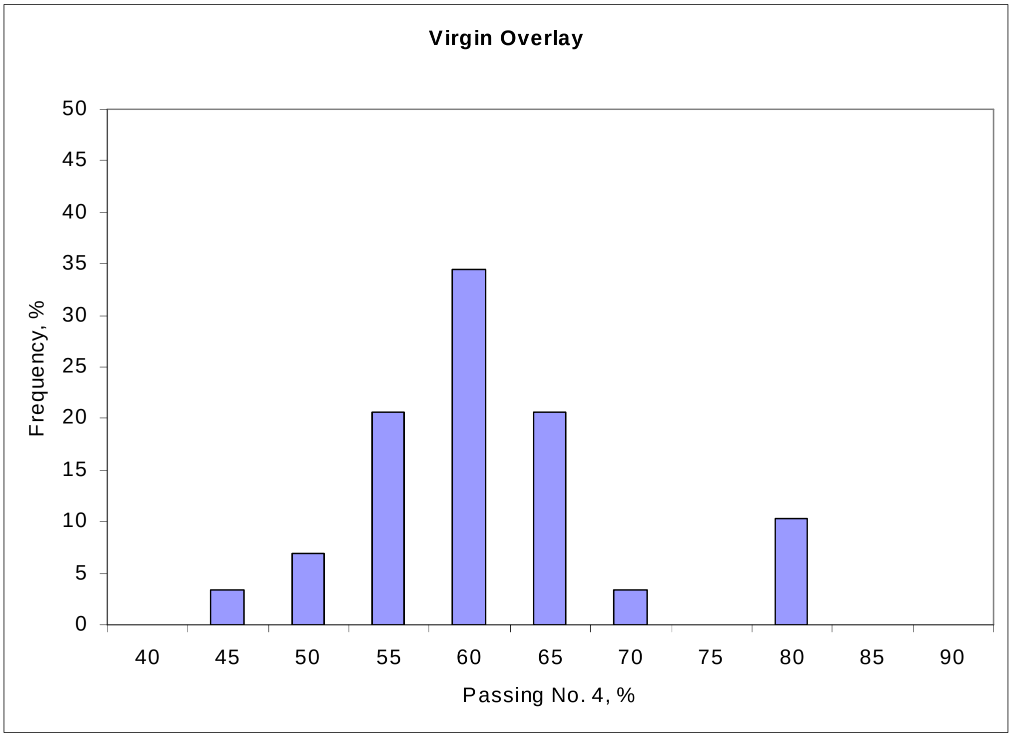


Figure 6. Histograms. Gradation of aggregate in RAP overlay.



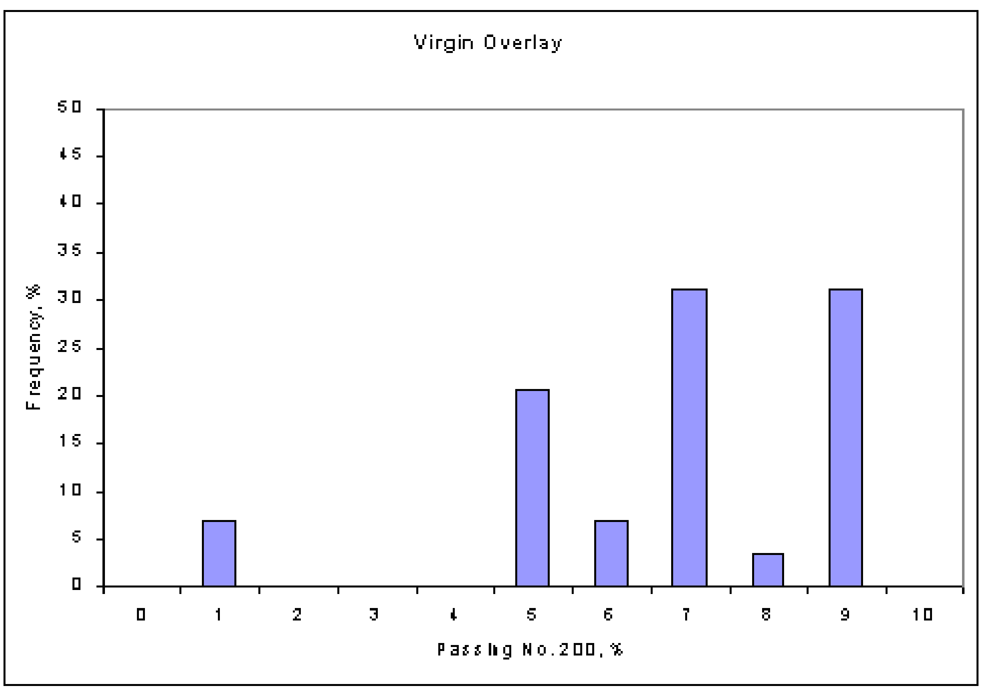


Figure 7. Histograms. Gradation of the aggregate contained in the virgin asphalt overlay.

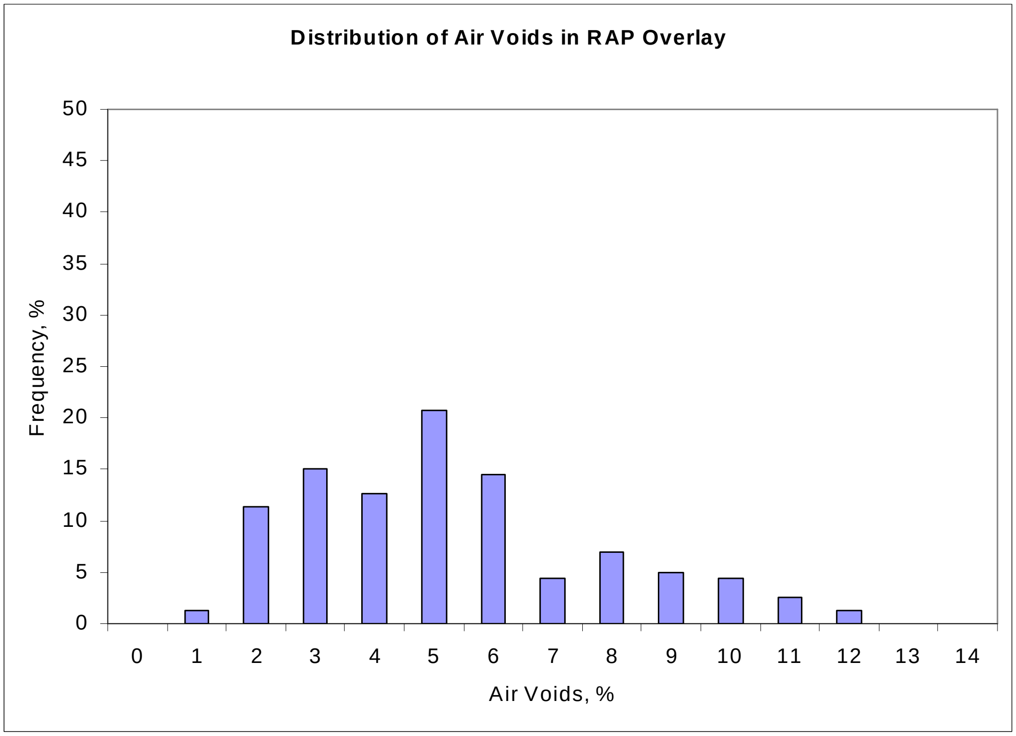


Figure 8. Histogram. Air voids measured on the virgin overlay.

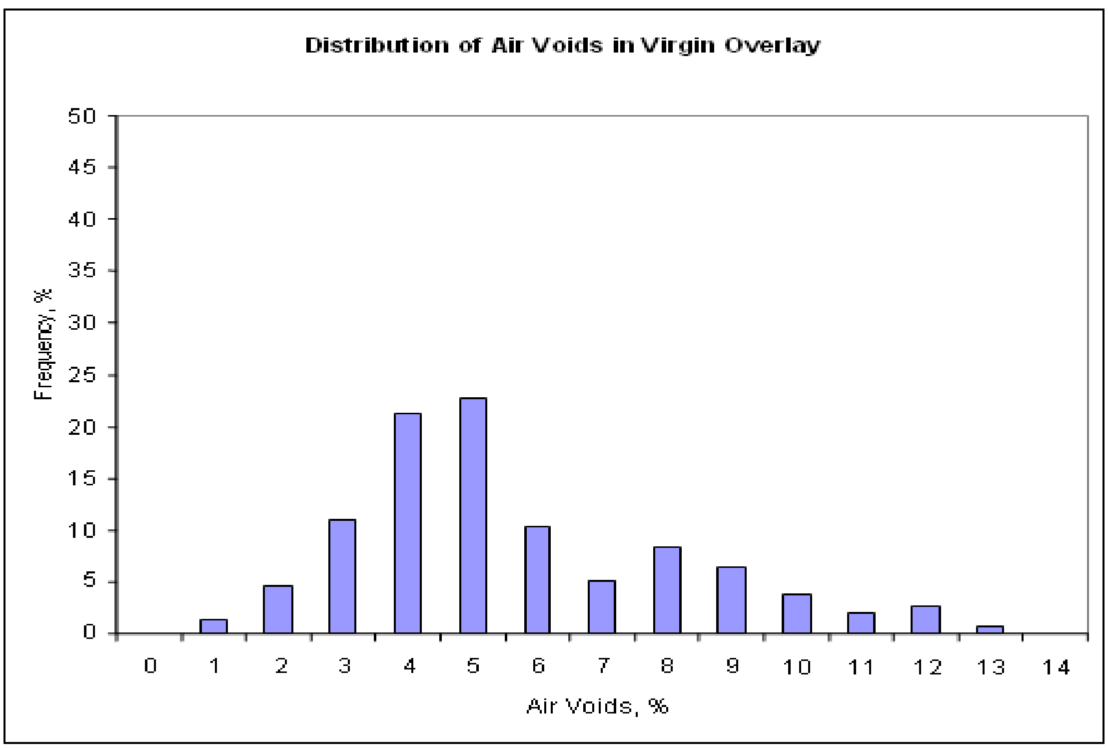


Figure 9. Histogram. Air voids measured on the RAP overlay.

Table 7 identified sites where traffic monitoring equipment had been installed as of the time of this report. As shown, 11 projects had the required equipment, while 7 did not. Table 9 summarized the number of continuous AVC and WIM days available for each project. Half of the SPS-5 projects (9 projects) had no traffic data at Level E. This is considered a significant detriment to the experiment.

In the original SPS-5 experiment, traffic was incorporated as a covariate in the experiment design. A traffic level of at least 85,000 ESALs per year was required for each project. The actual ESALs per year at each site are tabulated in table 9. The requirement was met for two of the three projects for which ESAL estimates were available. The more important point is that a reliable estimate of the annual ESALs was unavailable for 15 of the 18 SPS-5 projects at the time of data extraction.

The range of traffic loads between the sites will need to be fully considered in any comparative analysis of these data. More important, the missing traffic data will severely restrict the use of the SPS-5 experiment for validating mechanistic-empirical design and analysis methods. On the positive side, WIM equipment has been installed at nine of the SPS-5 sites, but not all data collected is at Level E in the IMS. Table 15 shows that the older projects have the greater amounts of Level E traffic data. A concerted effort is being made by LTPP and the RCOs to have the traffic monitoring equipment installed at the remaining sites.

MONITORING DATA

Several types of monitoring data are presented in the LTPP IMS, including distresses (from both manual and photographic surveys), longitudinal profiles, transverse profiles, deflection, and friction. Chapter 3 reviewed the required monitoring frequency for each data element for the SPS-5 experiment. In general, the requirements have been met for both the initial and long-term monitoring frequency. The number of measurements for each test section in each project are tabulated and discussed in appendix A.

Table 16 summarizes the minimum number of distress and other performance indicator measurements made at each SPS-5 site. Very few friction measurements had been performed on these projects, while there had been numerous deflection and longitudinal profile tests. Other than for the Missouri project, at least one survey for each of the monitoring data elements had been made at each site except for the friction and photographic surveys. As previously noted, the Missouri project had been constructed, but the data were unavailable at the time of data extraction. Table 17 summarizes the average time, in years, between each set of measurements for each performance indicator. Most monitored data have been measured more frequently than required by the guidelines.

Table 15. Summary of traffic data for the SPS-5 project sites.

Project	Age, years	Equipment installed	Number of AVC days	Number of WIM days
Manitoba	10.0	√	X(1)	X(1)
Arizona	9.2	√	409	290
Alberta	8.9	√	X(1)	X(1)
Mississippi	8.9	√	91	89
Minnesota	8.9	√	717	702
Montana	8.0	√	930	
Colorado	7.9	√	1,064	338
Texas	7.8	√	385	7
Alabama	7.7	–	–	–
California	7.3	√	32	32
Maryland	7.2	√	218	2
New Jersey	7.0	√	1,395	1,491
Georgia	6.2	–	–	–
Florida	4.3	–	–	–
Maine	4.1	–	–	–
New Mexico	2.9	–	–	–
Oklahoma	2.1	–	–	–
Missouri	0.0	–	–	–

Note 1. Traffic data collected at the site, but that data have not passed all of the QC checks to reach a Level E status in the IMS.

Table 16. Summary of the minimum number of distress and other performance indicator measurements made at each project site.

Project	Region	Age, Years	Deflection Surveys	Distress		Transverse Profiles	Longitudinal Profiles	Friction Surveys
				Manual	Photographic			
Maine	North Atlantic	4.1	3	3	1	4	3	3
Maryland	North Atlantic	7.2	5	4	2	6	8	3
New Jersey	North Atlantic	7.0	4	3	2	6	5	2
Minnesota	North Central	8.9	6	4	2	3	6	0
Missouri	North Central	–	1	2	0	0	0	0
Manitoba	North Central	10.0	7	6	3	5	8	4
Alabama	South	7.7	3	4	2	3	3	2
Florida	South	4.3	2	3	1	3	3	2
Georgia	South	6.2	4	4	2	3	3	4
Mississippi	South	8.9	6	2	3	4	6	0
New Mexico	South	2.9	2	2	0	1	1	0
Oklahoma	South	2.1	3	2	0	1	2	1
Texas	South	7.8	5	3	2	5	5	4
Arizona	West	9.2	7	4	3	6	7	3
California	West	7.3	5	4	3	8	8	1
Colorado	West	7.9	6	4	2	6	9	1
Montana	West	8.0	5	3	2	5	11	2
Alberta	West	8.9	5	4	3	4	10	2

Table 17. Summary of the average time interval between the different performance indicator surveys.

Project	Age, years	Longitudinal Profiles	Transverse Profiles	Distress		Deflection Surveys
				Manual	Photographic	
Manitoba	10.0	1.3	2.0	1.7	3.3	1.4
Arizona	9.2	1.3	1.5	2.3	3.1	1.3
Alberta	8.9	0.9	2.2	2.2	3.0	1.8
Minnesota	8.9	1.5	3.0	2.2	4.5	1.5
Mississippi	8.9	1.5	2.2	4.5	3.0	1.5
Montana	8.0	0.7	1.6	2.7	4.0	1.6
Colorado	7.9	0.9	1.3	2.0	4.0	1.3
Texas	7.8	1.6	1.6	2.6	3.9	1.6
Alabama	7.7	2.6	2.6	1.9	3.9	2.6
California	7.3	0.9	0.9	1.8	2.4	1.5
Maryland	7.2	0.9	1.2	1.8	3.6	1.4
N. Jersey	7.0	1.4	1.2	2.3	3.5	1.8
Georgia	6.2	2.1	2.1	1.6	3.1	1.6
Florida	4.3	1.4	1.4	1.4	4.3	2.2
Maine	4.1	1.4	1.0	1.4	4.1	1.4
N. Mexico	2.9	2.9	2.9	1.5	–	1.5
Oklahoma	2.1	1.1	2.1	1.1	–	0.7
Missouri	0.0	–	–	–	–	–

SUMMARY

Table 18 presents an overall summary of the SPS-5 projects (as of the time of this report), noting and identifying the project deviations, construction difficulties, and overall data completeness. These factors have been aggregated into an "adequacy code," which consists of a numerical scale from 0 to 5 that provides an overall rating of the project and test sections for fulfilling the original experimental objectives and expectations. A definition of this numerical scale for the adequacy code is given below.

- 5 = Project has adequate data to meet the experimental objectives and expectations.
- 4 = Project has minor limitations and limited missing data or data deficiencies that will have little impact on meeting the experimental objectives and expectations.
- 3 = Project has some missing data and deficiencies; however, assumptions combined with the existing data can be used to meet the experimental objectives and expectations.
- 2 = Project has missing data that will have an impact on the reliability of the results for achieving the experimental objectives and expectations.
- 1 = Project has major limitations in the data. There are significant data deficiencies or missing data that will have a significant and detrimental impact on meeting the experimental objectives and expectations.
- 0 = Project will be unable to meet the experimental objectives and expectations, or project has been recently constructed and has only limited data as of the time of this report.

Relatively few project deviations and construction problems were encountered during the construction of these projects. Of those difficulties and deviations noted, none are considered fatal to the overall expectations of the projects included in this experiment. However, there are some data elements at specific project sites that will have a negative effect on accomplishing the experiment objectives if they are not collected in the future. Primarily, these include traffic and some of the materials/layer properties. In fact, the essential material data elements and traffic data are considered vital to the SPS-5 experiment. The omission of these data elements is reflected in the overall adequacy code for each project.

As listed in table 18, only one project had an adequacy code of 0, the Missouri project. This project was recently constructed as of the time of this report and had little data in the database. It is expected that the adequacy code for this project will increase as more data become available and are entered into the IMS.

Three projects had an adequacy code of 2: Alabama, New Mexico, and Oklahoma. None had traffic monitoring equipment installed at the site; all had substantial materials test data that were unavailable; and not all of the preconstruction monitoring data were at Level E in the IMS.

Four projects (California, Florida, Georgia, and Manitoba) were assigned an adequacy code of 3 for a variety of reasons. A substantial amount of materials test data and some of the preconstruction performance data were unavailable at Level E. All other projects were assigned an adequacy code of 4 or 5.

Table 18. Summary of the overall construction difficulties, deviations, and adequacy codes for the projects included in the SPS-5 experiment.

Project	Construction Difficulties and Deviations	Adequacy Code
Alabama	Mix laid at low temperature on 010507 Milling performed by project without cooling agent Delamination occurred on existing pavement during milling operation	2
Arizona	Milling exceeded allowable limits on some of the minimum restoration sections Some areas of re-milling due to milling width Overlay placed at low temperature on some areas	3
California	Segregation in first lift Frequent stops and starts of the paver Problems with compaction in some areas	3
Colorado	Control section was overlaid	5
Florida	The first 15 m of 120502 were milled Evidence of segregation in RAP mix Area of 120508 was not sufficiently tacked	3
Georgia	Delay in paving on 130502 produced surface anomalies	3
Maine	No restoration on minimum restoration Overlay thickness too large on some sections	4
Maryland	Number 4 sieve for virgin mix did not meet project requirements	5
Minnesota	Variation in subgrade from fine to coarse Town in the middle of project	4
Mississippi	Production plant breakdowns caused delays Problems maintaining consistent mix	5
Missouri	Recently constructed	0
Montana	Control section was overlaid Number 4 sieve for RAP mix did not meet project requirement	5
New Jersey	Depth of milling was not measured Milling extended into granular base in some areas Fracturing of aggregate at center longitudinal joint on both the binder and surface overlay layers	5
New Mexico	High air voids on RAP mix Control section was milled and overlaid	2
Oklahoma	First batch of RAP mix contained too much asphalt cement Number 4 sieve for both the RAP and the virgin mix did not meet the project requirement	2
Texas	Rain delays Problems with the mix designs Breakdown of production plant	4
Alberta	Tack coat bubbling through overlay surface course on 810502 Depression left by pneumatic roller on 810505	4
Manitoba	Field sampling not conducted in accordance with guidelines Project located on coarse-grained soil Overlay thicknesses vary by more than 25 mm	4

5. ANALYSIS OF EARLY PERFORMANCE OBSERVATIONS

This chapter provides an evaluation of early observations based on initial performance data and identifies performance differences both within and between the SPS-5 projects, but it is not intended to be a comprehensive analysis of the experiment. Appendix A includes a summary of the amount of distress and performance data that had been collected at each of the 18 SPS-5 sites as of the time of this report.

GRAPHIC COMPARISON FROM TIME-SERIES DATA

Six performance indicators were reviewed initially to evaluate potential differences between the test sections (both within and between projects) and to identify performance trends from the early observations. These performance and structural response indicators included fatigue cracking, rutting, longitudinal cracking in and outside the wheel path, transverse cracking, IRI, and deflections measured by sensors 1 and 7.

The time-series data were plotted to observe trends for each of the monitoring data elements. The examples in figures 10 through13 compare the performance of the test sections for the different experimental factors for all of the SPS-5 projects (between-project differences). Figure 10 compares the total fatigue cracking for those sections with and without RAP in the HMA overlay mixture; figures 11 and 12 compare the total length of transverse cracks and rut depths for those sections with different surface preparations (defined as minimum and intensive). Figure 13 compares the IRI values for all SPS-5 projects for the existing pavements in different categories (fair and poor). As shown, a wide range of the performance indicators existed within the projects, making it difficult to identify any effect of the key experimental factors on performance. There also was extensive variability between the replicate projects within the same cell, making any graphic comparison difficult to interpret.

Time-series data were also plotted for individual projects to observe and evaluate trends between test sections of the same project and identify possible anomalies in performance data. Examples of the time-series distress data plots are shown in figures 14 through 19 for the Manitoba project. As shown, the data were variable and, more important, many of the distresses abruptly increased and decreased with time. Similar graphic comparisons of the individual test sections within a project were prepared for all other SPS-5 projects.

Examples of these inconsistent time-series data are provided in figures 20 through 24. Figures 20 and 21 show a significant decrease in fatigue cracking for the California and Colorado projects. For the California project (figure 20), the areas of fatigue cracking did not decrease for all test sections, whereas in Colorado (figure 21), the area of fatigue cracking for all test sections significantly decreased, suggesting that some type of maintenance may have been performed.

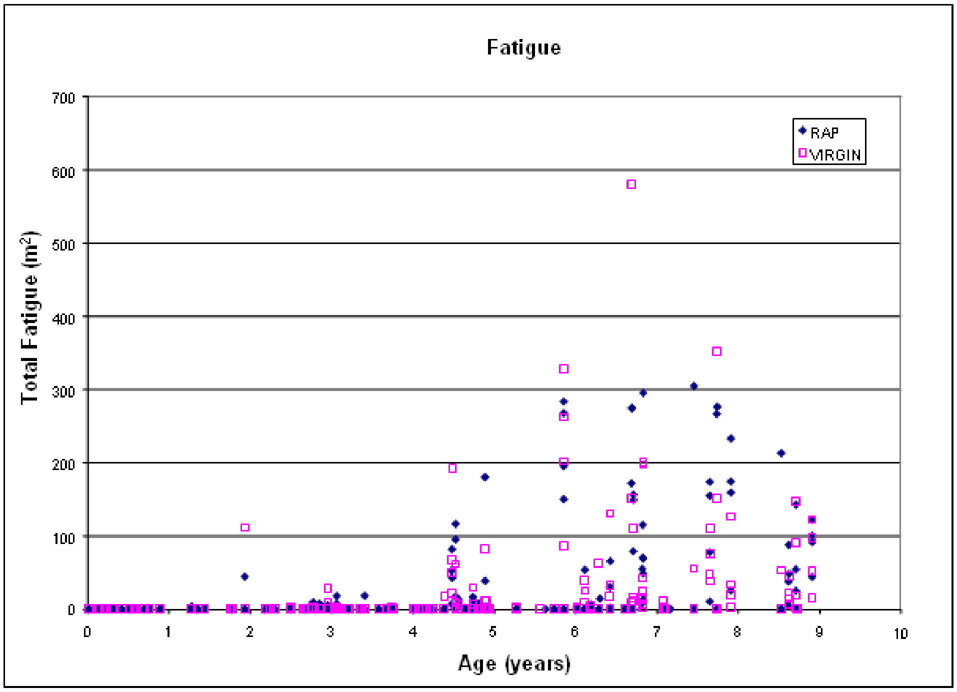


Figure 10. Graph. Fatigue cracking measured over time for the SPS-5 projects for those sections with HMA overlay mixtures with and without RAP.

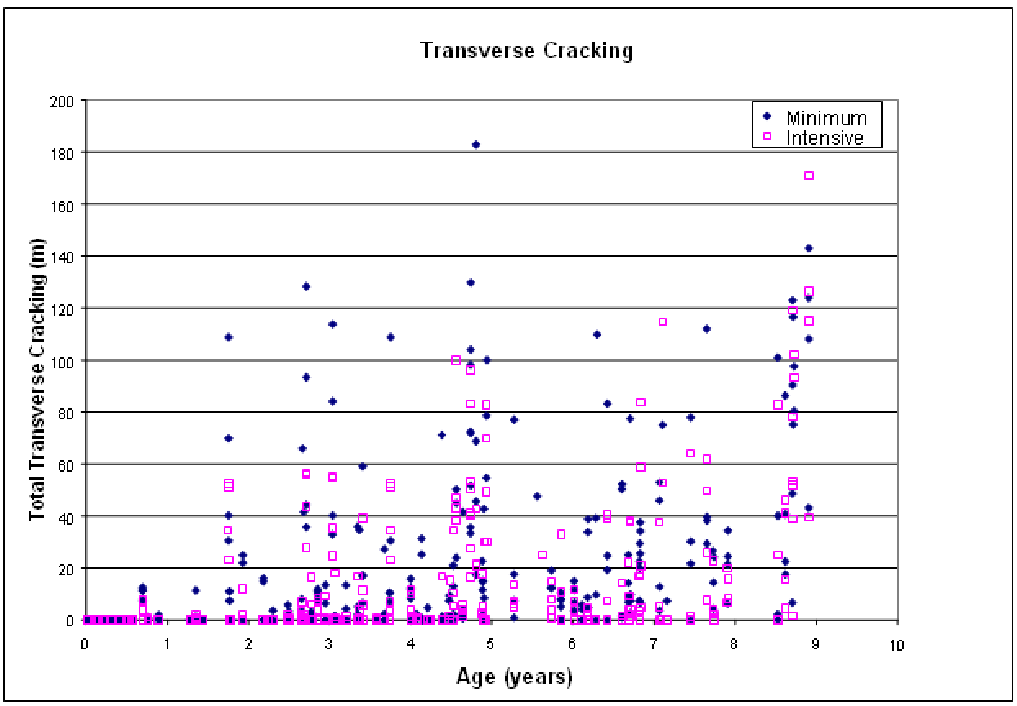


Figure 11. Graph. Total transverse cracking measured along the SPS-5 projects over time or age for those sections with minimum and intensive surface preparation.

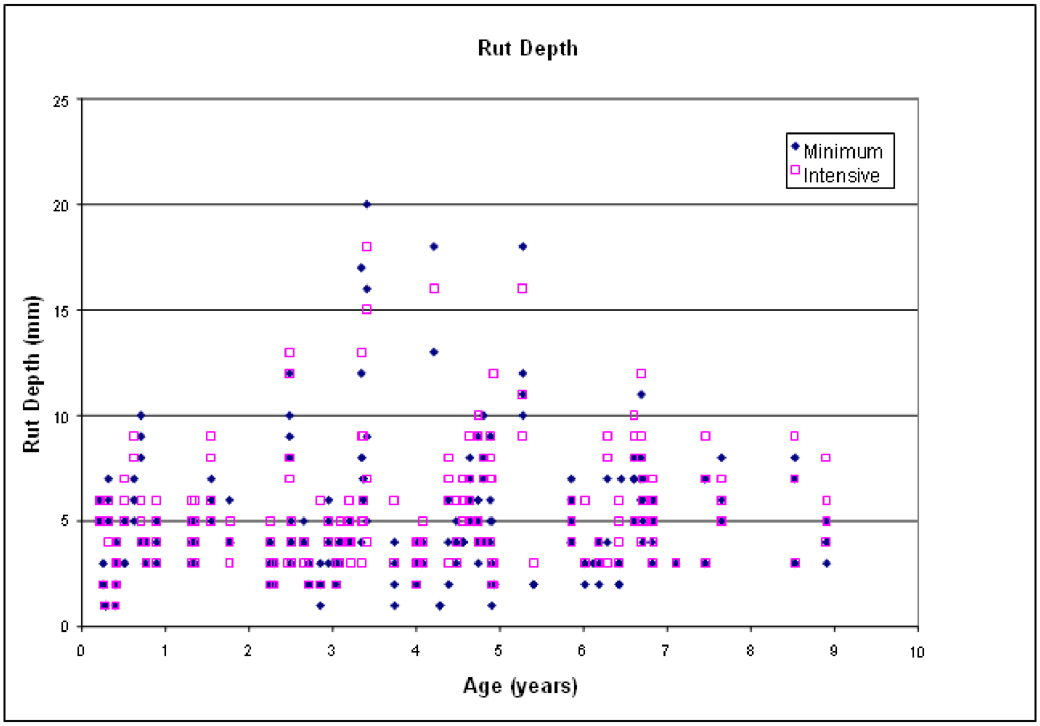


Figure 12. Graph. Rut depths measured over time for the SPS-5 projects for those sections with minimum and intensive surface preparation.

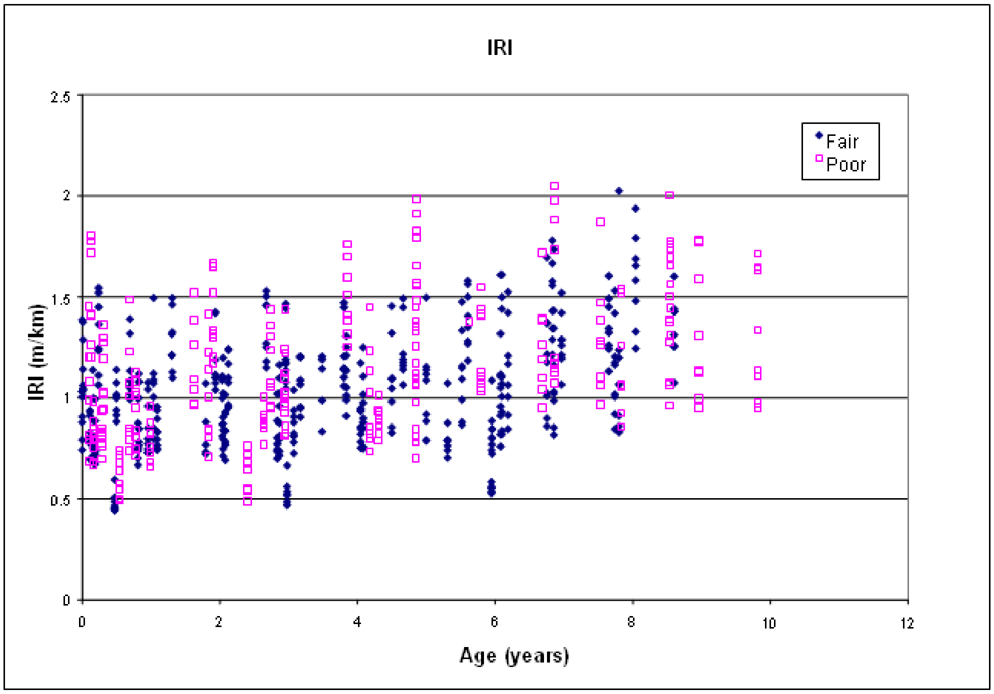
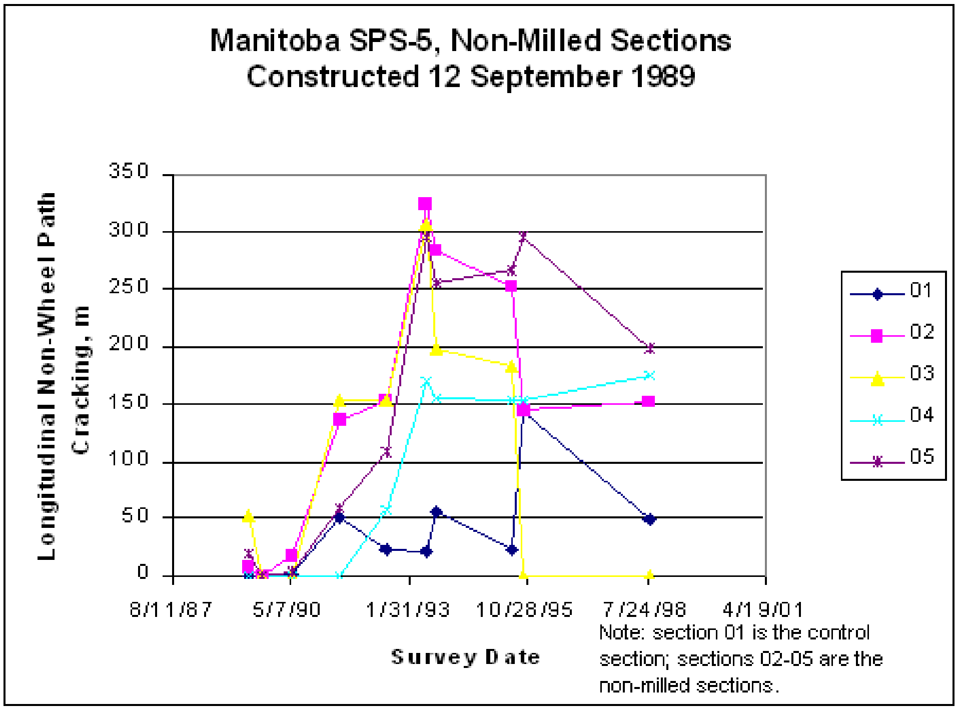


Figure 13. Graph. IRI measured over time for the SPS-5 projects for existing pavements in the fair and poor categories.



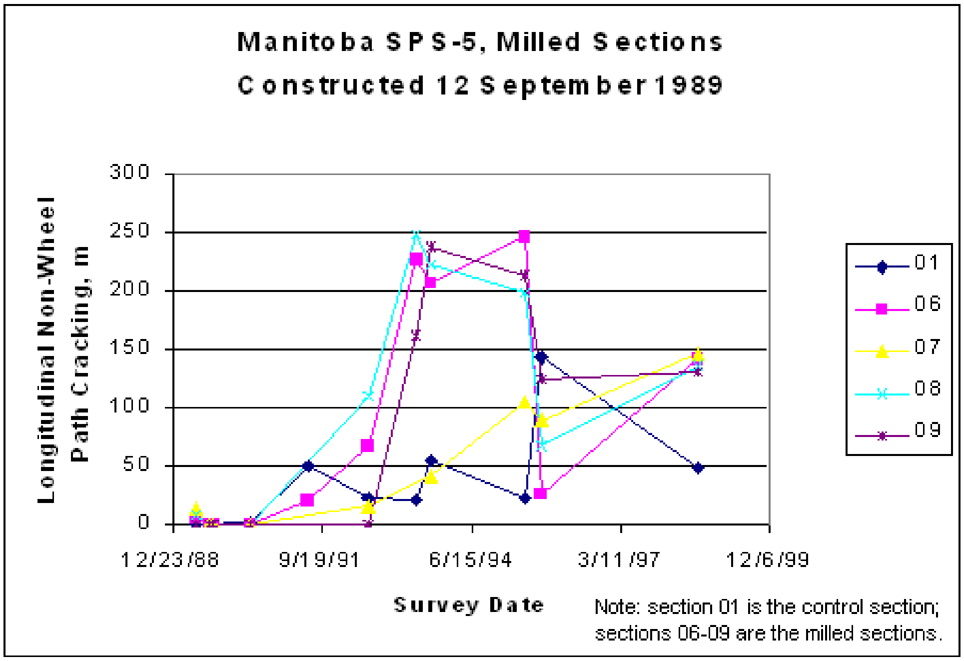
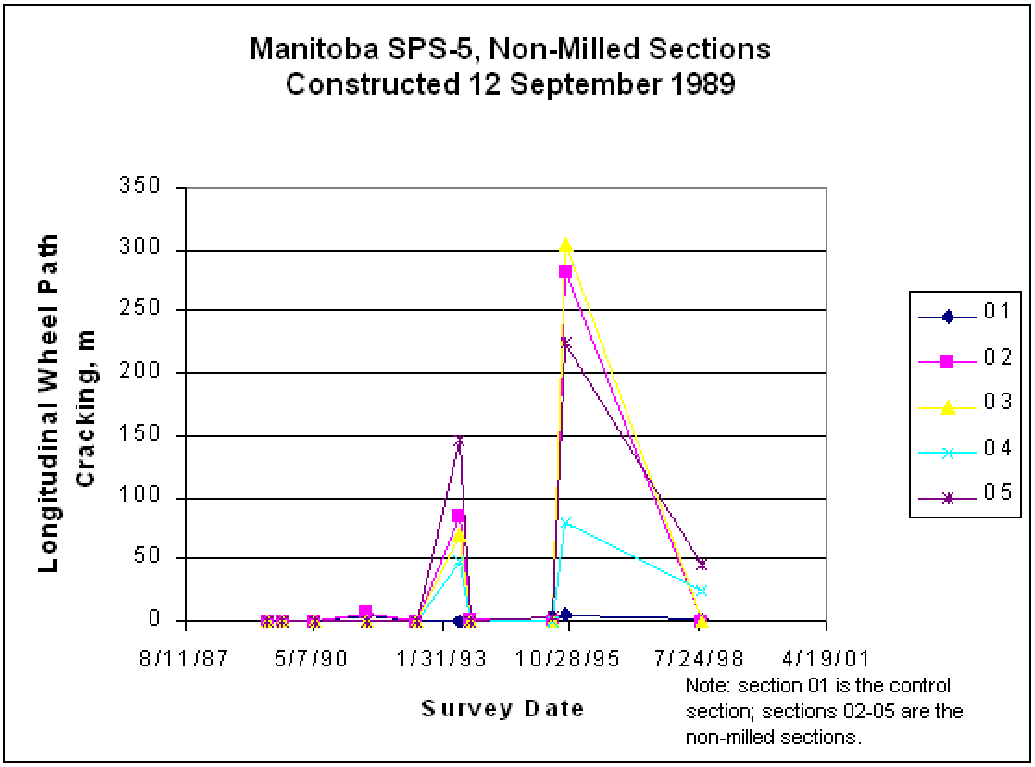


Figure 14. Graphs. Longitudinal cracking outside the wheel path time-series for the Manitoba project.



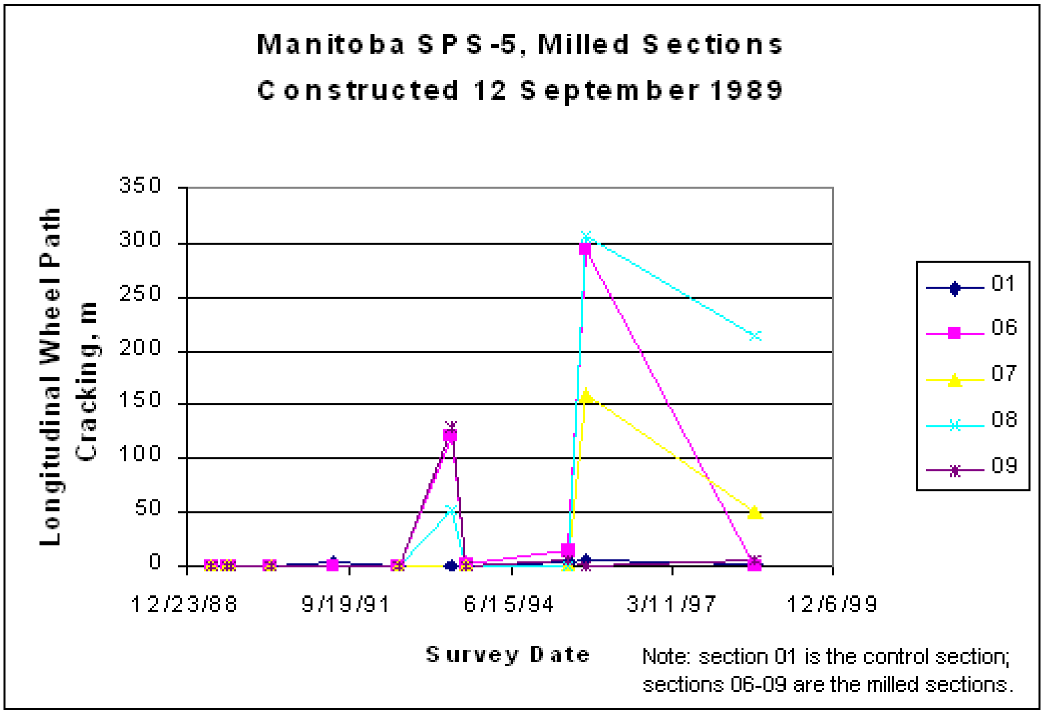
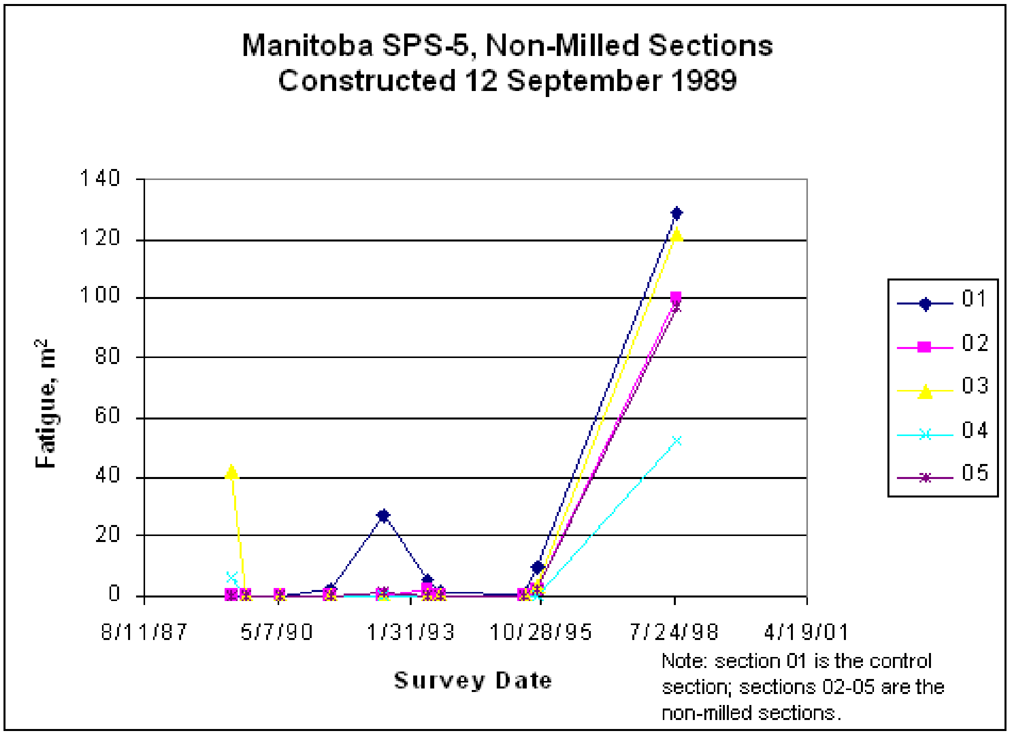


Figure 15. Graphs. Longitudinal cracking within the wheel path time-series data for the Manitoba project.



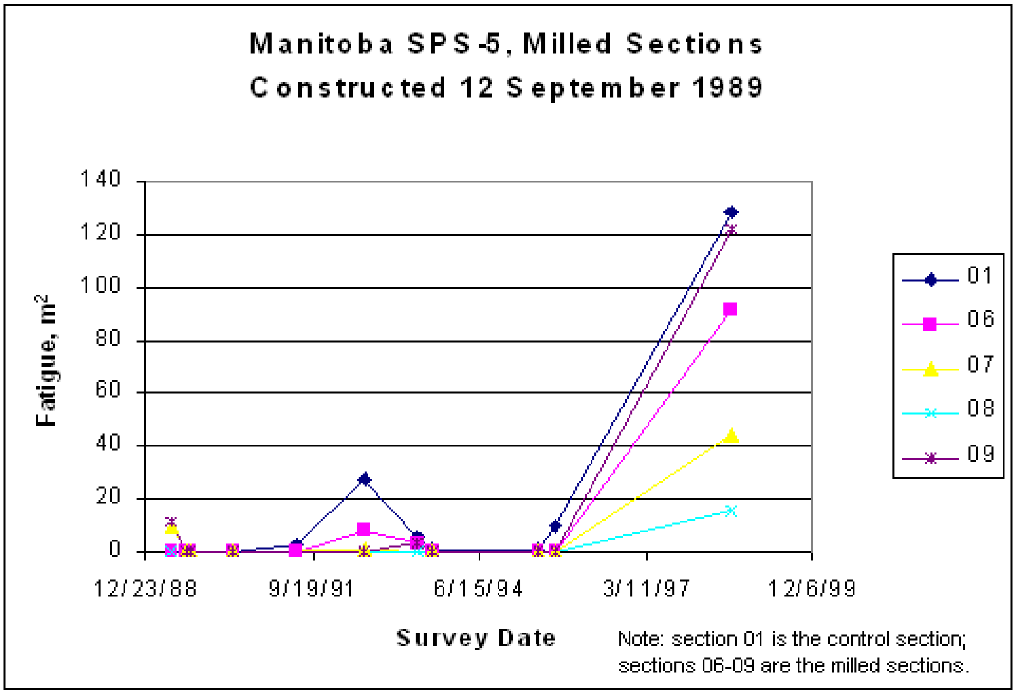
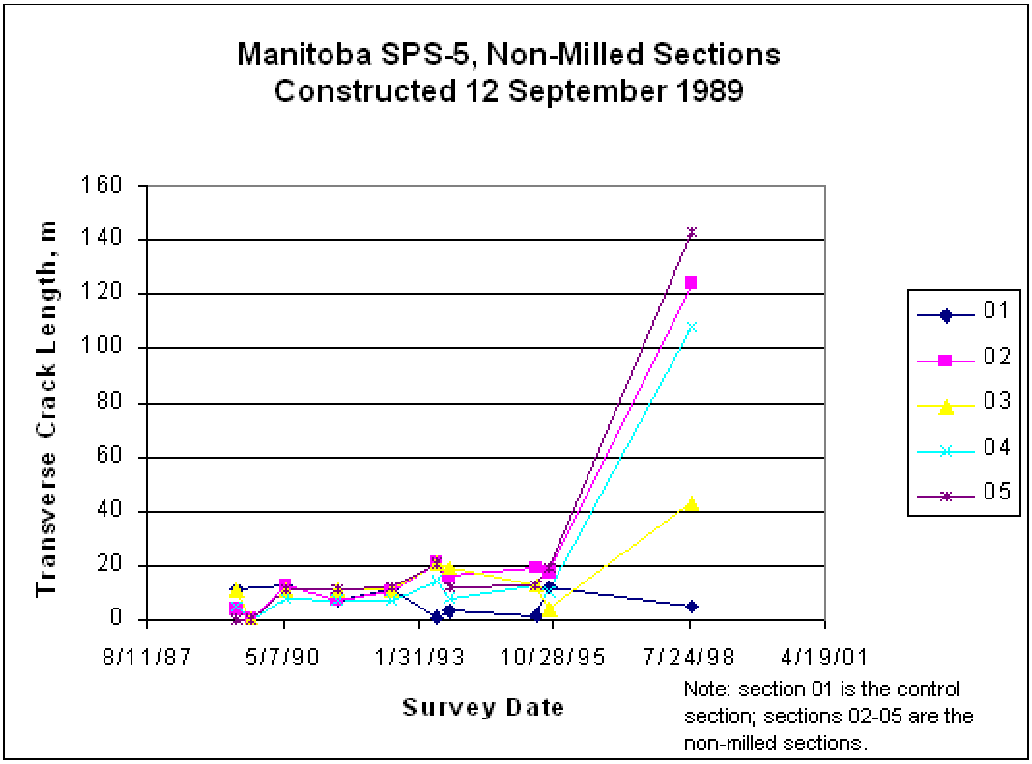


Figure 16. Graphs. Fatigue cracking time-series for the Manitoba project.



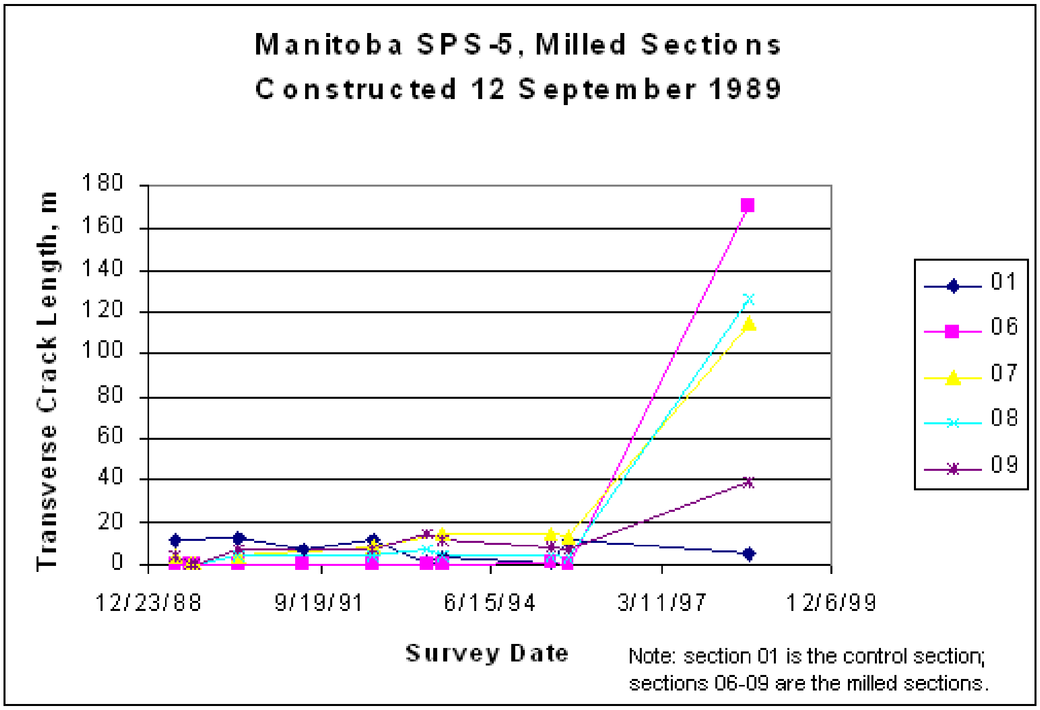
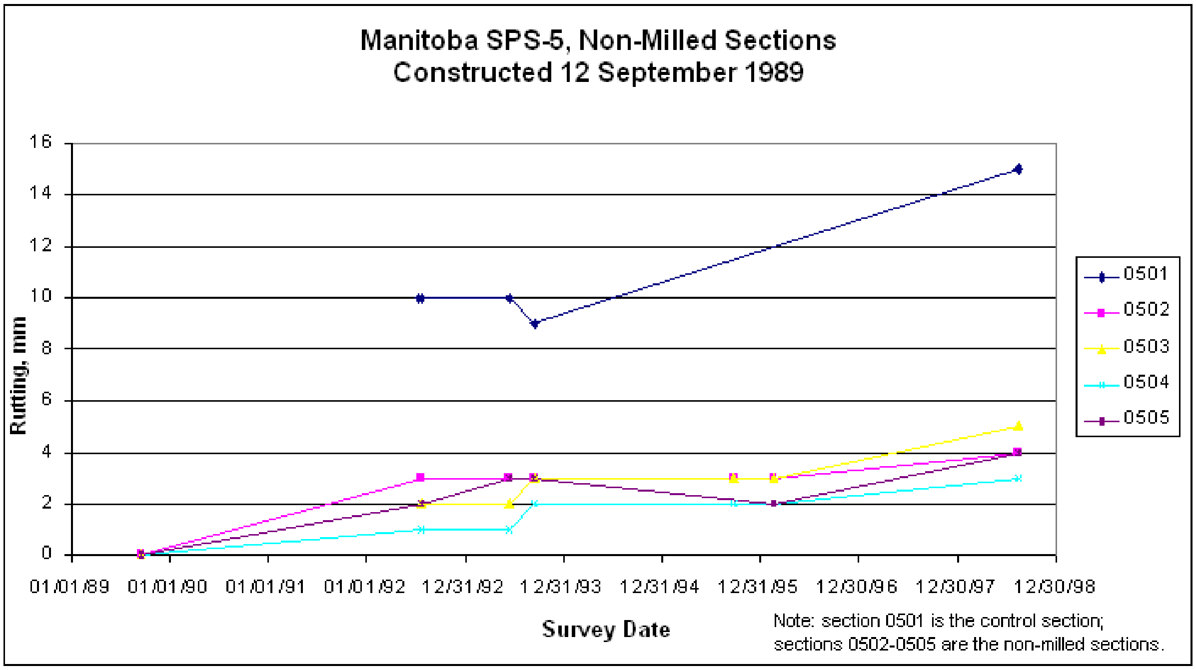


Figure 17. Graphs. Transverse crack length time-series data for the Manitoba project.



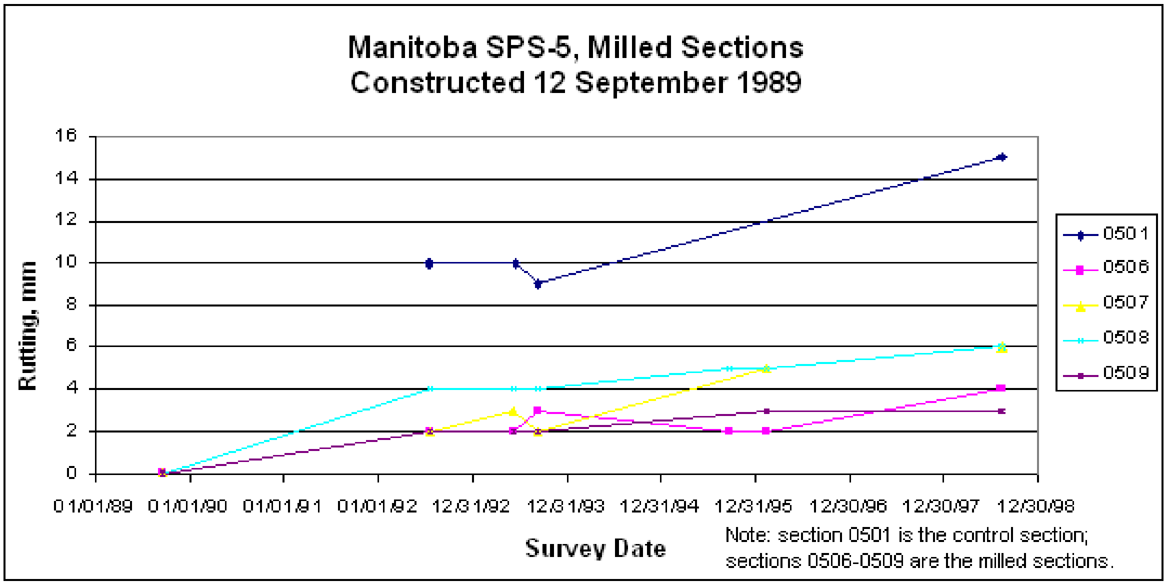
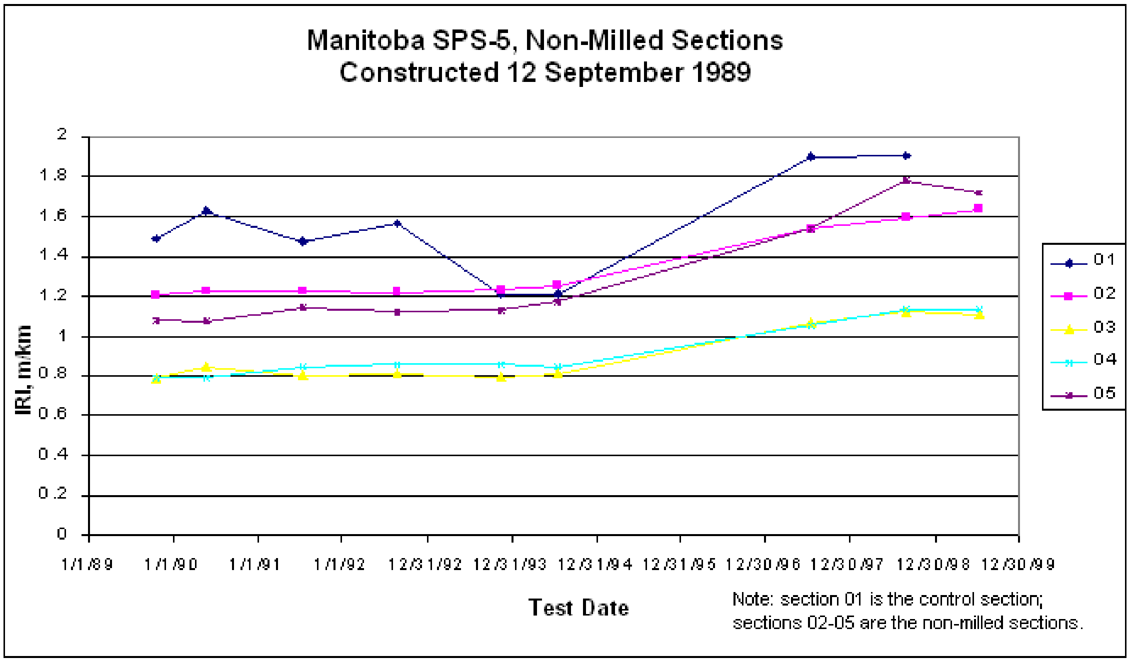


Figure 18. Graphs. Rut depths for the Manitoba project.



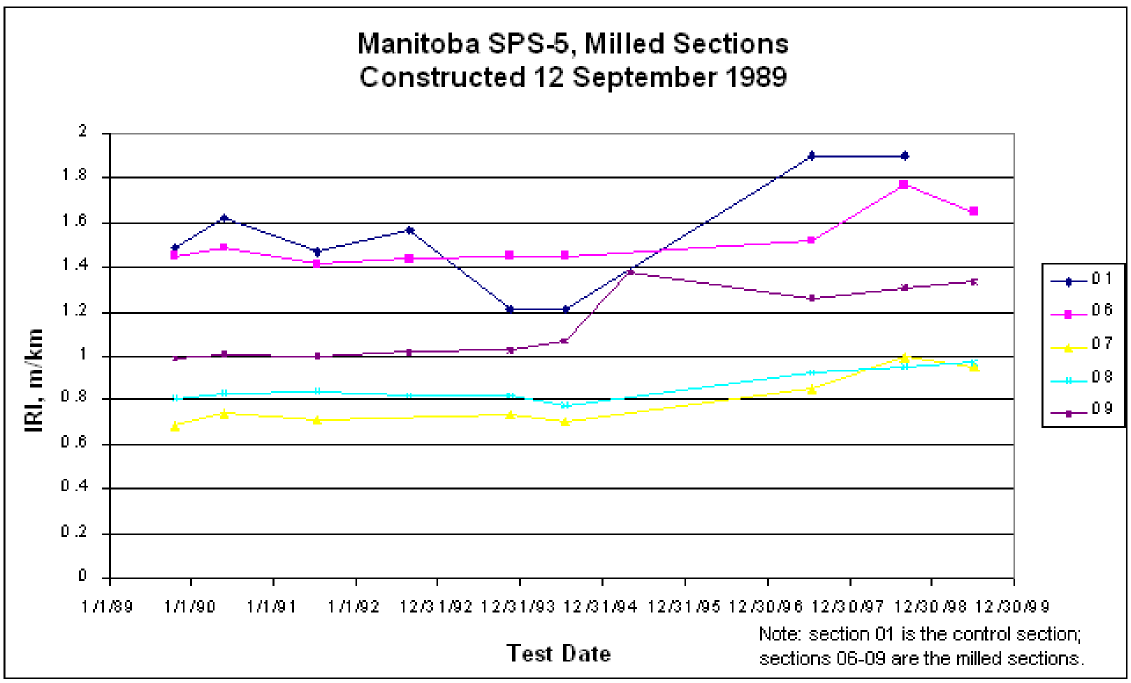
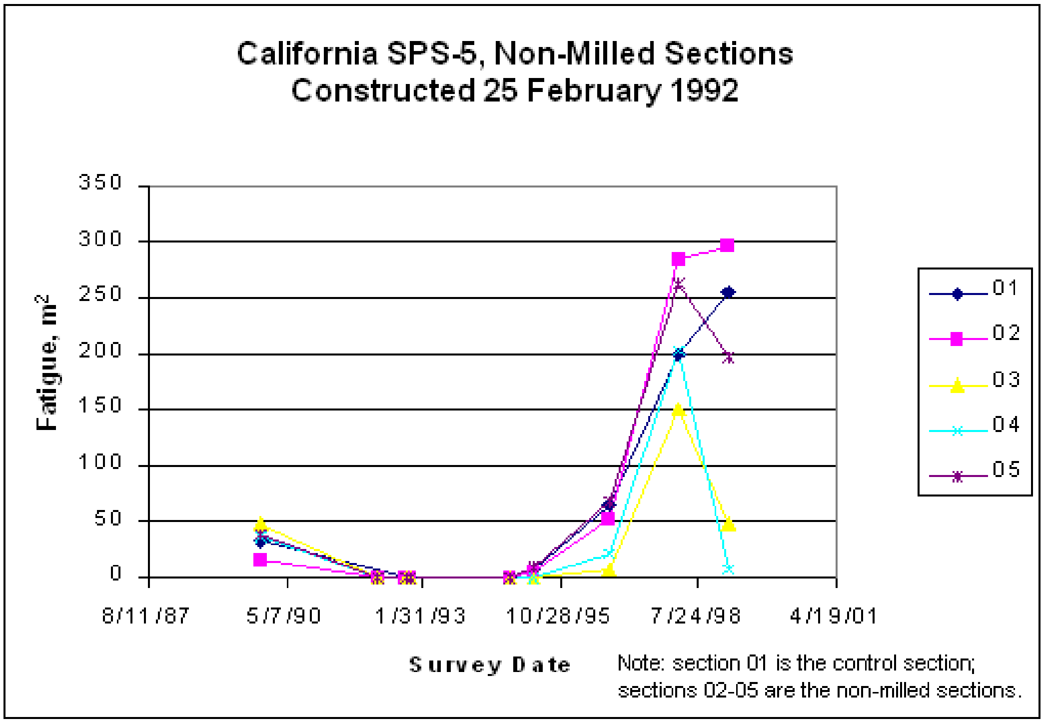


Figure 19. Graphs. IRI values for the Manitoba project.



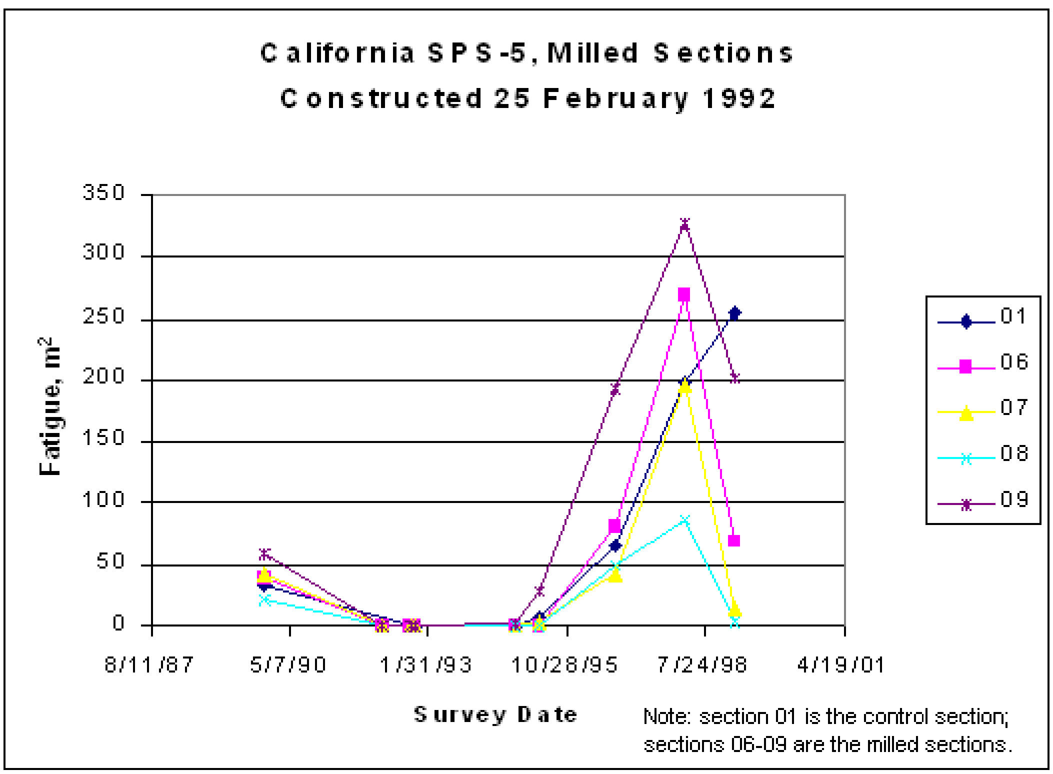
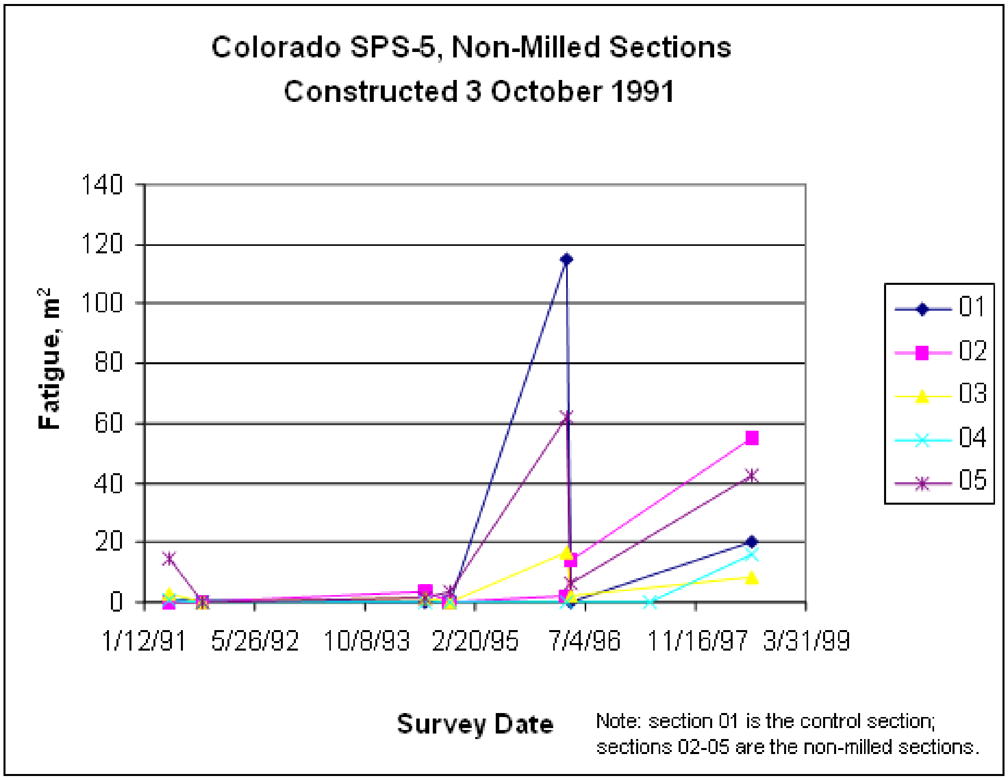


Figure 20. Graphs. Fatigue cracking time-series data for the California project.



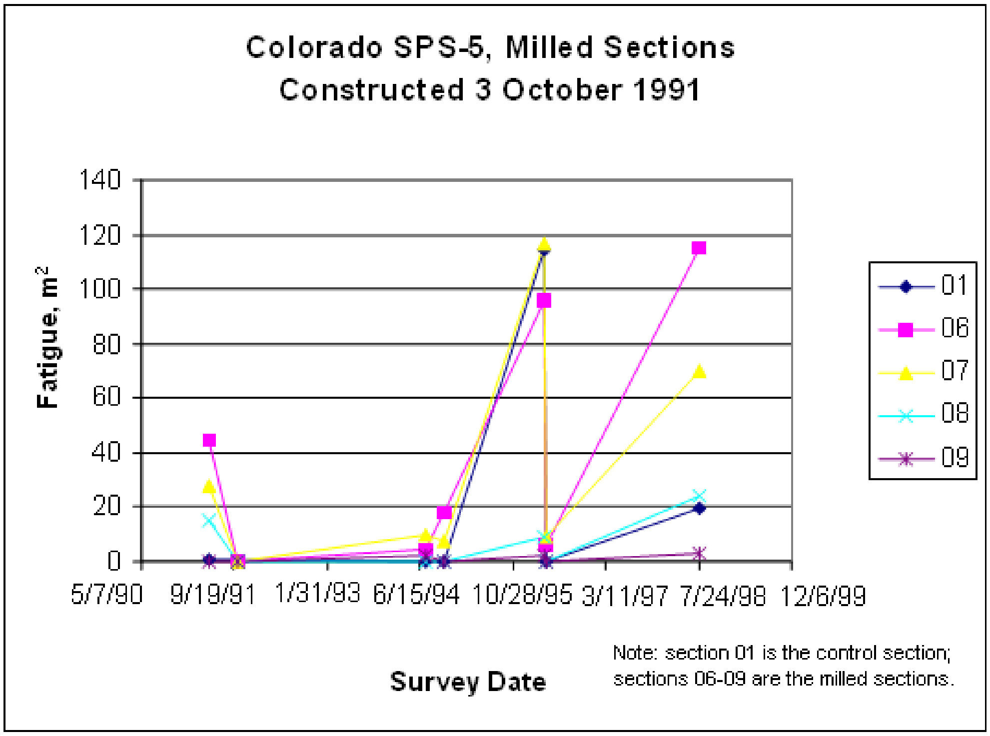
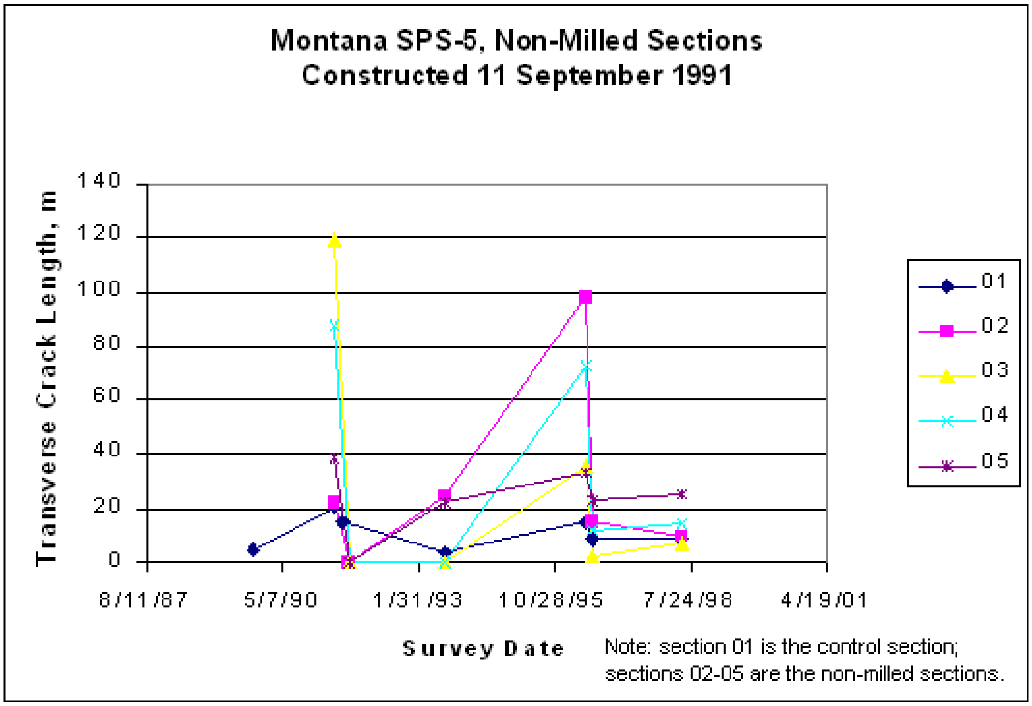


Figure 21. Graphs. Fatigue cracking time-series data for the Colorado project.



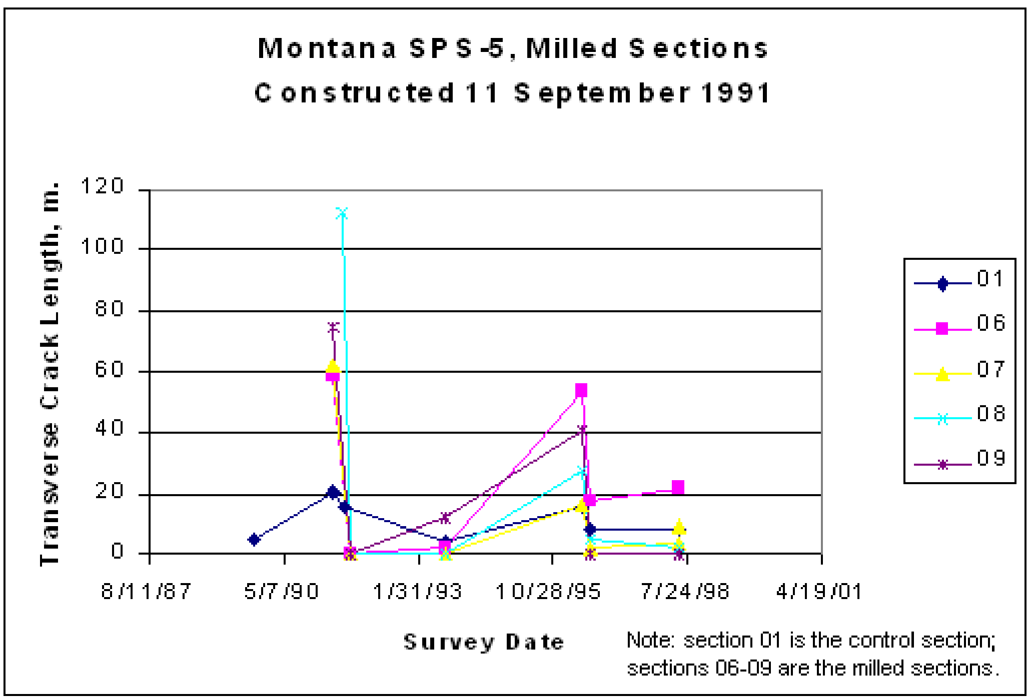
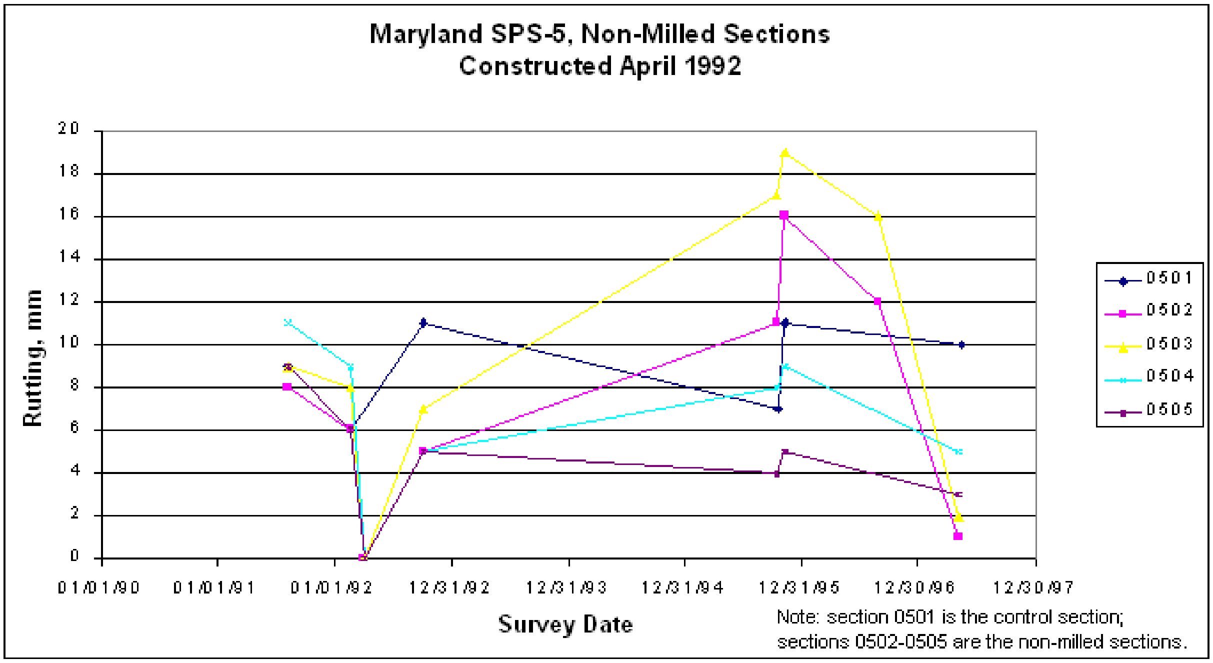


Figure 22. Graphs. Transverse crack length time-series data for the Montana project.



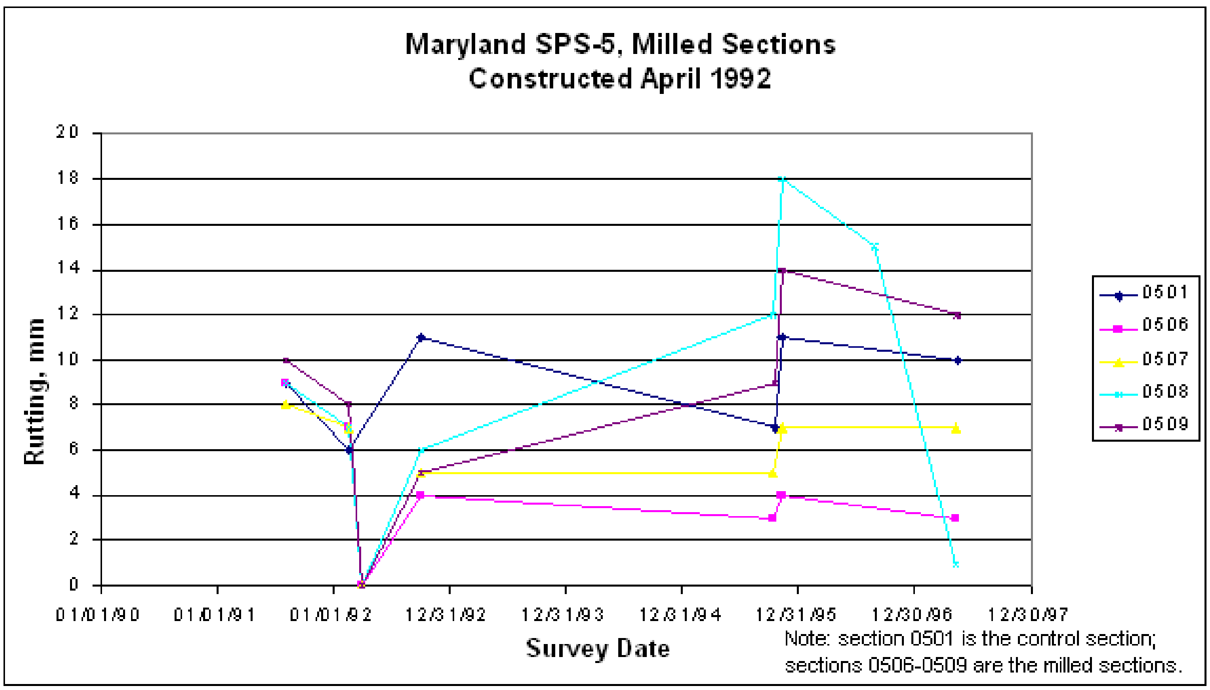
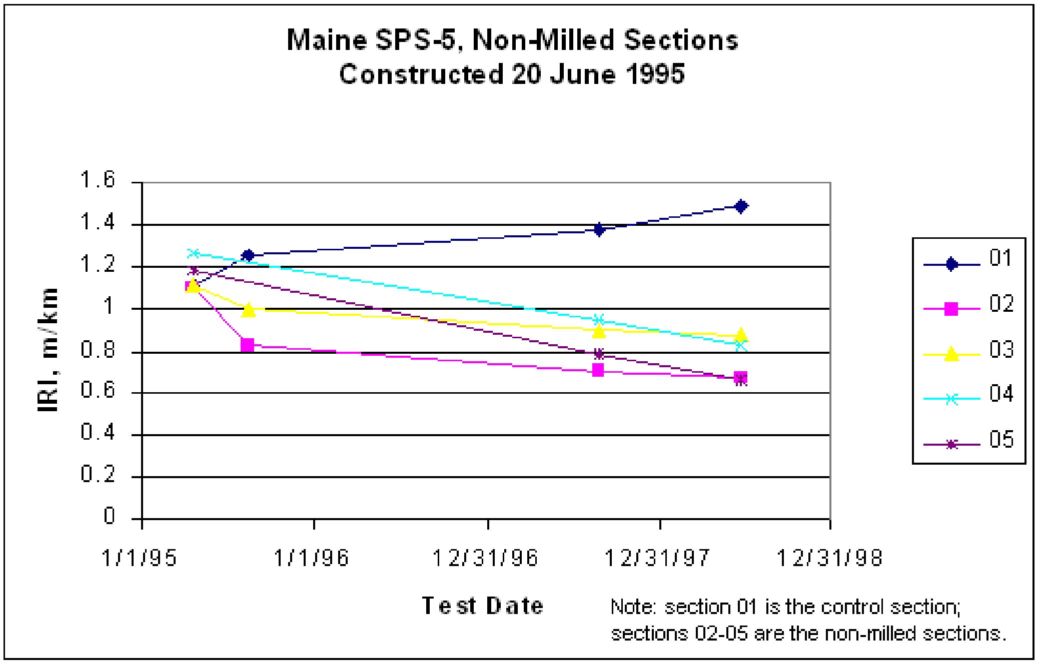


Figure 23. Graphs. Rut-depth time-series data for the Maryland projects.



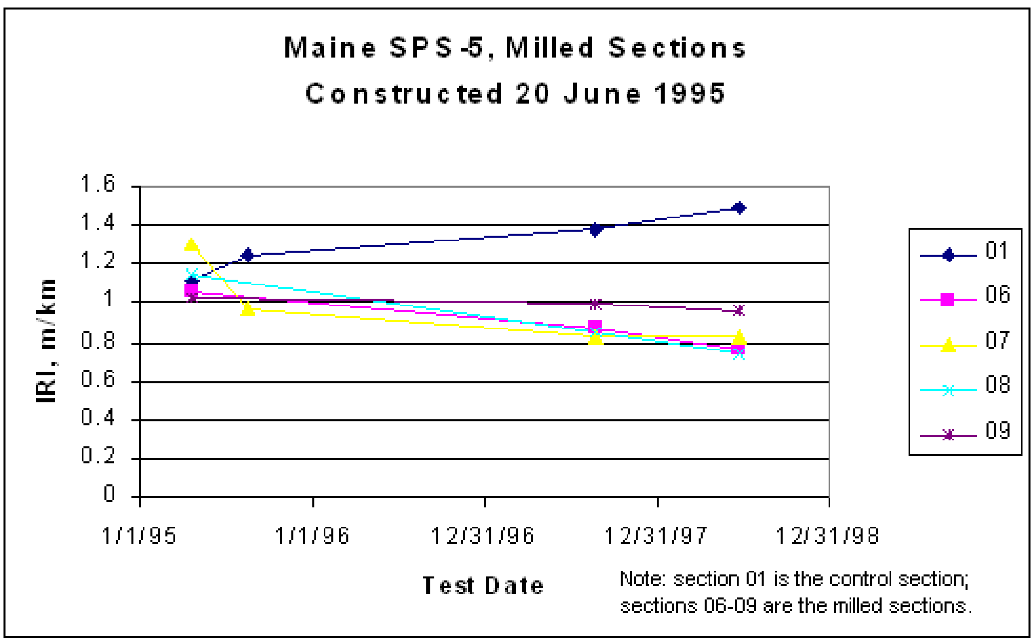


Figure 24. Graphs. IRI value time-series data for the Maine project.

Figure 22 also shows a substantial decrease in the total length of transverse cracks for all test sections in Montana. Figure 23 shows a slight but abrupt increase in the rut depths for all test sections in Maryland, and then a substantial decrease in rut depth for selected test sections of that project. Figure 24 shows a continual decrease in the IRI values for all test sections in Maine except the control section.

This decrease in the magnitudes of the individual distresses (or inconsistent time-series data) is probably related to differences in the distress interpretation between different surveyors and measurement error, or possible maintenance applications that were not recorded in the database. In either case, these inconsistent trends severely complicate graphical comparisons and other analyses based on early distress observations. Thus, four specific distresses were used to evaluate early performance trends from the experiment: fatigue cracking, transverse cracking, rut depths, and IRI.

Table 19 tabulates the percentage of core test sections with distress magnitudes that can be used in comparative studies and in future calibration and validation studies of distress prediction models. About 25 percent of the core test sections exhibited distress magnitudes that exceed the "minimum value" for each of the four distresses. The following discussion provides a brief overview of the four major distress types or performance indicators.

Table 19. Percentage of the SPS-5 test sections with distress magnitudes exceeding the value noted.

Performance Indicator	Distress Magnitude Minimal Value	Core Test Sections Exceeding Minimal Value	
		Percentage of Sections	Number of Sections
Fatigue cracking	> 25 m^2	25.7	35
Transverse cracking	> 9 m	43.4	59
Rut depth	> 7 mm	22.8	31
IRI	> 1.4 m/km	25.0	34

Note: The above table excludes all of the control test sections.

Fatigue Cracking

Fatigue cracking occurred on many test sections, but more frequently at older projects. In fact, projects less than 7.3 years old had little to no fatigue cracking, while those in service for more than 7.3 years had extensive fatigue cracking. Table 20 lists the average area of fatigue cracking observed at each project and the age of that project. Figure 25 is a graphic illustration of that data—the average area of fatigue cracking and the total number of test sections with fatigue cracking at a project. The average area of fatigue cracking was consistently less for younger projects. In general, all negative performance indicators increased with age.

Table 20. Summary of the average area of fatigue cracking observed at each project.

Project	Age, years	Fatigue Cracking of the Control Section, m^2	Average Area of Fatigue Cracking, m^2	Number of Sections with Fatigue Cracking
Missouri	0.0	0.0	0.0	0
Oklahoma	2.1	0.0	0.0	0
New Mexico	2.9	0.0	0.0	0
Maine	4.1	0.0	0.0	0
Florida	4.3	0.0	0.0	0
Georgia	6.2	0.0	0.0	0
New Jersey	7.0	193.7	1.7	3
Maryland	7.2	70.0	1.5	2
California	7.3	254.7	104.6	8
Alabama	7.7	248.6	16.1	4
Texas	7.8	5.1	0.0	0
Colorado	7.9	19.9	97.1	8
Montana	8.0	0.0	131.0	6
Minnesota	8.9	0.0	0.0	0
Mississippi	8.9	29.2	60.1	7
Alberta	8.9	1.8	33.8	8
Arizona	9.2	66.6	45.0	2
Manitoba	10.0	129.0	80.8	8

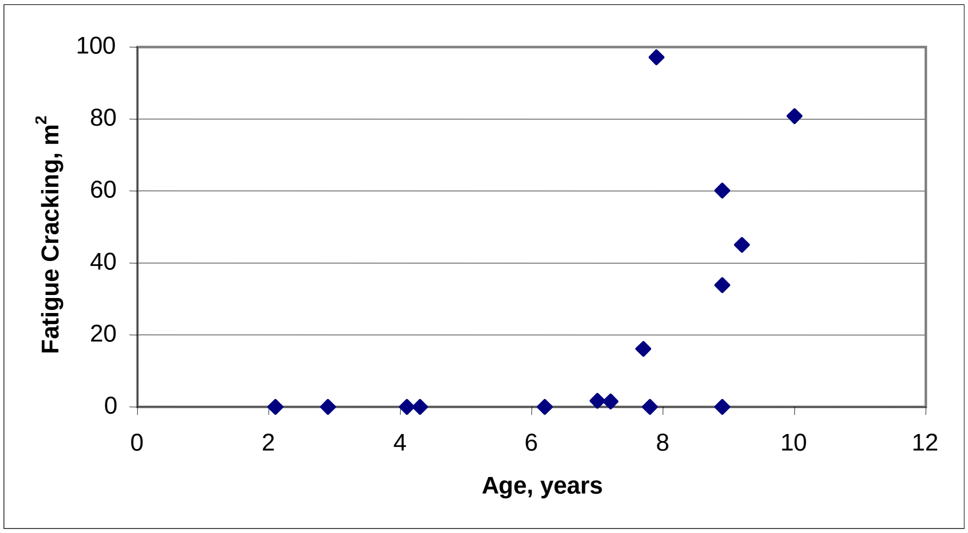
Figure 26 shows the average area of fatigue cracking for each project over time. The area of fatigue cracking increased with age (or traffic), as expected. The California, Colorado, and Montana projects had the greatest areas of fatigue cracking, while the Texas and Minnesota projects had no fatigue cracking at about the same age. To explain the differences between these projects requires that the traffic and materials data be available.

Transverse Cracking

Transverse cracking occurred on all but four of the SPS-5 projects—Florida, Georgia, Maine, and Missouri—all of which were less than 7 years old. Most projects that were older than 7 years exhibited at least moderate levels of transverse cracking, even including those in a no-freeze climate. For example, the Arizona, Mississippi, and Texas projects had extensive lengths of transverse cracking.

Table 21 lists the average length of transverse cracks for each project. Figure 27 is a graphic illustration of that data—the average length of transverse cracks and the total number of test sections with transverse cracks at a project. The length of transverse cracks increased with age.

Figure 28 shows the average length of transverse cracks with time for each project (time-series data). The average length of transverse cracks significantly increased and decreased with time for some projects. This extensive variability complicates any interpretation of the graphic comparisons. Materials data for each mixture are needed to determine the reasons for the extensive cracking in some warmer climates.



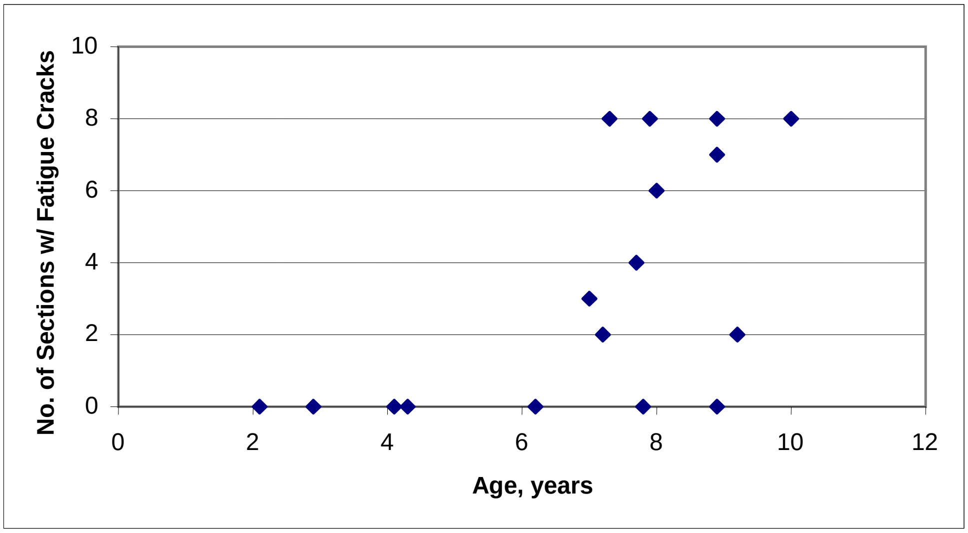
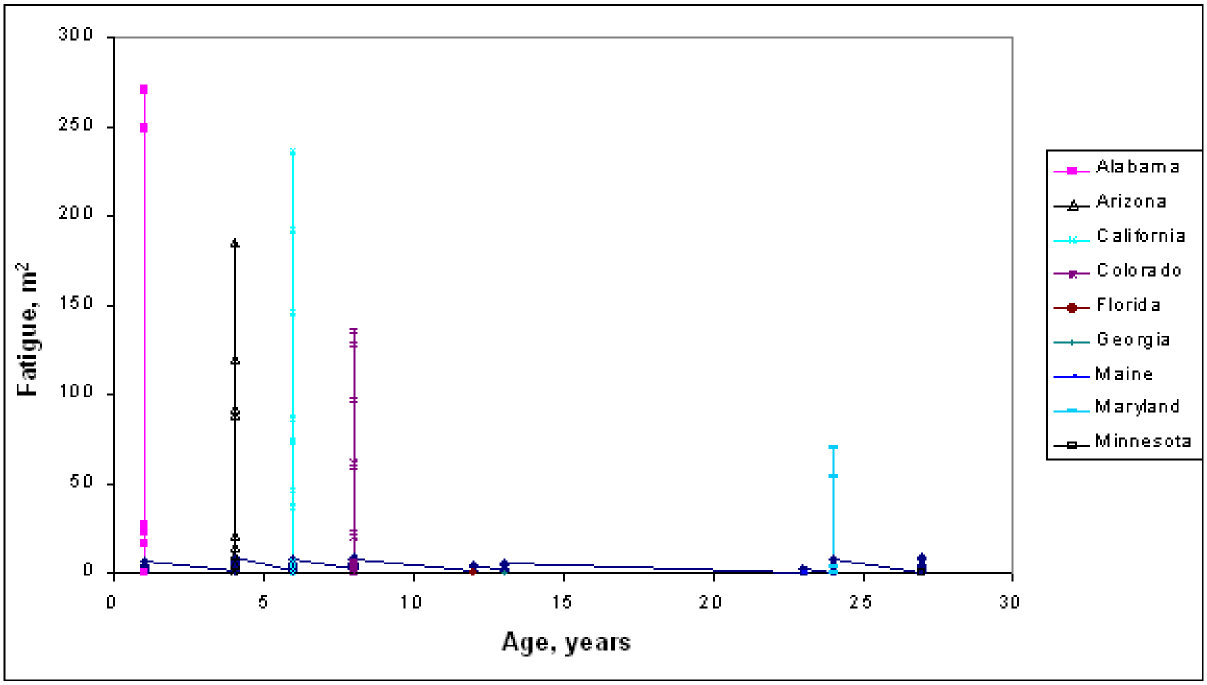


Figure 25. Graphs. Fatigue cracking observed on each project as of January 2000.



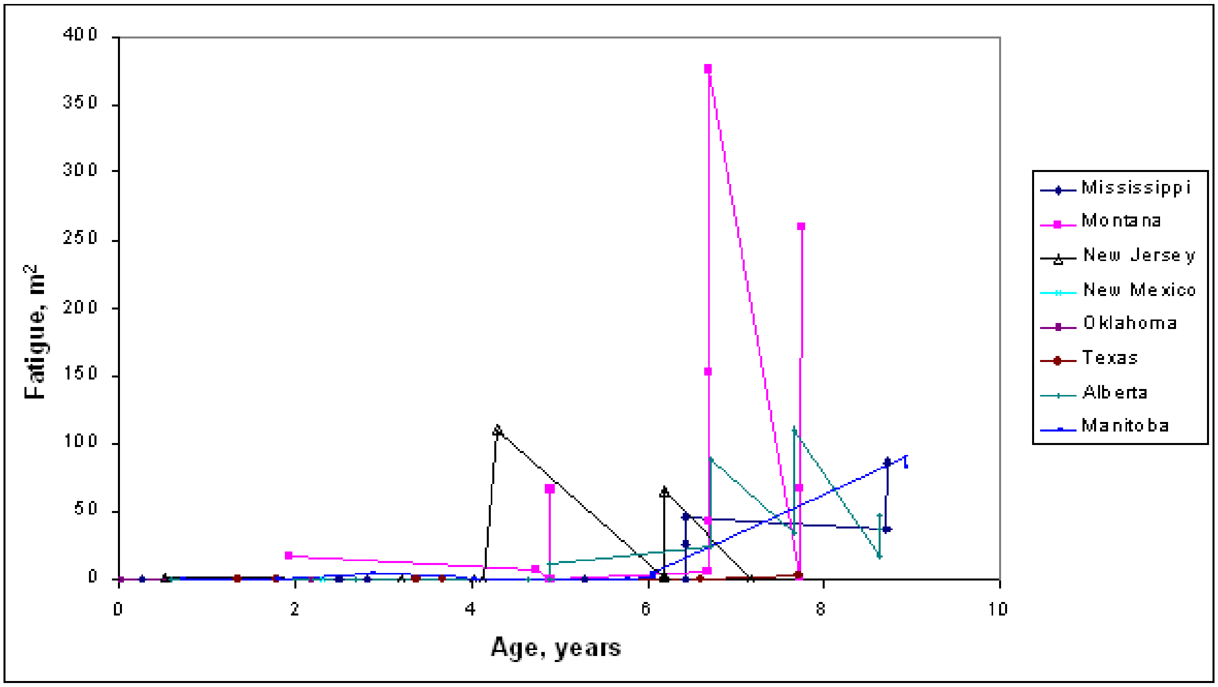


Figure 26. Graphs. Average area of fatigue cracking for each project over time.

Table 21. Summary of the average length of transverse cracks observed at each project.

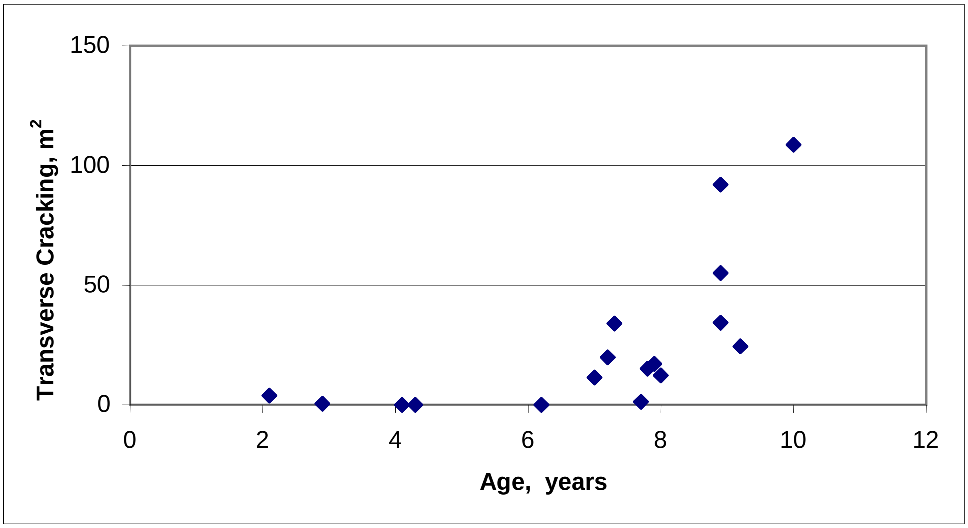
Project	Age, years	Average Length of Transverse Cracks, m	Number of Sections with Transverse Cracks
Missouri	0.0	0.0	0
Oklahoma	2.1	3.9	2
New Mexico	2.9	0.5	1
Maine	4.1	0.0	0
Florida	4.3	0.0	0
Georgia	6.2	0.0	0
New Jersey	7.0	11.4	6
Maryland	7.2	19.8	7
California	7.3	34.0	8
Alabama	7.7	1.3	2
Texas	7.8	15.1	6
Colorado	7.9	17.1	8
Montana	8.0	12.3	7
Minnesota	8.9	92.0	8
Mississippi	8.9	55.1	8
Alberta	8.9	34.3	8
Arizona	9.2	24.4	5
Manitoba	10.0	108.7	8

Rut Depths

Rut depths exceeding 7 mm were measured on eight projects: Arizona, Alberta, Manitoba, Maryland, Mississippi, Montana, Oklahoma, and Texas. However, on half of these projects only one or two of the test sections had rut depths exceeding 7 mm. The four projects where most of the test sections exceeded rut depths of 7 mm were Maryland, Mississippi, Montana, and Oklahoma. In all probability, rut depths measured along these four projects were more related to the HMA mixture characteristics and properties than to any key factor included in the experiment. Table 22 lists the average rutting measured on each project. All projects were in extremely different climates.

Smoothness—IRI Values

Table 22 lists the average IRI values for each project and the percentage of test sections within each project that exceeded an IRI value of 1.2 m/km. Most projects with IRI values exceeding 1.2 m/km were older than 7 years, with the exception of the Alabama project. These were the same test sections that had extensive transverse and fatigue cracking. Transverse and fatigue cracking probably caused the increased roughness (increased IRI values) at these sites. In fact, the authors found in previous studies that the IRI is related to the standard deviation of the rut depth, transverse cracking, fatigue cracking, and other distresses.[10] Thus, there are interactions among the performance measures that should be considered in future studies using data from this experiment.



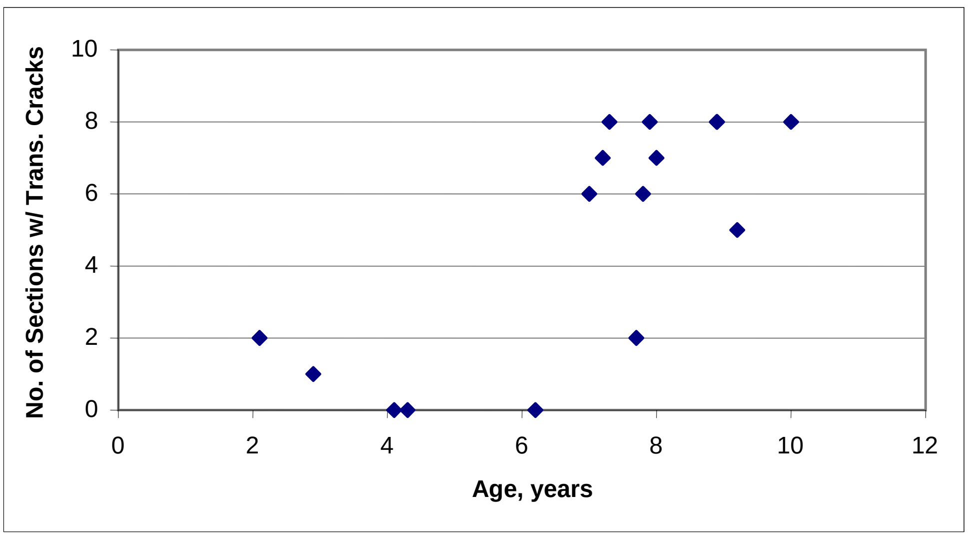


Figure 27. Graphs. Length of transverse cracks observed on each project as a function of time.

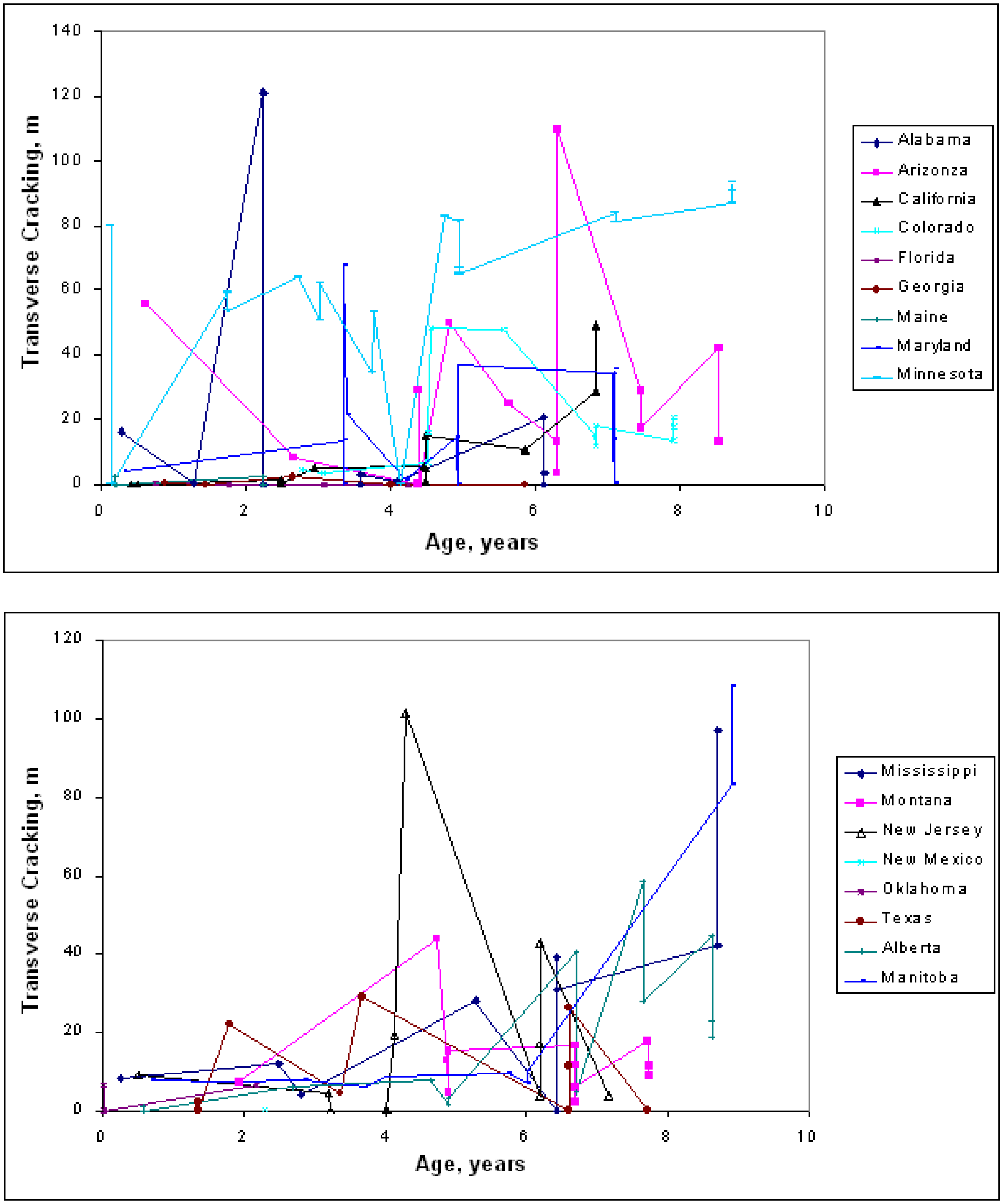


Figure 28. Graphs. Average length of transverse cracking for each project over time.

Table 22. Average rut depths and IRI values measured on each project.

Project	Age, years	Rut Depths, mm			IRI, m/km		
		Control Section	Average Rutting on Project	Percentage of Test Sections Exceeding 7 mm	Control Section	Average IRI on Project	Percentage of Test Sections Exceeding 1.2 m/km
Missouri	0.0	–	–	0	–	–	0
Oklahoma	2.1	10	7	25	1.32	1.00	0
New Mexico	2.9	3	3	0	0.45	0.49	0
Maine	4.1	14	5	0	1.49	0.79	0
Florida	4.3	–	3	0	–	0.62	0
Georgia	6.2	11	3	0	–	0.57	0
New Jersey	7.0	7	2	0	2.12	0.85	0
Maryland	7.2	9	3	13	1.54	1.14	25
California	7.3	6	5	0	1.73	1.45	38
Alabama	7.7	–	3	0	0.79	0.89	0
Texas	7.8	–	5	0	2.38	1.39	63
Colorado	7.9	11	4	0	1.20	1.11	13
Montana	8.0	–	8	50	1.02	1.16	25
Minnesota	8.9	8	3	0	3.47	1.59	88
Mississippi	8.9	14	12	100	1.67	1.62	88
Alberta	8.9	8	5	0	1.94	1.35	50
Arizona	9.2	8	4	0	1.34	1.33	50
Manitoba	10.0	13	4	0	1.90	1.31	50

ANALYSIS OF VARIANCE

An analysis of variance (ANOVA) was completed for each of the four major distress types to determine if the main factors of the experiment had an effect on those distresses from these early observations. The major factors included in the ANOVA are listed below:

- HMA overlay thickness: Thin versus thick overlays.
- Surface preparation: Minimal (no milling) versus intensive (milling).
- HMA overlay material: Mixture with and without RAP.
- Climatic conditions: Wet versus dry and freeze versus no-freeze.
- Condition of existing pavement: Fair versus poor.

Results from this one-way ANOVA are summarized in table 23, which indicates that surface preparation and climatic conditions had an effect on the pavement distress (the p-values are low, indicating a low probability of a chance event). However, the overriding factor that had a significant effect on all of the distresses was age. In fact, the age of the overlay was so important that it probably reduced the effect of some of the other key experimental factors. Age represents both aging effects on materials (i.e., stiffness increases) and of temperature and moisture. Age also was correlated with traffic loadings over time, although different SPS-5 experiments had different traffic levels.

Table 23. Effect of experimental factors on selected performance indicators, p-values from the ANOVA.

Experimental Factor	Performance Indicator/Surface Distress			
	Fatigue Cracking	Transverse Cracking	Rut Depths	IRI
Nominal HMA overlay thickness	0.514	0.847	0.942	0.865
HMA overlay mixture	0.304	0.529	0.354	0.110
Existing pavement condition	0.600	0.126	0.133	0.0003
Nominal milling depth	0/762	0.0007	0.832	0.0060
Precipitation	<0.0001	0.185	<0.0001	0.687
Freeze index	0.0005	<0.0001	0.128	0.0607
Age of overlay	<0.0001	<0.0001	<0.0001	<0.0001

The following summarizes the effect of the key factors of the experiment on individual distresses using data extracted from the IMS in January 2000. A description of the effects and possible reasons for those effects are discussed in the next section of this chapter.

Fatigue Cracking—Age of the overlay and the climatic factors, temperature and moisture, were important and had an effect on the fatigue cracking at each project. The thickness of the overlay was much less important than these two factors, based on these early observations. More fatigue cracking occurred on those test sections placed in a climate with less precipitation but higher freeze indices.

Transverse Cracking—Age of the overlay, milling depth, and freeze index were found to have an important effect on the length of transverse cracks along each test section. Longer transverse cracks occurred on the older pavements in areas with higher freeze indices. In addition, fewer or shorter transverse cracks occurred on sections that had been milled.

Rut Depths—Age of the overlay and precipitation were the two factors found to have an important effect on rut depths. The rut depth increased as the age of the overlay increased, as expected. Sections with increased precipitation had larger rut depths. However, increased precipitation may not have been the primary factor related to increased rut depths. The HMA mixture properties were probably more important, but they were unavailable for the ANOVA. The precipitation may have been a biased effect, simply because those projects with the higher rut depths were located in climates with higher precipitation. This topic needs further study using the materials testing data.

IRI—The age of the overlay, condition of the pavement before overlay placement, and surface preparation or milling depth were factors found to be important relative to the IRI values. The IRI values of the overlay were found to be lower for the overlays placed over pavements in the fair category and when the existing surface was milled before overlay.

EFFECT OF KEY EXPERIMENTAL FACTORS ON PERFORMANCE

The remaining sections of this chapter discuss the effect of each key factor of the experiment in relation to the magnitude and relative occurrence of observed distresses. Tables 24 through 27 summarize the differences on the average performance measures between the key factors of the experiment.

Table 24. Average performance differences of the test sections for different types of surface preparation in the SPS-5 experiment.

Distress or Performance Indicator		Surface Preparation—Milled or Non-milled Surfaces		
		Control	Minimal (Non-Milled)	Intensive (Milled)
Fatigue cracking	Mean, m^2	37.5	17.1	16.1
	Std. deviation, m^2	73.4	51.4	55.4
	COV*, %	196	301	344
Transverse cracking	Mean, m	36.8	18.5	12.7
	Std. deviation, m	50.8	30.8	24.8
	COV, %	37	166	195
Rut depth	Mean, mm	10	5	5
	Std. deviation, mm	3.7	3.0	2.9
	COV, %	38	62	56
IRI	Mean, k/km	1.48	1.10	1.05
	Std. deviation, m/km	0.53	0.32	0.29
	COV, %	36	29	28

* COV = coefficient of variance

Table 25. Average performance differences of the test sections for different categories of the existing pavement surface in the SPS-5 experiment.

Distress or Performance Indicator		Existing Pavement Condition		
		Control	Poor	Fair
Fatigue cracking	Mean, m^2	37.5	18.7	15.5
	Std. deviation, m^2	73.4	54.3	53.7
	COV, %	196	290	347
Transverse cracking	Mean, m	36.8	12.7	17.8
	Std. deviation, m	50.8	28.4	28.1
	COV, %	37	223	158
Rut depth	Mean, mm	10	5	5
	Std. deviation, mm	3.7	2.7	3.2
	COV, %	38	56	60
IRI	Mean, k/km	1.48	1.13	1.04
	Std. deviation, m/km	0.53	0.341	0.283
	COV, %	36	30	27

Table 26. Average performance differences of the test sections for different HMA overlay thickness in the SPS-5 experiment.

Distress or Performance Indicator		Overlay Thickness		
		Control	Thin (51 mm)	Thick (127 mm)
Fatigue cracking	Mean, m^2	37.5	15.3	17.9
	Std. deviation, m^2	73.4	48.2	58.2
	COV, %	196	314	326
Transverse cracking	Mean, m	36.8	16.0	15.3
	Std. deviation, m	50.8	29.3	26.9
	COV, %	37	183	176
Rut depth	Mean, mm	10	5	5
	Std. deviation, mm	3.7	2.9	3.0
	COV, %	38	59	58
IRI	Mean, k/km	1.48	1.07	1.08
	Std. deviation, m/km	0.53	0.314	0.304
	COV, %	36	29	28

Table 27. Average performance differences of the test sections for different HMA overlay mixtures in the SPS-5 experiment.

Distress or Performance Indicator		Overlay Mixture		
		Control	With RAP	Without RAP, Virgin Mix
Fatigue cracking	Mean, m^2	37.5	18.6	14.5
	Std. deviation, m^2	73.4	54.4	52.3
	COV, %	196	292	360
Transverse cracking	Mean, m	36.8	16.2	15.0
	Std. deviation, m	50.8	29.2	27.0
	COV, %	37	180	179
Rut depth	Mean, mm	10	5	5
	Std. deviation, mm	3.7	3.0	2.9
	COV, %	38	58	59
IRI	Mean, k/km	1.48	1.09	1.06
	Std. deviation, m/km	0.53	0.314	0.304
	COV, %	36	29	29

Surface Preparation

The amount of transverse cracking of sections with intensive surface preparation before overlay was much lower than for sections with minimal surface preparation (table 24). Figure 29 illustrates that the percentage of test sections with more than 9 m of transverse cracking was much larger for those sections with minimal surface preparation, regardless of the freeze environment.

The IRI was slightly larger for sections with minimal surface preparation. The difference in the values in table 24 is small. However, figure 30 illustrates that the percentage of test sections with an IRI value greater than 1.2 m/km was much larger for sections with minimal surface preparation.

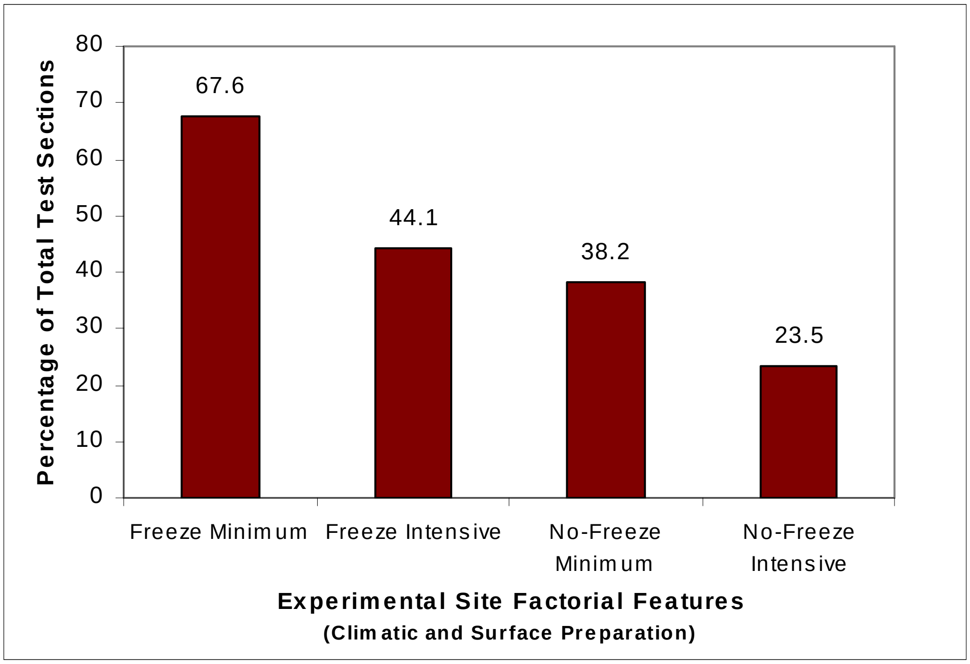


Figure 29. Graph. Percentage of test sections that have more than 9 m of transverse cracking.

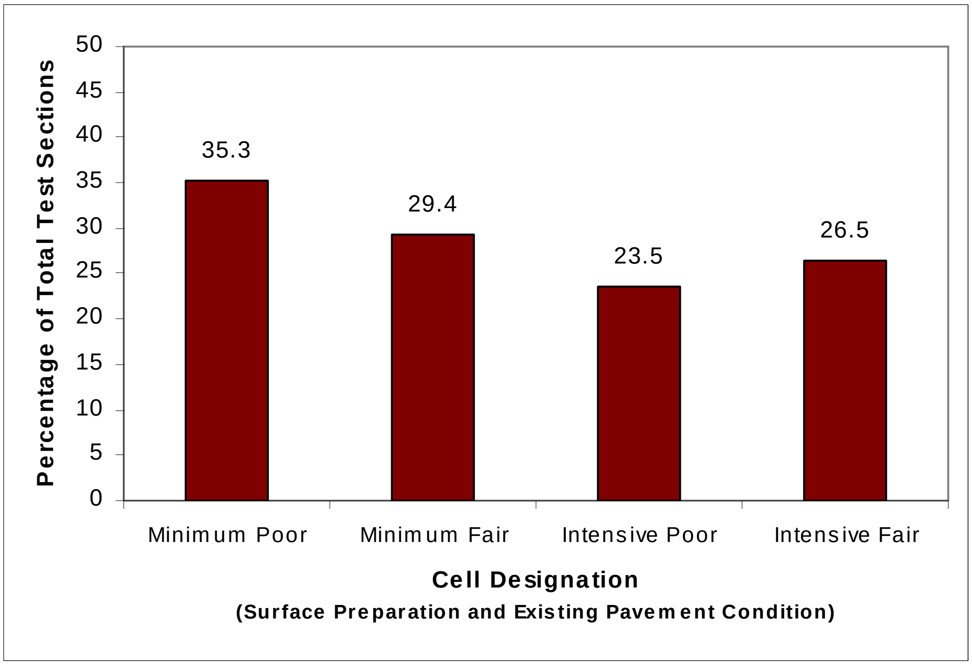


Figure 30. Graph. Percentage of test sections that have an IRI value greater than 1.2 m/km.

Neither the amount of fatigue cracking nor the amount of rutting observed on the sections after overlay appeared to be affected by the surface preparation before overlay.

Pavement Condition

The amount of transverse cracking observed on sections that were in fair condition before overlay was higher than in sections that were in poor condition before overlay (table 25). A bias may have influenced this result: in some cases, the surveyors classified the cracking as reflective cracking while other surveyors classified it as transverse cracking.

Sections in fair condition before overlay were rougher than those in poor condition before overlay. Figure 30 illustrates that this conclusion was not consistent among the different surface preparation conditions. The percentage of sections with more than 1.2 m/km of IRI was larger for sections in poor condition with minimal surface preparation than any of the other categories. However, the sections that were in poor condition with intensive surface preparation had the least number of sections with an IRI greater than 1.2 m/km. This observation indicates that the early pavement condition can be overcome by the amount of surface preparation before overlay.

HMAC Overlay Thickness and Material

Very little difference was observed between the distresses for either the overlay thicknesses or the virgin/RAP mixtures (tables 26 and 27, respectively). While little difference was observed, the oldest of these projects was 10 years old. Hence, it is possible that the amount of distress was not affected by these factors in the short term, but these factors might be very important to the amount of distress in the long term. Only long-term monitoring will answer this question and many similar questions for other design features.

SUMMARY

It should be noted that some of these observations were not new findings (for example, condition of the pavement before overlay affects the roughness of the overlay), but they demonstrate that results from the SPS-5 experiment are consistent with previous experience. Early observations from the SPS-5 experiment clearly demonstrate its potential value and that the experimental objectives can be met over the long term. Clearly, findings from the SPS-5 experiment will affect highway agency designs and standards.

The construction and deviation reports were also found to be extremely valuable and important to explain possible anomalies in the experiment and performance differences from the other projects and test sections. Use of these reports should limit or reduce the possibility of having biased conclusions from the data related solely to construction. However, to extract the full benefit of SPS-5, the materials testing program planned for this experiment must be completed and the truck traffic data must be collected on projects that had no data at the time of this report.

6. SUMMARY AND CONCLUSIONS

The SPS-5 experiment entitled *Rehabilitation of Asphalt Concrete Pavement* is a key experiment of the LTPP program. The main objective of SPS-5 is to determine the long-term effectiveness of different rehabilitation techniques on pavement performance and service life. There are some concerns about whether SPS-5 can meet its expectations given that several projects were constructed on coarse-grained, subgrade soils. Although this is considered a significant deviation from the experimental plan, it is not believed to be detrimental to the overall expectations for this experiment as long as it is fully considered in the data analyses.

This report presents results from the first comprehensive review and evaluation of SPS-5. Issues of experiment design, construction quality, data availability and completeness, and early performance trends have been addressed. That unavailable data have been identified here does not necessarily mean that the data were not collected or submitted by the RCO or owner agency that built the individual projects. There can be several reasons that good data can be delayed before reaching Level E status. Following are some reasons that some data elements could be shown as unavailable when the data actually had been collected.

- Data were under regional review.
- Data failed one of the quality checks and were being reviewed.
- Data failed one of the quality checks and were identified as anomalies.
- Data needed to be quality checked.

Some initially unavailable data were located and forwarded to the IMS during the course of this study. The key findings or observations from this detailed review are summarized in this chapter.

SPS-5 EXPERIMENTAL SITE STATUS

As of January 2000, 18 SPS-5 projects had been identified throughout North America. The full factorial of the original experiment design had been completely filled except for 2 cells. One project was required in a dry-freeze environment on a pavement in poor condition. This project would serve as a replicate to the Manitoba project (refer to table 8). Two projects were required for the wet-no-freeze climate with a pavement in fair condition. These missing projects were not believed to be critical because the factorial covered the range of environments and pavement conditions previously included in the experiment design.

Each SPS-5 project had 9 core test sections, and some had supplemental test sections built by the individual agency; 162 core test sections and 48 supplemental test sections were available, a total of 210 test sections. This number of test sections should provide excellent data for future studies for calibrating and validating design procedures.

The primary value of the supplemental sections is to serve as a direct comparison to the core test sections within that specific SPS-5 project. However, these supplemental sections also can be used in regional or national studies through the use of mechanistic analysis principles. Thus, efforts should be made to ensure that their construction and monitoring data are collected and entered in the IMS for future use.

An important issue in the experimental factorial is the different soil classifications. Half the projects were built over coarse-grained and half over fine-grained soils. This deviation from the original experiment design is not believed to be critical, but should be considered when analyzing the data to determine the main factor effects on performance.

DESIGN VERSUS ACTUAL CONSTRUCTION

Experimental design factors were compared to the actual values measured during construction. These include both the site condition factors and rehabilitation design features in the IMS database. Most SPS-5 sections followed the experiment design for the large majority of design factors. Overall, very few construction deviations were reported for the SPS-5 projects, with the exception of overlay thickness.

Most overlay thickness measurements deviated from the project's experiment design requirements. However, none of the thickness data for the thin and thick overlays overlapped. Two projects (Maine and Manitoba) had significant thickness deviations from the planned overlay thickness. In both cases, the SHA was attempting to correct problems in the cross-slope of the pavement.

The other construction deviations were primarily related to the HMA mixtures. The percentage passing the number 4 sieve for the HMA mixture and air voids of the compacted mat exceeded the specified values for many test sections. These deviations were considered minor and should not be critical to the overall experiment. Other minor deviations were noted in the construction of these projects. For example, breakdowns of the hot mix facility and paving equipment caused delays in construction. Most of these types of deviations were considered minor and should not be critical to the overall experiment.

Three projects incorporated a control section that was overlaid during project construction of the other test sections: Colorado, Montana, and New Mexico. In each case, the condition of the existing pavement was believed to be a risk to the traveling public.

DATA AVAILABILITY AND COMPLETENESS

The data availability and completeness for the SPS-5 experiment were good overall, with the exception of two data elements. These two elements were materials testing and traffic data. Furthermore, some monitoring data still needed to be collected and/or checked to fill in the gaps of the time-history performance data for selected projects. Three projects (Minnesota, New Mexico, and Oklahoma) did not have sufficient time-history data for transverse profile to establish performance trends. The transverse profile should be measured at each of these sites. The reasons that data had not achieved Level E status need to be ascertained and the situation rectified before detailed analyses of the experiment can be completed. Most other data elements that had been collected at each site were at level E.

The SPS-5 data deficiencies are summarized below.

- Level E traffic data were not available for 50 percent of the SPS-5 sites. More important, traffic monitoring equipment had not been installed at 7 of the 18 sites.

- Materials test data were very deficient for most of the pavement and overlay materials and subgrade soils. The resilient modulus and other fundamental properties of these materials need to be measured and entered in the database if these sites are to be used for mechanistic studies. The testing program for many projects was still underway, and data were continually being forwarded to the RCOs for processing.
- The Missouri project had been constructed, but data were not yet in the database.

It is recommended that a significant effort be put forth to obtain these missing data. The following sections summarize the availability of each data element and its effect on following studies, such as for the *2002 Design Guide* (NCHRP 1-37A).[10]

Construction Reports/Data

The construction and deviation reports were extremely valuable in reviewing and explaining performance anomalies of individual test sections. Construction and deviation reports were available for all of projects except Missouri. The Missouri project was recently constructed, but the construction report was unavailable at the time of the detailed review.

Materials Data

The materials data were partially complete for all of the projects, with the exception of the new projects that had no test data at Level E. The laboratory material testing was divided into preconstruction and postconstruction tests. Preconstruction tests were to be performed on each existing pavement layer and the subgrade, while postconstruction tests were confined to the HMA overlay mixture.

Tables 10 through 12 summarized the availability of selected test data by material type for each project. Extensive test data were unavailable at the time of the data extraction—especially for the HMA materials. In general, the younger the project, the less testing had been completed. None of the resilient modulus, indirect tensile strength, and creep compliance tests had been completed on the HMA mixtures for any project.

Unavailable materials test data to determine the physical properties of the pavement and soils will be a significant limitation in the SPS-5 projects' use in mechanistic studies (such as NCHRP 1-37A). Completion of the materials testing program should be a high priority to ensure achieving the full benefit of the SPS-5 experiment. The RCOs recognized the importance of this data element and were pursuing these data. The materials testing program was still underway, and materials test data were being submitted to the RCOs periodically.

Climatic Data

No climatic data were missing. The SPS-5 experiment design called for a project to be located in one of four different climates (refer to tables 1 and 3). The climatic data are estimated from historical data from five nearby weather stations (virtual weather stations). The IMS contains monthly and average annual summary statistics for all 18 projects.

Traffic Data

The SPS-5 experiment design calls for continuous AVC monitoring, with WIM data collected at least 2 days of the year, as permitted by WIM scale operating divisions. Continuous AVC monitoring was defined as more than 300 AVC monitoring days in a given year. Table **TRF_MONITOR_BASIC_INFO** was examined to identify the SPS-5 records with WIM, AVC, and annual ESAL estimates.

Table 15 summarizes the amount of data for the SPS-5 sites and identifies those projects that had no traffic data at Level E. In summary, 14 (about 75 percent) of the SPS-5 sites had no traffic monitoring equipment at the site. Most of the older projects did have some traffic data, while most of the newer projects were missing the traffic data. All projects had an annual estimate of the number of ESALs; however, the reliability of these data was unknown for 15 of the 18 projects.

Performance Indicator Data

Several types of monitoring data are included in the LTPP IMS, including distresses (from both manual and photographic surveys), longitudinal profiles, transverse profiles, and deflection. Performance data are collected for both preconstruction and postconstruction time frames. All projects have preconstruction information on the surface condition of the pavement. Table 16 summarizes the number of postconstruction distress and other performance indicator measurements made at each project site; table 17 summarizes the average number of years between the surveys for each performance indicator.

Performance indicator monitoring data were available for all projects. However, the time interval between data collections was beginning to exceed the recommended frequency for a few of the projects, as noted below.

- Longitudinal profiles: New Mexico.
- Transverse profiles: Alabama and New Mexico.
- Distress surveys: None.
- Deflection surveys: None.

The RCOs had taken steps to collect some missing data or submit data that had been collected but not forwarded to the IMS. In summary, the amount of performance indicator data was good. The time-series data for each measure of performance will be a significant benefit for future studies on the design and performance of rehabilitated flexible pavements.

Friction Data

With few exceptions, friction surveys had not been performed on the SPS-5 projects. This testing, however, was not required at the time nor is it essential to the SPS-5 experiment. That friction data were missing should have no impact on future studies on structural behavior and performance of HMA overlays.

Summary

Table 28 summarizes the unavailable and limited data for the SPS-5 experiment, as of January 2000, in terms of the revised experimental factorial. Table 29 summarizes the limitations and action items to correct these deficiencies in each SPS-5 project. Every effort should be made to obtain these data elements.

EARLY PERFORMANCE TRENDS

Most SPS-5 projects were still relatively young. As of January 2000, less than 45 percent of the test sections had distress magnitudes that exceeded values believed necessary to complete meaningful comparisons. Based on preliminary statistical analyses and comparisons, age, surface preparation, and pre-existing surface condition were found to have an effect on performance indicators. The long-term performance trends could be significantly different from these early observations as more and more data are collected for these test sections.

The specific experimental expectations of the SPS-5 experiment were to determine the main effects and interactions of the following key design features:

- Amount of surface preparation before overlay.
- Material type used for the overlay.
- Overlay thickness.

These main effects and interactions were to be determined for each of the following subgrade and climatic conditions:

- Condition of pavement before overlay.
- Wet climates and dry climates.
- Freeze or cold climates and no-freeze or warm climates.
- Fine- and coarse-grained subgrade soils.

The following conclusions were drawn from the preliminary performance analyses conducted for this report.

- More fatigue cracking occurred on test sections placed in a climate with less precipitation but higher freeze indices.
- Less transverse cracking occurred on sections with intensive surface preparation than on sections with minimal surface preparation before overlay.
- The IRI values were found to be lower for: (1) overlays placed over pavements in the fair category and (2) when the existing surface was milled before overlay.

This evaluation has shown that several problems will limit results that can be obtained by the SPS-5 experiment, two of minor and two of major importance. Of minor importance are (1) the misinterpretation of the different distress types with time by the distress surveyors and (2) the measurement error of low levels of distress, which results in difficulties in interpreting performance trends and in determining the effects between the experiment factors.

Table 28. Summary of unavailable and limited data for the SPS-5 experiment.

Pavement Condition Before Overlay	Subgrade Soil Type	Climate, Moisture-Temperature by State, Section, and Age[1,2,3]			
		Wet-Freeze	**Wet-No-Freeze**	**Dry-Freeze**[1]	**Dry-No-Freeze**[1]
Fair	Fine grained	**GA(8)-6.2:** No WIM/AVC equipment installed. Subgrade—Limited classification, resilient modulus and M-D data. Existing HMA—Limited mix, asphalt and aggregate data. HMA overlay—Missing asphalt and aggregate data, and limited mix data. Preconstruction transverse profile unavailable.	No projects	**MN(3)-8.9:** Missing recent transverse profile. Subgrade—Missing resilient modulus data. Exist. HMA—Missing asphalt and aggregate data, and limited mix data. HMA overlay—Missing mix, asphalt, and aggregate data. Preconstruction transverse profile unavailable.	**OK(1)-2.1:** No WIM/AVC equipment installed. Subgrade—Missing classification, resilient modulus, and M-D data. Existing HMA—Limited mix data. HMA overlay—Missing aggregate and asphalt data, and limited mix data. Preconstruction transverse profile unavailable.
				CO(2)-7.9: Existing HMA—Limited mix, asphalt and aggregate data. HMA overlay—Limited mix, asphalt, and aggregate data.	**TX(0)-7.8:** HMA overlay—Missing aggregate data, and limited asphalt and mix data. Preconstruction distress survey unavailable.
	Coarse grained	**NJ(2)-7.0:** Subgrade—Missing M-D data and limited classification and resilient modulus data. Exist. HMA—Missing asphalt and aggregate data, and limited mix data. HMA overlay—Limited asphalt data.	No projects	**AB(0)-8.9:** Subgrade—Limited resilient modulus data. Preconstruction transverse profile unavailable.	**NM(0)-2.9:** No WIM/AVC equipment installed. Missing recent transverse profile. Subgrade—Missing classification, resilient modulus, and M-D data. Existing HMA—Limited mix data. HMA overlay—Missing mix, asphalt, and aggregate data. Preconstruction transverse profile unavailable.
				MT(2)-8.0: No WIM equipment installed. Subgrade—Limited resilient modulus data.	

Table 28. Summary of unavailable and limited data for the SPS-5 experiment (continued).

Pavement Condition Before Overlay	Subgrade Soil Type	Climate, Moisture-Temperature by State, Section, and Age[1,2,3]			
		Wet-Freeze	Wet-No-Freeze	Dry-Freeze[1]	Dry-No-Freeze[1]
Poor	Fine grained	**MD(1)-4.1:** Subgrade—Missing classification, resilient modulus, and M-D data. **MO(0)-0.0:** The Missouri project was constructed recently—no data are available as of January 2000.	**MS(1)-8.9:** Limited distress surveys and transverse profiles. Existing HMA—Missing aggregate and asphalt data, and limited mix data. HMA overlay—Missing asphalt and aggregate data, and limited mix data.	**MB(0)-10.0:** No WIM equipment installed. Subgrade—Missing resilient modulus data & limited classification data. Existing HMA—Missing mix, asphalt, and aggregate data. HMA overlay—Missing asphalt and aggregate data, and limited mix data. Preconstruction transverse and longitudinal profiles unavailable.	No projects
	Coarse grained	**ME(1)-4.1:** No WIM/AVC equipment installed. Subgrade—Missing resilient modulus data. Existing HMA—Missing asphalt data. HMA overlay—Limited mix data.	**FL(6)-4.3:** No WIM/AVC equipment installed. Subgrade—Limited classification, resilient modulus, and M-D data. Existing HMA—Missing asphalt and aggregate data, and limited mix data. Preconstruction transverse profile unavailable.	No projects	**AZ(2)-9.2:** Subgrade—Missing resilient modulus data. Preconstruction transverse profile unavailable.
			AL(2)-7.7: No WIM/AVC equipment installed. Limited transverse profiles. Existing HMA—Missing mix, asphalt, and aggregate data. HMA overlay—Missing mix, asphalt, and aggregate data. Preconstruction transverse profile unavailable.		**CA(13)-9.2:** Subgrade—Missing resilient modulus data. Existing HMA—Missing mix, asphalt, and aggregate data. HMA overlay—Missing asphalt, mix, and aggregate data.

Notes:
1. The values in parentheses are the numbers of supplemental test sections for each project. The other value provided for each project is the age of that project in years, as of January 2000.
2. The moisture susceptibility tests for the existing HMA surface and HMA overlay are missing for all projects, with the exception of the Florida, Maryland, and Maine projects.
3. The indirect tensile resilient modulus, strength, and creep compliance test for the existing HMA surface and HMA overlay are missing for all projects.

Table 29. Deficiencies and action items for each SPS-5 project.

SPS-5 Project	Deficiency - Issue	Suggested Action
AL, FL, GA, ME, MO, NM, OK	No traffic measuring equipment installed at the site.	Install traffic monitoring equipment at the sites.
AB, LA, FL, GA, ME, MO, MB, NM, OK	No traffic data has Level E status.	Process the traffic data that has been collected or address the reasons data do not have a Level E status.
All projects	Insufficient materials test data available for the essential material properties.	Complete the test program. Use back-calculation of elastic layer modulus until laboratory test data become available.
All projects	Layer thickness deviates from the planned thickness more than allowed by project requirements.	None—Adjust or normalize the performance to account for the thickness difference between the test sections.
All projects	In-place air voids deviate from the recommended values for the HMA layers.	None—Adjust or normalize the performance to account for the difference in air voids between the same test sections.
AZ, AB, AL, FL, GA, MN, MB, NM OK	Preconstruction transverse profile not at Level E.	Process data or determine reasons data are not at Level E.
TX	Preconstruction distress data not at Level E.	Process data or determine reasons data are not at Level E.
MB	Preconstruction longitudinal profile not at Level E.	Process data or determine reasons data are not at Level E.
AL, MO, NM, OK	Data from IMS table **TST_L05B** not at Level E.	Process data or determine reasons data are not at Level E.
MN, MO	Data from IMS table **SPS5_LAYER** not at Level E.	Process data or determine reasons data are not at Level E.
Ms, MT, TX	Limited manual distress data.	Take immediate action to collect these data or process the data collected.
AL, MN, NM	Limited transverse profile data.	Take immediate action to collect these data or process the data collected.
AL, NM	Limited longitudinal profile data.	Take immediate action to collect these data or process the data collected.

The two problems that could result in major limitations to the value of SPS-5 are the materials test data and traffic data that are unavailable in the IMS. Without these data, the experimental objectives can be accomplished only in an empirical sense in terms of the general performance of different sections, but the development and calibration of mechanistic procedures will not be possible.

EXPECTATIONS FROM THE OWNER AGENCIES

At one national workshop, input was received from the States and Provinces on the SPS-5 experiment (April 27, 2000, in Newport, Rhode Island).(5) Several agencies made presentations on the status of their individual SPS-5 project and on their expectations for the experiment. Panel discussions on the future direction and analysis of the SPS-5 data are summarized in this section.

In general, the owner agencies seem to be satisfied with the experiment and believed that it would produce valuable information on different design factors and features. Many agencies had been conducting or were planning their own analyses on their individual SPS-5 projects. Some of these analyses were yielding useful results; however, the agencies wanted a focus on implementation.

First and foremost, agencies wanted a research-quality database from SPS-5. Second, the agencies wanted to be able to determine the impacts of the rehabilitation design features on overlay performance and the effectiveness of the SPS-5 experiment design factors, such as:

- Condition of Existing Pavement—What effect does the condition of the existing pavement or types of distress (both in severity and extent) have on the performance of the rehabilitation strategy?
- HMA Overlay Thickness—How thick should the overlay be and what properties of the HMA have a significant effect on performance?
- Surface Preparation Intensity—How effective are certain surface preparation strategies in extending the service life of the overlay?

In addition to the structural design features, the agencies also wanted to know what major site condition factors influence the performance of HMA overlays over flexible pavements, including:

- Climate.
- Traffic volume and weights.
- Existing pavement condition.

Other expectations from the agencies included:

- Evaluation of existing performance prediction equations.
- Better rehabilitation design procedures.
- Better understanding of the distress mechanisms of HMA overlays.
- Validation and confirmation of pavement analysis methods.
- Calibration of mechanistic-empirical distress prediction models.

- Comparison of laboratory measured and field derived (back-calculated) material properties.

As to the future analysis plan for SPS-5, the agencies believed that it was worthwhile first to fill in the missing data—specifically, obtain traffic and materials test data. Some presenters at the SPS conference requested that fundamental studies be conducted to determine how the SPS-5 sections were responding to load and environmental stresses and loads. It also was suggested that an integrated analysis plan be developed for future research studies.

CAN THE SPS-5 EXPERIMENT MEET EXPECTATIONS?

This data review and evaluation of early performance trends showed that several significant data issues will limit the results that can be obtained from SPS-5. The missing traffic data and key material test data must be obtained before meaningful global analysis can be performed. A few SPS-5 sites had significant construction deviations. However, these construction deviations will not have a detrimental effect on the value of the experiment if the materials test data become available.

This does not mean that many important and useful findings cannot be obtained from the SPS-5 experiment even if no more traffic and materials data become available. Some important early trends were already identified that will be useful for the design and construction of HMA overlays of flexible pavements, even though all projects were less than 10 years old. Continual monitoring of the projects and test sections will provide valuable performance data that can be used in future studies to answer the questions asked by the owner agencies. Thus, it is concluded from this comprehensive study of the SPS-5 experiment that the expectations from the owner agencies and HMA industry can be met.

RECOMMENDATIONS FOR FUTURE ACTIVITIES

As stated in chapter 1, the key objective of the SPS-5 experiment is to determine the relative influence of different rehabilitation techniques on flexible pavement performance. It is believed that the experiment will be able to achieve this key objective with time. At the time of this report, the oldest SPS-5 project was just over 10 years (most were 5 to 7 years old), so many test sections had a moderate amount of surface distress, but only a few had been taken out service. The real benefit from this experiment will occur in the years ahead, as a greater percentage of test sections exhibit higher levels of distress—magnifying the effect of the experimental and other rehabilitation factors on performance.

The SPS-5 assessment report focused on the quality and completeness of SPS-5 construction and monitoring data, and on the adequacy of the experiment to achieve the original expectations and objectives. Some data were unavailable, but this will not significantly limit the value of the results. Detailed analysis of the effect of different design factors on performance was outside the scope of work for this study. Thus, future studies using SPS-5 experimental data should be planned and prioritized so they can be initiated as the SPS-5 projects exhibit higher levels of distress.

These future studies should be planned in two stages that focus on local and national expectations from SPS-5. The first stage would be a detailed assessment of each structural cell in the experiment to support local interests. The second would examine selected data elements to evaluate the effect of different structural features across the whole experiment. Both are discussed below.

Initial Stage—Analysis of Local Expectations or Individual Factorial Cells

A detailed evaluation of the projects within each cell should be completed as soon as some test sections begin to exhibit higher levels of at least one distress type. The purpose of these case studies is to:

- Resolve construction and monitoring anomalies and experimental cell differences for projects that changed cell locations from the original experiment design.

- Conduct comparative analyses of the individual test sections at each site including the supplemental test sections to identify differences in pavement performance and response. These comparative studies should include performance measures, material properties, and as-built conditions.

- Determine the effect of any construction difficulties and problems and material noncompliance issues with the SPS-5 project specifications, if any, on pavement performance and response.

- Develop findings on comparisons made between the projects and test sections and prepare a case study report that can be used for the national studies.

Second Stage—Analysis of National Expectations or Experimental Findings

The second-stage analyses should not be pursued until the first stage is complete. It is expected that the analyses performed as a part of the second stage can be coordinated with the *Strategic Plan for LTPP Data Analysis*. The SPS-5 experiment can contribute to the following specific analyses outlined in the strategic plan.

- Develop relationships to enable interchangeable use of laboratory- and field-derived material properties (Strategic Plan No. 2B).
- Establish procedures for determining as-built material properties (Strategic Plan No. 2C).
- Identify quantitative information on the performance impact of different levels of material variability and quality (Strategic Plan No. 2D).
- Estimate material design parameters from other materials data (Strategic Plan No. 2E).
- Quantify information as to the relationship between as-designed and as-built material characteristics (Strategic Plan No. 2F).
- Develop recommendations for collection of climatic data collection to adequately predict pavement performance (Strategic Plan No. 3D).
- Develop models relating functional and structural performance (Strategic Plan No. 4C).
- Calibrate relationships or transfer functions between pavement response and individual distress types (Strategic Plan No. 5C).

- Identify quantitative information on the impact of design features on measured pavement responses (deflection, load-transfer, strains, etc.) (Strategic Plan No. 7B).
- Develop guidelines for the selection of pavement design features (Strategic Plan No. 7C).

A description of some future studies that could be pursued at the national level using all of the SPS-5 experimental data are summarized in tables 30 through 41. The future research studies were prepared based on the discussions with and presentations from SHA personnel at the various SPS conferences that were held in 1999 and 2000. These future analysis objectives are believed to be achievable from data collected within the SPS-5 experiment and have been subdivided into two categories. The first category includes the analysis objectives that are related to the main factors of the SPS-5 experiment; objectives in the second are related to other experimental factors.

The following second-stage analysis objectives are recommended for the SPS-5 experiment; they are presented in more detail in tables 30 through 41.

Future Analysis Objectives Related to Main Experimental Factors (by table number)

(30) Perform test-section-by-test section analyses of the projects included in the SPS-5 experiment to gain an understanding of the performance of the individual test sections and how the performance and response of each test section compare to the other test sections within that project and between the projects. This objective is the initial analysis of the individual factorial cells.

(31) Determine the effect of the main SPS-5 experimental factors on the performance of flexible pavements.

(32) Determine the effect of layer thickness variations on LTPP and initial ride quality.

(33) Estimate the effect of seasonal conditions or changes on pavement response and the response of individual materials and on the subgrade soils.

(34) Quantify the effect of the existing pavement condition and distress extent on the performance measures (specifically ride quality) and minimum overlay thickness over the existing pavement.

(35) Quantify the effect of milling the existing HMA surface before overlay placement.

(36) Determine the effect of HMA mixture characteristics and the use of RAP on the performance of HMA overlays.

Future Analysis Objectives Related to Other Experimental Factors (by table number)

(37) Determine the effect of HMA compaction and material properties (gradation and resilient modulus) on pavement performance and whether there are consistent differences between HMA mixture with and without RAP.

(38) Quantify the remaining life of cracked or damaged HMA overlays.

(39) Confirm the hypothesis of surface-initiated fatigue cracks and identify those HMA mixture properties and pavement conditions most conducive to the occurrence of fatigue cracks starting at the surface of the pavement.

(40) Conduct mechanistic analyses of the SPS-5 project sites and test sections to gain knowledge of critical stresses, strains, and deflections to explain their performance in terms of fatigue cracking, permanent deformation within each layer, and ride quality.

(41) Quantification of the subgrade protection criteria for limiting the vertical compressive strains in the subgrade and overall deflection for overlay thickness design.

Data-Collection Efforts

It is recommended that the following data-collection efforts be emphasized in the future in support of the second-stage analyses:

- Collect routine data:
  - WIM and AVC traffic monitoring should receive close attention. Steps should be taken to ensure the routine data-collection guidelines are followed for both AVC and WIM.
  - Resolve irregular distress measurements over time for each SPS-5 section.
- Collect new data:
  - Dynamic modulus of asphalt concrete to predict fatigue and other load-related distresses.
  - Indirect tensile creep tests to predict low temperature cracking.
  - Performance-grade of the asphalt binder in the HMA overlay mixtures.
  - Coring along the cracks in HMA to determine the initiation of the crack and direction of its propagation (top-down or bottom-up cracking).

Table 30. Identification of future research studies from the SPS-5 experiment—Initial analysis of the individual factorial cells and companion projects.

OBJECTIVE NO. 1

Perform test-section-by-test-section analysis of the SPS-5 projects to gain an understanding of the performance of the individual test sections as compared to the performance and behavior or response of the other test sections within that project.

TOPIC AREA Pavement design	***PROBABILITY OF SUCCESS*** High
LTPP STRATEGIC PLAN 7.A, 7.B, 7.C	***SUPPLEMENTAL EXPERIMENTS***
END PRODUCT Impact of specific design features and level of significance on pavement performance and the occurrence of pavement distress. • Identify the test sections that perform well and poorly at each of the SPS-5 project sites. • Prepare case study reports that identify and define the effect of any construction difficulty or anomaly and material noncompliance with the project specifications on pavement performance and response. • Compare the projects within a specific cell of the factorial and determine any bias in performance differences that may be caused by construction anomalies and/or material noncompliance.	***POTENTIAL PRODUCT USE*** Future analysis projects.

GENERAL TASKS

- Resolve construction and monitoring data anomalies and experimental cell differences for those projects that changed cell locations from the original experiment design as they relate to the specific cell in the experiment.
- Conduct comparative analyses of the individual test sections at each site, including the supplemental test sections, to identify differences in pavement performance and response.
- Determine the effect of any construction difficulties and problems and material noncompliance issues with the SPS-5 project specifications, if any, on pavement performance and response.
- Develop findings regarding comparisons made between the projects and test sections and prepare a case study report that will be useful for the SHAs involved and also will be useful for the national studies.

Table 31. Identification of future research studies from the SPS-5 experiment—Overall effect of the main experimental factors on performance.

OBJECTIVE NO. 2
Determine the effect of the main SPS-5 experimental factors on the performance of the flexible pavements.

TOPIC AREA	***PROBABILITY OF SUCCESS***
Pavement design	High
LTPP STRATEGIC PLAN 7.A, 7.B, 7.C	***SUPPLEMENTAL EXPERIMENTS***

END PRODUCT
Improvement in pavement materials characterization as related to performance and construction, and impact of specific design features and level of significance on pavement performance and the occurrence of pavement distress.

- Minimum overlay thickness needed for different existing surface conditions, different surface treatments, and performance characteristics—minimum IRI levels.
- The effect of different surface repair techniques (milling versus non-milling the existing surface before overlay placement) on overlay performance.
- The effect of different HMA mixtures (with and without RAP) on overlay performance and identification of differences in mixture placement properties (for example, expected initial IRI values).
- Seasonal factors that describe changes in the response of the pavement and materials related to performance and incremental deterioration.

Potential Product Use

- Design cost-effective and reliable overlays and other rehabilitation techniques of flexible pavements.
- Calibration and validation of HMA overlay design procedures/methods and distress prediction models for HMA overlays.

GENERAL TASKS

- Review results and findings from each SPS-5 test section and project.
- Conduct statistical analysis to determine significant factors and interactions on performance.
- Conduct mechanistic-empirical analyses for cracking, rutting, and IRI.
- Based on the statistical and mechanistic analyses, determine the effect of different experimental factors or design features on pavement performance and response.
- Prepare practical presentations of the results, including software, decision trees, etc., for use by practicing engineers to aid them in determining the end products above.

Note: The future research topics or objectives that follow for the individual main or primary factors of the experiment are included as individual project objective statements.

Table 32. Identification of future research studies from the SPS-5 experiment—Effect of overlay thickness variations on performance.

OBJECTIVE NO. 3
Determine the effect of thickness variations on long-term HMA overlay performance and initial ride quality.

TOPIC AREA Design	***PROBABILITY OF SUCCESS*** Moderate to high*
LTPP STRATEGIC PLAN 2.D, 7.B	***SUPPLEMENTAL EXPERIMENTS*** SPS-1 experiment
END PRODUCT Impact of HMA overlay thickness and the variation of that thickness on overlay performance and the occurrence of pavement distress. A relationship or tabulation between increased thickness variances or standard deviations (coefficient of variations) and reduced ride quality or reduced pavement service life.	***POTENTIAL PRODUCT USE*** Development of pay-reduction factors based on thickness deviations.

GENERAL TASKS

- Review specific findings from each SPS-5 project related to the initial stage.
- Establish the thickness variability along each test section.
- Complete a regression study of the variation in overlay thickness (HMA) and the different performance measures and determine if threshold limits of variances in HMA thickness affect selected distresses.
- Accumulate and/or determine the initial IRI measured at each test section.
- Complete a regression study of the variation in thickness (HMA) and the initial IRI and determine if threshold limits of variances in HMA thickness increase the initial roughness (reduced ride quality) of the as-built pavement.
- Develop reduction in service life based on these increased variances in HMA thickness.

* The initial IRI values (longitudinal profile measured within 6 months of construction, assuming reasonable performance of the test sections) are needed to obtain the full benefit of the research study. The initial IRI values will need to be predicted from the time series data for some of the test sections or SPS-5 projects.

Table 33. Identification of future research studies from the SPS-5 experiment—Effect of existing pavement surface condition on overlay performance.

OBJECTIVE NO. 4
Determine the effect of the existing pavement surface condition on selection of repair techniques and on the performance of HMA overlays.

TOPIC AREA Design/construction	***PROBABILITY OF SUCCESS*** High
LTPP STRATEGIC PLAN 2.A, 2.B, 2.D, 2.E, 3.A, 7.A, 7.B, 7.C	***SUPPLEMENTAL EXPERIMENTS*** GPS*-6B
END PRODUCT Improvement in identifying pavement surface condition/distress as related to overlay performance and providing guidance for maintenance and rehabilitation strategy selection and performance predictions. A tabulation or decision tree of existing pavement surface condition for selecting repair techniques and minimum HMA overlay thickness required for different performance criteria.	***POTENTIAL PRODUCT USE*** Overlay design/construction criteria, as related to performance.

GENERAL TASKS

- Review specific findings from each SPS-5 project related to the initial analysis stage.
- Evaluate the existing surface condition on construction properties—thickness variations, initial IRI values, performance characteristics—and categorize the different test sections with significant differences.
- Correlate the physical properties and response properties to the condition of the existing surface and repair techniques.
- Determine the effect, if any, on the performance and individual distresses of the pavement, including the decrease in ride quality with time and traffic.
- Establish threshold limits or other criteria that can be used in design and construction—effect of construction variability of the existing surface condition and performance.

* GPS—General Pavement Studies

Table 34. Identification of future research studies from the SPS-5 experiment—Effect of surface repair technique on overlay construction and performance.

OBJECTIVE NO. 5
Determine the effect of repair techniques on HMA overlay construction and on the performance of HMA overlays.

TOPIC AREA Design/construction	***PROBABILITY OF SUCCESS*** High
LTPP STRATEGIC PLAN 2.A, 2.B, 2.D, 2.E, 3.A, 7.A, 7.B, 7.C	***SUPPLEMENTAL EXPERIMENTS*** GPS-6B
END PRODUCT Guidance for maintenance and rehabilitation strategy selection and performance predictions. A tabulation for selecting repair techniques for different surface conditions as related to different performance criteria.	***POTENTIAL PRODUCT USE*** Overlay design/construction criteria, as related to performance.

GENERAL TASKS

- Review specific findings from each SPS-5 project related to the initial analysis stage.
- Evaluate the existing surface condition on construction properties—thickness variations, initial IRI values, performance characteristics—and categorize the different test sections with significant differences as related to those test sections with and without milling.
- Correlate the HMA construction and response properties to the condition repair techniques.
- Determine the effect of different repair techniques, if any, on the performance and individual distresses of the pavement, including the decrease in ride quality with time and traffic.
- Establish threshold limits or other criteria that can be used in design and construction—effect of construction repair technique and existing surface condition on overlay performance.

Table 35. Identification of future research studies from the SPS-5 experiment—Effect of HMA mixture properties with and without RAP on overlay performance.

OBJECTIVE NO. 6
Determine the effect of HMA material properties or mixtures with and without RAP on overlay performance.

TOPIC AREA	***PROBABILITY OF SUCCESS***
Design/construction	High
LTPP STRATEGIC PLAN 2.A, 2.D, 2.E,. 3.C, 3.E, 7.B, 7.C	***SUPPLEMENTAL EXPERIMENTS*** GPS-1, GPS-2, and GPS-6
END PRODUCT Improvement in HMA mixture characterization for overlay and new pavement design and the occurrence of pavement distress. A set of material or mixture properties that can be used in mixture design and material selection, and in structural design for layer thickness determination.	***POTENTIAL PRODUCT USE*** Assist in the development of performance-related specifications and to develop material specifications to be used in construction (layer acceptance) and in design for determining overlay thickness.

GENERAL TASKS

- Review specific findings from each SPS-5 project related to the initial analysis stage.
- Determine the physical properties at construction for each HMA mixture of each test section.
- Compare the back-calculated layer modulus with the laboratory-measured resilient modulus, define any differences, and determine those factors or variables that have an effect on those differences.
- Establish if any performance differences in ride quality and pavement distresses (cracking and rut depths) can be attributed to mixture type or a combination of material/mixture properties related to mixtures with and without RAP.
- Establish threshold properties and/or criteria that result in an increased level of distresses or a reduction in ride quality.
- Establish whether some of the material-related distresses (raveling or bleeding) are related to these values.
- Develop criteria for mixture design and construction acceptance criteria.

Table 36. Identification of future research studies from the SPS-5 experiment—Effect of seasonal changes on pavement response and material responses related to overlay performance.

OBJECTIVE NO. 7
Effect of seasonal conditions or changes on the response of the pavement structure and HMA overlay response or modulus and on the other pavement layers and subgrade soils as related to pavement performance.

TOPIC AREA Materials and pavement management	***PROBABILITY OF SUCCESS*** High
LTPP STRATEGIC PLAN 2.A, 3.C, 3.E	***SUPPLEMENTAL EXPERIMENTS*** GPS-6A and B
END PRODUCT Improvement of environmental effects and considerations in overlay design, mixture selection (or specifications), and performance predictions. A table summarizing the seasonal modulus ratio and a map showing locations or areas with significant seasonal effects for different pavement types and overlays.	***POTENTIAL PRODUCT USE*** Allow designers and pavement management engineers to identify typical times of year when the pavement and overlay responses change significantly.

GENERAL TASKS

- Review specific findings from each SPS-5 project related to the initial analysis stage.
- Categorize the pavement structure with different soil types and pavement types in different climatic areas.
- Identify and select those projects and test sections with sufficient time series deflection data (three or four measurements during different seasons of the year).
- Calculate the modulus ratio for each season or measurement date from a “standard” modulus value or time of year.
- Conduct a regression analysis of the seasonal modulus ratios to determine their correspondence with surface cracking (or permeability), type of pavement structure, layer thickness, subgrade soil type, and various climatic parameters (such as rainfall).

Table 37. Identification of future research studies from the SPS-5 experiment—Effect of HMA overlay properties on pavement performance.

OBJECTIVE NO. 8
Determine the effect of HMA compaction and material properties (gradation and resilient modulus) on overlay performance.

TOPIC AREA Materials and construction	***PROBABILITY OF SUCCESS*** High
LTPP STRATEGIC PLAN 2.A, 2.D, 2.E, 3.C, 3.E, 7.B, 7.C	***SUPPLEMENTAL EXPERIMENTS*** SPS-1, GPS-1, GPS-2, GPS-6
END PRODUCT Improvement of HMA mixture characterization and impact of HMA overlay properties and specifications on performance and the occurrence of distress. A set of material or mixture properties that can be used in mixture design and material selection, and in structural design for layer thickness determination.	***POTENTIAL PRODUCT USE*** Assist in the development of performance-related specifications, the development of pay-reduction factors, and the development of material specifications to be used in construction (layer acceptance) and in design for determining overlay thickness.

GENERAL TASKS

- Review specific findings from each SPS-5 project related to the initial analysis stage.
- Determine the physical properties at construction for the HMA overlay of each test section.
- Compare the back-calculated layer modulus with the laboratory-measured resilient modulus, define any differences, and note those factors or variables that have an effect on those differences.
- Establish if any performance differences in ride quality and pavement distresses (cracking and rut depths) can be attributed to one or a combination of material/mixture properties.
- Establish threshold properties and/or criteria that result in an increased level of distresses or a reduction in ride quality.
- Establish whether some of the material-related distresses (raveling or bleeding) are related to these values.
- Develop criteria for mixture design and construction acceptance criteria.

Table 38. Identification of future research studies from the SPS-5 experiment—Quantification of remaining life of cracked or damaged HMA layers.

OBJECTIVE NO. 9 Quantification of the remaining life of cracked or damaged asphalt concrete layers.	
TOPIC AREA Pavement management and overlay design	***PROBABILITY OF SUCCESS*** High
LTPP STRATEGIC PLAN 4.B, 5.B, 5.C, 6.B	***SUPPLEMENTAL EXPERIMENTS*** SPS-1, SPS-9, GPS-1, GPS-2, GPS-6A, GPS-6B
END PRODUCT Improvement of HMA layer characterization and guidance for maintenance and rehabilitation strategy selection and HMA overlay performance predictions. A reduced modulus scale that is representative of a cracked HMA layer. This scale would be based on deflection and distress so that the results from distress surveys can be used to estimate the remaining life of an HMA surface.	***POTENTIAL PRODUCT USE*** Pavement management studies to determine the expected time for maintenance and/or rehabilitation, and overlay designs and rehabilitation studies.
GENERAL TASKS • Review specific findings from each SPS-5 project related to the initial analysis stage. • Back-calculate the modulus of test sections with different types, extents, and severity levels of cracking. • Estimate the HMA modulus to the uncracked condition, taking into account aging and temperature effects on the HMA modulus. • Relate these modulus values to the laboratory test results and compute a modulus damage ratio. • Complete a regression analysis of all ratios to define in mathematical terms the equivalent modulus ratio based on the initial or uncracked value.	

Note: One component needed to improve the accuracy of the results is comparable time measurements of deflection data and distress surveys. In addition, the resilient modulus of the HMA mixtures will be needed to improve the universal application of the results.

Table 39. Identification of future research studies from the SPS-5 experiment—Identification of those properties and conditions most conducive to the development of surface-initiated fatigue cracks.

OBJECTIVE NO. 10
Confirm the hypothesis of surface-initiated fatigue cracks and identify those properties or conditions most conducive to the development of surface-initiated fatigue cracks.

TOPIC AREA Design	***PROBABILITY OF SUCCESS*** Moderate to high*
LTPP STRATEGIC PLAN 2.A, 5.C, 7.B	***SUPPLEMENTAL EXPERIMENTS*** SPS-1 and GPS-2
END PRODUCT Improvement in HMA mixture characterization for distress prediction, and development of new pavement response model and performance/distress prediction models applicable to overlay design. • Mixture design criteria to minimize the occurrence of surface-initiated fatigue cracks. • Identification and listing of those factors and/or properties that increase the probability of surface-initiated fatigue cracks.	***POTENTIAL PRODUCT USE*** Identifying the mixture design properties and pavement conditions for which surface-initiated fatigue cracks are likely to develop, and determining the criteria to be used in design.

GENERAL TASKS
- Review specific findings from each SPS-5 project related to the initial analysis stage.
- Identify and prioritize the test sections that are susceptible to fatigue cracks initiating at the surface.
- Verify that those sites have fatigue cracks that initiated at the surface of the HMA layer (through distress surveys and coring studies).
- Conduct statistical studies to identify the properties of the HMA layer and pavement that are conducive for fatigue cracks to initiate at the surface of the pavement.
- Establish pavement response criteria (for example, deflection criteria) that can be used to design pavements to minimize the occurrence of surface-initiated fatigue cracks.
- Determine the mixture properties and environmental/pavement conditions (soil conditions, base type and thickness, traffic levels, and climate) in which surface initiated fatigue are most likely to develop.

* The probability of success will increase greatly if cores are performed as a part of special interim studies and all forensic studies to confirm the location of where the fatigue cracks initiated.

Table 40. Identification of future research studies from the SPS-5 experiment—Mechanistic analysis of the SPS-5 sites.

OBJECTIVE NO. 11 Conduct mechanistic analyses of the SPS-5 project sites to gain knowledge of critical stresses, strains, and deflections to explain their performance in terms of fatigue cracking, permanent deformation within each layer, and ride quality.	
TOPIC AREA Pavement design and construction	***PROBABILITY OF SUCCESS*** Moderate to high
LTPP STRATEGIC PLAN 2.D and 7.B	***SUPPLEMENTAL EXPERIMENTS***
END PRODUCT Evaluation and/or development of new pavement response and performance prediction models applicable to overlay design and performance predictions. In-depth field-verified knowledge as to the effects of critical measured structural responses that will be useful in pavement design, evaluation, and rehabilitation.	***POTENTIAL PRODUCT USE*** Knowledge gained from this experiment will be useful to researchers and others for improving design procedures to make HMA pavements a more cost-effective and reliable pavement whose performance can be predicted with structural response models.
GENERAL TASKS • Review specific findings from each SPS-5 project related to the initial analysis stage. • Establish a comprehensive input database that includes design, construction, materials test results, traffic, climate, monitoring data, and structural monitoring data (deflections). • Analyze the cracking and rutting that have occurred at all sites using the longitudinal and transverse profile data and distress data that have been measured with time. • Perform mechanistic analyses to determine the critical response stress, strain and/or deflection and cumulative fatigue damage, and permanent deformation for the traffic loadings and site-specific conditions. • Analyze the results and develop findings and recommendations as to the impacts of loading and material properties on the performance of flexible pavements.	

Table 41. Identification of future research studies from the SPS-5 experiment—Applicability of the subgrade protection criteria for use in overlay design of flexible pavements.

OBJECTIVE NO. 12
Quantify the applicability of the subgrade protection criteria—limiting subgrade vertical compressive stains and deflections for use in design of flexible pavements.

TOPIC AREA Design	***PROBABILITY OF SUCCESS*** Moderate to high*
LTPP STRATEGIC PLAN 5.A, 5.B, 5.C, 7.C	***SUPPLEMENTAL EXPERIMENTS*** GPS-6A and 6B
END PRODUCT Improvement in subgrade soil characterization for design, and development/confirmation of design criteria to protect the subgrade soil and foundation layers for different rehabilitation strategies. Limiting subgrade vertical strain and deflection criteria if found to be appropriate.	***POTENTIAL PRODUCT USE*** Identifying the conditions for which subgrade protection is required and would control the design, and determining the criteria to be used in design.

GENERAL TASKS
- Review specific findings from each SPS-5 project related to the initial analysis stage.
- Identify and prioritize the test sections that are susceptible to distortions in the subgrade.
- Verify that those sites have subgrade distortion (either through distress surveys, transverse profiles, or trenches).
- Determine the limiting subgrade vertical strains and the conditions (soil conditions, traffic levels, and pavement structure) for which the subgrade protection is required.

* The probability of success will increase greatly if trenches are performed as a part of all forensic studies to confirm any subgrade distortion.

APPENDIX A. PROJECT SUMMARIES

Appendix A includes an overview and summary, as of the time of this report, of each SPS-5 project relative to the experiment plan. Each overview includes a general description of the project's location and specific values for the key factors of the experiment factorial (table 1). Deviations from the initial project nomination and difficulties reported during construction are identified and briefly discussed. In addition, a summary of the materials data that are available is provided. As stated in chapter 2, the number of tests required for each project varies with the number of supplemental sections built within each project.

A summary of the data completeness for each project is presented in tabular format for construction and monitoring data elements. Data completeness and any project deviations are used in determining an adequacy code that is assigned to each project. This code represents a numerical scale from 0 to 5 and provides an overall rating of the project in regard to fulfillment of the original experimental objectives and expectations. This numerical scale is:

- 0 = The project will be unable to meet the experimental objectives and expectations or the project has been recently constructed and has only limited data at this time.
- 1 = The project has major limitations in the data. There are significant data deficiencies/missing data that will have a significant detrimental impact on meeting the experimental objectives and expectations.
- 2 = The project has missing data that will have an impact on the reliability of the results for achieving the experimental objectives and expectations.
- 3 = The project has some missing data and deficiencies. However, assumptions combined with the existing data can be used to meet the experimental objectives and expectations.
- 4 = The project has minor limitations, missing data, or data deficiencies that will have little impact on meeting the experimental objectives and expectations.
- 5 = The project has adequate data to meet the experimental objectives and expectations.

ALABAMA

The Alabama project is located on U.S. 84 highway in the eastbound direction, between Dothan and Enterprise. The original pavement was constructed on borderline fine/coarse loamy soil, and had about 700 mm of a predominantly coarse soil aggregate mixture base, and about 97 mm of an HMA surface.

Alabama elected to extend its SPS-5 project by adding two supplemental test sections to study the performance of other rehabilitation treatments of interest; these are identified in table 42. All test sections had been monitored and the data collected were available to the Department of Transportation (DOT) for evaluation.

Table 42. Alabama SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL THICKNESS
014155	None	Control section
010502	Minimum	51 mm RAP* overlay
010503	Minimum	127 mm RAP overlay
010504	Minimum	127 mm virgin overlay
010505	Minimum	51 mm virgin overlay
010506	Intensive	51 mm virgin overlay with milling
010507	Intensive	127 mm virgin overlay with milling
010508	Intensive	127 mm RAP overlay with milling
010509	Intensive	51 mm RAP overlay with milling
010563	Intensive	51 mm milling and inlay with virgin mix
010564	Intensive	51 mm milling and inlay with RAP mix

Notes: SHRP Sections (010501-09; 014155 is a General Pavement Studies (GPS) section that corresponds to 010501)
Alabama DOT Sections (010563-64)

* RAP = Recycled asphalt pavement.

Preconstruction Monitoring

Pavement surface distress was collected on each section of the project before overlay construction. Each test section was manually surveyed. Low-severity longitudinal cracking was the predominant distress.

Surface profile was also conducted on the project, utilizing the SHRP/LTPP profilometer. Deflection measurements were obtained with the FWD for the evaluation of the structural capacity of each test section. Material samples were obtained in accordance with the LTPP criteria.

Construction Difficulties

Milling operations used a drum width of 2.2 m, which required the contractor to make two passes per lane. On the first day of construction, the pump to be used to transfer water from the tanker was inoperable. Milling continued without the benefit of water as a cooling agent. Milling with water as a coolant was used the next day.

On the third day of construction on section 010507, a temperature of 119 ^{o}C was observed before laydown and 104 ^{o}C after laydown, which was below allowable limits. On the sixth day of construction, it was noticed during the milling operations that the sections located between Stations 365+00 and 395+00 exhibited some fatigue-like longitudinal cracking in both wheel paths following the milling operation. In addition, the surface layer (about 25 mm thick) appeared to be lifting in sheets due to delamination. The milling machine pulled up large chunks of asphalt concrete about 150 mm by 90 mm in size. Consequently, the contractor was required to use more material from the U.S. 84 highway to compensate for the large particles that would have been screened out when preparing for the recycled mix at the plant.

Postconstruction Monitoring

Following construction, automated pavement distress surveys were to be obtained for all the test sections. Rod-and-level measurements were taken on the surface of all sections. In addition, the surface was profiled with the high-speed profilometer. Transverse profiles were taken using the automated method.

Structural capacity was evaluated using FWD measurements. Improvement in the structural capacity was noted in the overlaid sections, with the highest improvement in the sections with thicker overlays.

Coring was performed; 102-mm cores were obtained 15 m from approach and leave ends of each section following the outline in the material sampling plan.

Data Completeness

As shown in table 43, no thickness data were available from the L05B testing table. Thickness data from the **SPS5_LAYER** table were available, but were not reported here because L05B results are determinant values for the layer thickness.

Longitudinal profile monitoring was performed 6 months before overlaying, 6 months, and every 2 years after construction on all the sections except the control section, 014155.

FWD data were collected 6 months before and after construction on sections 014155 through 010503 and 010505. All other sections failed to meet either the preconstruction or the postconstruction monitoring requirements. Not all sections met the long-term requirements.

Distress monitoring was conducted 6 months before construction on all sections except section 010502. Only the control section was monitored for distress within 6 month after construction. The long-term monitoring requirement for distress was met for all sections after treatment.

Transverse profile monitoring was performed within 6 months after construction for all sections. Transverse profile was not measured on any section 6 months before construction. The long-term monitoring requirements for transverse cracking were met for all sections after treatment application.

No friction data were collected on any of the sections within 6 months before overlay. All core sections were monitored for friction data within 6 months after construction except the control, 014155, and the supplemental sections, 010563 and 010564. The long-term monitoring requirement was met for all sections after treatment.

No traffic data were available for this project except for the control section, which had 47 days of WIM and 2 years worth of monitored traffic data. There was one year with more than 45 days of AVC per year.

Table 44 summarizes the project testing data. It can be seen that only a small number of tests still needed to be conducted for the unbound base layers. However, almost no tests had been completed on the AC surface layers. Most of the available data were at Level E in the IMS database. No testing had been conducted on the overlay materials placed on this project.

Table 43. Key project information for the Alabama SPS-5.

ALABAMA SPS-5 PROJECT SUMMARY

Age as of Aug 1999:	7.68	Construction Date:	12/20/91
Subgrade Type:	Coarse	Climatic Zone:	Wet-No-Freeze
Climatic Data Availability:	NA	Automated Vehicle Class:	None
Construction Problems:	Some milling without water. Mix too cool at lay down.	Weigh-In-Motion:	None

Site Key Information Summary:

	Overlay Thickness, mm			Milled		Original Pavement Structure				
ID	Design	Actual	Material	Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
4155	0			0		97	700	Soil Agg		
502	51		RAP	0		97	700	Soil Agg		
503	127		RAP	0		97	700	Soil Agg		
504	127		Virgin	0		97	700	Soil Agg		
505	51		Virgin	0		97	700	Soil Agg		
506	51		Virgin	51		97	700	Soil Agg		
507	127		Virgin	51		97	700	Soil Agg		
508	127		RAP	51		97	700	Soil Agg		
509	51		RAP	51		97	700	Soil Agg		
563	51 Inlay		Virgin	51		97	700	Soil Agg		
564	51 Inlay		RAP	51		97	700	Soil Agg		

Key monitoring data availability summary—Number of tests recorded in IMS to date

			Distress					
ID	IRI	FWD	Manual	Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
4155	6	5	4	5	5	4	2	1
502	4	4	4	2	3	2	0	1
503	4	4	4	2	3	2	0	1
504	4	4	4	2	3	2	0	1
505	4	4	4	2	3	2	0	1
506	4	3	4	2	3	2	0	1
507	4	4	4	2	3	2	0	1
508	4	4	4	2	3	2	0	1
509	5	4	4	2	3	2	0	1
563	2	2	4	2	3	1	0	1
564	2	2	4	2	4	1	0	1

	IRI		Distress		Transverse	
ID	Pre	Post	Pre	Post	Pre	Post
4155	12/12/90	8/24/92	6/20/91	4/1/92	6/10/90	4/1/92
502	7/8/91	4/1/92	9/18/91	4/1/93	—	4/1/92
503	7/9/91	4/2/92	9/18/91	4/1/93	—	4/1/92
504	7/8/91	4/1/92	9/18/91	4/1/93	—	4/1/92
505	7/8/91	4/1/92	9/18/91	4/1/93	—	4/1/92
506	7/8/91	4/1/92	9/18/91	4/1/93	—	4/1/92
507	7/8/91	4/1/92	9/18/91	4/1/93	—	4/1/92
508	7/9/91	4/2/92	9/18/91	4/1/93	—	4/1/92
509	7/9/91	4/2/92	9/18/91	4/1/93	—	4/1/92
563	—	8/10/94	9/18/91	4/1/93	—	3/21/94
564	—	8/10/94	9/18/91	4/1/93	—	3/21/94

Table 44. Alabama SPS-5 materials testing summary.

	Test	Minimum No. Per Layer	Number Conducted	Percent at Level E
Alabama SPS-5 Materials Testing Summary—Preconstruction				
Subgrade:	Sieve Analysis	3	9	100.0
	Hydrometer Analysis	3	9	100.0
	Atterberg Limits	3	9	100.0
	Moisture-Density Relations	3	3	100.0
	Resilient Modulus	3	4	100.0
	Natural Moisture Content	3	12	100.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	3	100.0
	Atterberg Limits	3	9	100.0
	Moisture-Density Relations	3	9	22.2
	Resilient Modulus	3	2	100.0
	Permeability	3	0	0.0
	Natural Moisture Content	3	12	100.0
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	28	15	100.0
	Bulk Specific Gravity	9	0	0.0
	Maximum Specific Gravity	3	0	0.0
	Asphalt Content	3	0	0.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	0	0.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	0	0.0
	Specific Gravity of Asphalt Cement	3	0	0.0
	Viscosity of Asphalt Cement	3	0	0.0
Alabama SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	0	0.0
	Bulk Specific Gravity	40	0	0.0
	Maximum Specific Gravity	6	0	0.0
	Asphalt Content	6	0	0.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity Fine Aggregate	6	0	0.0
	Bulk Specific Gravity Coarse Aggregate	6	0	0.0
	Aggregate Gradation	6	0	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	0	0.0
	Specific Gravity	6	0	0.0
	Viscosity of Asphalt Cement	6	0	0.0

ARIZONA

The Arizona SPS-5 project is in the dry-no-freeze environmental zone. It is located on Interstate 8, approximately 27 km west of Casa Grande, AZ. The original pavement was placed on a silty gravel with sand subgrade, had 361 mm to 447 mm of a granular base of soil aggregate mixture predominantly coarse, and 107 mm to 140 mm of HMA surface.

Arizona elected to extend its SPS-5 project by adding two supplemental test sections to study the performance of other rehabilitation treatments of interest. Each of these treatments is identified in table 45. All of these test sections had been monitored, and the data collected were available to the DOT for evaluation. However, these supplemental sections were not included in this investigation.

Table 45. Arizona SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
040501	None	Control section
040502	Minimum	51 mm RAP overlay
040503	Minimum	127 mm RAP overlay
040504	Minimum	127 mm virgin overlay
040505	Minimum	51 mm virgin overlay
040506	Intensive	51 mm virgin overlay with milling
040507	Intensive	127 mm virgin overlay with milling
040508	Intensive	127 mm RAP overlay with milling
040509	Intensive	51 mm RAP overlay with milling
040559	Intensive	51 mm milling and inlay with recycled mix
040560	Intensive	51 mm milling and inlay with Asphalt Rubber Asphalt Concrete (AR-AC) mix

Notes: SHRP Sections (040501-09)
Arizona DOT Sections (040559-60)

Preconstruction Monitoring

Monitoring data on rutting, roughness, and fatigue cracking were gathered on the sections before the application of overlays. At the time of construction, fatigue cracking was about 20 percent.

Surface profiling was conducted on the project utilizing the SHRP/LTPP profilometer. Deflection measurements were obtained with the FWD for the evaluation of the structural capacity of each test section. Material samples were obtained in accordance with the LTPP criteria.

Construction Difficulties

When paving the first of three lifts, the average temperature behind the paver was 107 ^{o}C, causing concern. There was some confusion about the calibration of the nuclear density for taking readings from the second lift of the overlays. An 80-kg/m^3 correction was added to the density gauge. Later, the correction factor was determined to be 32 kg/m^3. The compliance calculations were determined using 32 kg/m^3 and subtracting the 80 kg/m^3 only where data sheets noted that it had been added in.

Low stability was evidenced in the asphalt rubber concrete mix. The mix used in construction had a stability value of 49 kN. Milling on the minimum restoration sections was as high as 25 mm in some cases.

A 1.8-m milling width in one pass was used. This caused re-milling in several areas. Compacted density problems were encountered on the left lanes of sections 040507 and 040504.

Postconstruction Monitoring

Samples of the asphalt mix, granulated rubber, and reacted asphalt rubber binder material were taken. The AC-10 material was also sampled and sent to Central Materials for testing.

Data Completeness

As shown in table 46, thickness data were available from the L05B testing table. Thickness data from the **SPS5_LAYER** table were available, but were not reported here because the L05B results are the determinant values for layer thicknesses. It can be seen that the thicknesses were generally thicker than what was designed, especially with section 040506. This section's thickness data were not yet at Level E in the IMS database.

Longitudinal profile data were collected within 6 months before and after overlaying on all the sections. The long-term monitoring requirement was not met except for section 040501.

FWD data were collected within 6 months before construction on all the sections. However, the requirements for postconstruction and long-term monitoring were not met for any of the sections.

Distress monitoring was conducted within 6 months before construction except for sections 040503, 040559, and 040560. Distress monitoring was not conducted within 6 months after construction. The long-term monitoring requirement for distress was met for all sections after treatment.

Transverse profile was not measured on any section within 6 months before or after construction. The long-term monitoring requirements for transverse cracking were not met for any section after treatment application.

No friction data were collected on any of the sections within 6 months before or after overlay. All core sections were monitored for friction data every 2 years after construction.

Approximately 5 years of traffic data and 290 days of WIM data were available for all sections. There were 4 years with more than 45 days of AVC per year.

Table 46. Key project information for the Arizona SPS-5.

ARIZONA SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	9.21	Construction Date:	6/13/90
Subgrade Type:	Coarse	Climatic Zone:	Dry-No-Freeze
Climatic Data Availability:	29 Years	Automated Vehicle Class:	409 days
Construction Problems:	Mix placed at low temperature	Weigh-In-Motion:	290 Days

Site Key Information Summary:

ID	Overlay Thickness, mm Design	Overlay Thickness, mm Actual	Material	Milled Design	Milled Actual	Original Pavement Structure Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	NA		0		107	373	Soil Agg	—	—
502	51	68.6	RAP	0		107	373	Soil Agg	—	—
503	127	119.4	RAP	0		107	373	Soil Agg	—	—
504	127	121.9	Virgin	0		107	447	Soil Agg	—	—
505	51	71.1	Virgin	0		104	325	Soil Agg	—	—
506	51	132.1	Virgin	51		102	325	Soil Agg	—	—
507	127	172.7	Virgin	51		109	526	Soil Agg	—	—
508	127	165.1	RAP	51		119	381	Soil Agg	—	—
509	51	99.1	RAP	51		119	376	Soil Agg	—	—
559	51 min inlay	152.4	RAP	51		104	335	Soil Agg	442	Soil Agg
560	51 min inlay	55.9		51		104	356	Soil Agg	—	—

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
501	4	5	2	3	4	3	5	2
502	7	7	4	3	7	3	5	2
503	7	7	4	2	7	3	5	2
504	7	7	4	3	7	3	5	2
505	7	7	4	3	7	3	5	2
506	7	7	4	3	6	3	5	2
507	7	7	4	3	7	3	5	2
508	7	7	4	3	7	3	5	2
509	7	8	4	3	7	3	5	2
559	7	7	4	2	4	3	5	2
560	7	7	4	2	4	3	5	2

ID	IRI Pre	IRI Post	Distress Pre	Distress Post	Transverse Pre	Transverse Post
501	2/5/90	9/21/90	11/29/89	1/15/91	—	1/15/91
502	2/5/90	9/21/90	11/29/89	10/19/94	—	1/15/91
503	2/5/90	9/21/90	11/29/89	10/18/94	—	1/15/91
504	2/5/90	9/21/90	11/29/89	10/18/94	—	1/15/91
505	2/5/90	9/21/90	11/29/89	10/20/94	—	1/15/91
506	2/5/90	9/21/90	11/29/89	10/20/94	—	9/22/91
507	2/5/90	9/21/90	11/29/89	10/18/94	—	1/15/91
508	2/5/90	9/21/90	11/29/89	10/19/94	—	1/15/91
509	2/5/90	9/21/90	11/29/89	10/19/94	—	1/15/91
559	2/5/90	9/21/90	—	10/20/94	—	10/20/94
560	2/5/90	9/21/90	—	10/20/94	—	10/20/94

Table 47 summarizes the testing data of the project. It can be seen that most of the required tests have been completed on this project. Most of the testing data are currently at Level E in the IMS database.

Table 47. Arizona SPS-5 materials testing summary.

Arizona SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	6	83.3
	Hydrometer Analysis	3	6	83.3
	Atterberg Limits	3	6	83.3
	Moisture-Density Relations	3	6	83.3
	Resilient Modulus	3	0	0.0
	Natural Moisture Content	3	26	76.9
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	5	100.0
	Atterberg Limits	3	7	100.0
	Moisture-Density Relations	3	6	100.0
	Resilient Modulus	3	0	0.0
	Permeability	3	5	100.0
	Natural Moisture Content	3	16	100.0
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	26	28	89.3
	Bulk Specific Gravity	9	8	100.0
	Maximum Specific Gravity	3	2	100.0
	Asphalt Content	3	5	100.0
	Moisture Susceptibility	3	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	5	100.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	5	80.0
	Specific Gravity of Asphalt Cement	3	5	100.0
	Viscosity of Asphalt Cement	3	5	100.0
Arizona SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	32	40	100.0
	Bulk Specific Gravity	32	39	100.0
	Maximum Specific Gravity	6	6	100.0
	Asphalt Content	6	6	100.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	3	0	0.0
	Tensile Strength	3	0	0.0
Extracted Aggregate:	Bulk Specific Gravity Fine Aggregate	9	6	100.0
	Bulk Specific Gravity Coarse Aggregate	9	6	100.0
	Aggregate Gradation	9	6	100.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	9	6	100.0
	Penetration of Asphalt Cement	12	6	100.0
	Specific Gravity	12	6	100.0
	Viscosity of Asphalt Cement	12	6	100.0

CALIFORNIA

The California SPS-5 project is in a dry-no-freeze environmental zone. It is located on Interstate 40 in San Bernardino County. The original pavement was constructed on poorly graded soil with silt, had 406 mm to 584 mm of predominantly coarse soil aggregate mixture subbase, 100 to 150 mm of cement aggregate mixture base, and 126 to 150 mm of AC surface.

California elected to extend its SPS-5 project by adding 13 supplemental test sections to study the performance of other rehabilitation treatments of interest; these treatments are identified in table 48. It should be noted that the control section, which was to receive no treatment, was also overlaid. All test sections had been monitored, and the data collected were available to the DOT for evaluation.

Preconstruction Monitoring

Preconstruction monitoring was performed on the above sections except two of the supplemental sections that were added before construction of the SPS-5 main sections. The preconstruction monitoring consisted of distress surveys, profile measurements, deflection measurements, and material sampling.

Distress surveys were performed using mostly automated surveys. Manual surveys were used when it was not possible to use automated surveys. Profile measurements were performed using a high-speed profilometer. Averaging the measurements over a moving 0.3-m interval provided the longitudinal profile of the travel lane for each section. Pavement deflections were measured using FWD. Two passes were applied: at mid-lane, and at the outer wheel path.

Sampling of materials was done by extracting 102-, 152-, and 305-mm diameter pavement cores; 152-mm auger probes; 305-mm bore holes, and 1.8-m by 1.2-m test pits to a depth of 305 mm below the top of the untreated subgrade.

Construction Difficulties

Overall, construction was not problematic, but some problems were encountered. There was segregation of the first lift and mat checking in the overlays that could be attributed to frequent starts and stops by the paver. There were also some problems during compaction of several sections. Several inconsistencies and incomplete work were encountered in the milling operations on sections 060502, 060503, and 060509. Slipping of the paver occurred on supplemental sections 060560 and 060561 resulting in torn pavement reinforcing fabric, which in some areas was removed, but not replaced.

Postconstruction Monitoring

The postconstruction monitoring performed on the California SPS-5 site consisted of a distress survey, profile measurements, deflection measurements, and 102-mm core sampling of the overlay material. The cores were taken 6 m from the beginning and end of each section.

Table 48. California SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
060501	None	Control section, 51 mm recycled asphalt pavement (RAP) overlay
060502	Minimum	51 mm RAP overlay
060503	Minimum	127 mm RAP overlay
060504	Minimum	127 mm virgin overlay
060505	Minimum	51 mm virgin overlay
060506	Intensive	51 mm virgin overlay with milling
060507	Intensive	127 mm virgin overlay with milling
060508	Intensive	127 mm RAP overlay with milling
060509	Intensive	51 mm RAP overlay with milling
060559	Intensive	9.5 mm chip seal on 51 mm virgin overlay
060560	Intensive	51 mm virgin overlay on pavement reinforcing fabric (PFR)
060561	Intensive	51 mm rubberized overlay on PFR
060562	Intensive	51 mm rubberized overlay
060563	Intensive	51 mm rubberized overlay on SAMI
060565	Intensive	51 mm virgin overlay on SAMI
060565	Intensive	19 mm open-graded AC on SAMI on 51 mm virgin overlay
060566	Intensive	19 mm open-graded AC on 51 mm virgin overlay
060567	Intensive	100 mm virgin overlay
060568	Intensive	51 mm virgin overlay on 100 mm virgin AC base with 38 mm max. agg.
060569	Intensive	51 mm stone mastic asphalt (Vestoplast) overlay
060570	Intensive	51 mm stone mastic asphalt (Modified) overlay
060571	Intensive	Stone mastic asphalt control section, 51 mm dense grade overlay

Notes: SHRP sections (060501-09)
CALTRANS sections (060559-71)
SAMI = stress absorbing membrane interlayer
The 38 mm max. agg. in section 060568 is also known as “Monster Rock”

Data Completeness

Table 49 shows the summary data pertaining to the California SPS-5 project in the IMS database, where it can be seen that the actual thicknesses for the core SPS-5 sections in California were substantially higher that the design values. It is also evident that the control section was overlaid. The construction report notes that a 58- to 71-mm recycle mix overlay was applied to the control section.

Longitudinal profile data were collected within 6 months before construction. However, even though the construction report mentions that the data were collected within 6 months after construction, the data in the IMS database do not show that. The frequency of the longitudinal profile data collection met the long-term monitoring frequency requirement.

FWD data were collected within 6 months before construction except for sections 060501, 060559, and 060564 through 060569. There were no data recorded within 6 months after construction. The data collection met the long-term monitoring requirement except for sections 060559, 060567, 060568, and 060571.

Distress surveys were conducted every 2 years after construction except for section 060560; however, no data were recorded for distress surveys within 6 months before and after construction.

Transverse profile data were collected within 6 months before construction and every 2 years after construction; however, there were no data within 6 months after construction.

The frequency of the friction data collection did not meet any preconstruction, postconstruction, or long-term requirements.

Only 1 year of traffic data was available, which includes 32 days of WIM and less than 45 days of AVC.

Table 50 summarizes the availability of materials testing data for the California SPS-5 project. It can be seen that there was a serious deficiency in the testing data for both the preconstruction and postconstruction data. In addition, none of the tests conducted were at Level E in the IMS database.

Table 49. Key project information for the California SPS-5.

CALIFORNIA SPS-5 PROJECT SUMMARY

Age as of Aug 1999:	7.33	Construction Date:	4/24/92
Subgrade Type:	Fine/Coarse	Climatic Zone:	Dry-No-Freeze
Climatic Data Availability:	17 Years	Automated Vehicle Class:	32 Days
Construction Problems:	Segregation in first lift. Tearing of reinforcing fabric. Incomplete milling on three sections.	Weigh-In-Motion:	32 Days

Site Key Information Summary:

ID	Overlay Thickness, mm		Material	Milled		Original Pavement Structure				
	Design	Actual		Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	45.7		0		109	127	CTB*	422	Soil Agg
502	51	76.2	RAP	0		112	140	CTB	437	Soil Agg
503	127	165.1	RAP	0		112	140	CTB	526	Soil Agg
504	127	144.8	Virgin	0		114	124	CTB	538	Soil Agg
505	51	91.4	Virgin	0		119	132	CTB	508	Soil Agg
506	51	109.2	Virgin	51		122	135	CTB	505	Soil Agg
507	127	170.2	Virgin	51		130	137	CTB	493	Soil Agg
508	127	167.6	RAP	51		137	142	CTB	485	Soil Agg
509	51	111.8	RAP	51		137	135	CTB	495	Soil Agg
559	51	203.2	Virgin	51		114	147	CTB	500	Soil Agg
560	51	109.2	Virgin	51		114	147	CTB	493	Soil Agg
561	51	106.7	Rubber AC	51		122	142	CTB	508	Soil Agg
562	51	111.8	Rubber AC	51		127	104	CTB	566	Soil Agg
563	51	101.6	Rubber AC	51		130	97	CTB	582	Soil Agg
564	51	109.2	Virgin	51		130	112	CTB	582	Soil Agg
565	51	109.2	Virgin	51		127	119	CTB	544	Soil Agg
566	51	109.2	Virgin	51		117	142	CTB	508	Soil Agg
567	100	101.6	Virgin	51		119	140	CTB	503	Soil Agg
568	51	152.4	Virgin	51		119	127	CTB	498	Soil Agg
569	51	182.9	Stone Mastic	51		137	135	CTB	485	Soil Agg
570	51	182.9	Stone Mastic	51		122	140	CTB	500	Soil Agg
571	51	246.4	Stone Mastic	51		109	145	CTB	513	Soil Agg

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress		Transverse Profile	Friction	Traffic	Adequacy Code
			Manual	Photographic				
501	8	6	5	3	8	1	1	3
502	8	8	5	3	8	1	1	3
503	8	7	5	3	8	1	1	3
504	8	8	5	3	8	1	1	3
505	8	7	5	3	8	1	1	3
506	8	7	5	3	8	1	1	3
507	8	7	5	3	8	1	1	3
508	8	7	5	3	8	1	1	3
509	8	7	5	3	8	1	1	3
559	7	5	4	2	4	1	1	3
560	6	5	4	2	5	1	1	3
561	6	7	5	2	6	1	1	3
562	7	6	5	2	6	1	1	3
563	8	7	4	2	5	1	1	3
564	7	5	5	2	5	1	1	3
565	8	6	5	2	5	1	1	3
566	8	6	5	2	4	1	1	3
567	8	5	4	2	4	1	1	3
568	8	5	4	2	4	1	1	3
569	6	5	4	2	5	0	1	3
570	6	6	4	2	5	0	1	3
571	6	5	4	2	5	0	1	3

*CTB = cement-treated base

Table 49. Key project information for the California SPS-5, continued.

ID	IRI		Distress		Transverse	
	Pre	Post	Pre	Post	Pre	Post
501	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/23/92
502	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/23/92
503	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/24/92
504	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/24/92
505	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/24/92
506	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/24/92
507	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/24/92
508	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/24/92
509	2/11/92	2/2/93	11/13/89	9/24/92	2/9/92	9/24/92
559	2/6/91	2/2/93	–	9/25/92	–	4/7/95
560	2/14/92	2/2/93	–	9/25/92	–	9/25/92
561	2/14/92	2/2/93	–	9/25/92	–	9/25/92
562	2/14/92	2/2/93	–	9/25/92	–	9/25/92
563	2/14/92	2/2/93	–	9/25/92	–	10/28/94
564	2/14/92	2/2/93	–	9/25/92	–	10/28/94
565	2/14/92	2/2/93	–	9/25/92	–	10/28/94
566	2/14/92	2/2/93	–	9/25/92	–	10/28/94
567	2/14/92	2/2/93	–	9/25/92	–	4/7/95
568	2/14/92	2/2/93	–	9/25/92	–	4/7/95
569	2/11/92	2/2/93	–	11/2/92	–	10/25/94
570	2/11/92	2/2/93	–	11/2/92	–	10/26/94
571	2/11/92	2/2/93	–	11/2/92	–	10/27/94

Table 50. California SPS-5 materials testing summary.

California SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	3	0.0
	Hydrometer Analysis	3	3	0.0
	Atterberg Limits	3	3	0.0
	Moisture-Density Relations	3	3	0.0
	Resilient Modulus	3	0	0.0
	Natural Moisture Content	3	0	0.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	0	0	0.0
	Atterberg Limits	0	0	0.0
	Moisture-Density Relations	0	0	0.0
	Resilient Modulus	0	0	0.0
	Permeability	0	0	0.0
	Natural Moisture Content	0	0	0.0
Bound Base:	Classification	3	0	0.0
Asphalt Surface:	Core Examination	26	0	0.0
	Bulk Specific Gravity	9	0	0.0
	Maximum Specific Gravity	3	0	0.0
	Asphalt Content	3	0	0.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	0	0.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	0	0.0
	Specific Gravity of Asphalt Cement	3	0	0.0
	Viscosity of Asphalt Cement	3	0	0.0
California SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	0	0.0
	Bulk Specific Gravity	40	0	0.0
	Maximum Specific Gravity	6	0	0.0
	Asphalt Content	6	0	0.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity Fine Aggregate	6	0	0.0
	Bulk Specific Gravity Coarse Aggregate	6	0	0.0
	Aggregate Gradation	6	0	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	0	0.0
	Specific Gravity	6	0	0.0
	Viscosity of Asphalt Cement	6	0	0.0

COLORADO

The Colorado SPS-5 project is in the dry-freeze environmental zone. The project is located on Interstate 70 in Lincoln County. The original pavement rested on clayey soil mixed with coarse material ranging from sand to gravel. The original pavement had an AC surface thickness that ranged from 55 mm to 170 mm. The AC surface thickness rests on a 25 mm to 99 mm dense graded, hot laid, emulsion mixture treated base.

Colorado extended its SPS-5 project by adding two supplemental test sections to study the performance of other rehabilitation treatments of interest. Each of these treatments is identified in table 51. The SPS-5 control section also received a rut level-up course, although it was to receive no treatment. All of these test sections had been monitored, and the data collected were available to the DOT for evaluation.

Table 51. Colorado SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
080501	None	Control section, 33 mm rut level-up course
080502	Minimum	51 mm RAP overlay
080503	Minimum	127 mm RAP overlay
080504	Minimum	127 mm virgin overlay
080505	Minimum	51 mm virgin overlay
080506	Intensive	51 mm virgin overlay with milling
080507	Intensive	127 mm virgin overlay with milling
080508	Intensive	127 mm RAP overlay with milling
080509	Intensive	51 mm RAP overlay with milling
080559	None	51 mm HMAC overlay on 108 mm HMAC overlay
080560	None	51 mm polymer-modified overlay on 108 mm virgin overlay

Notes: SHRP Sections (080501-09)
Colorado Department of Highways sections (080559, 080560)

Preconstruction Monitoring

Samples were collected according to the testing plan. The sampling was done outside the 152-m test sections. A distress survey, deflection, and profile measurements were done 3 months before rehabilitation.

Construction Difficulties

While treatment was not scheduled for the control section, the severity of its rutting caused a hydroplane concern; therefore, a rut level-up was placed on that section. No other construction difficulties were reported for the Colorado SPS-5 project.

Postconstruction Monitoring

Cores 162 mm in diameter were taken in the approach and leave areas around each test section after construction. The drilling locations were different because of weather conditions. Twenty additional 102-mm cores were taken at section 080504 for additional study at Pennsylvania State University. Profile, deflection, and distress survey measurements were performed less than one year after construction.

Data Completeness

Table 52 shows a summary of the key elements for the Colorado SPS-5 project. Layer thicknesses reported in the IMS were substantially larger than the design values. In addition to the overlay, a rut level-up layer of 33 mm was placed on the minimum surface preparation sections.

Longitudinal profile monitoring was performed within 6 months before and after treatment, and then at 2-year intervals after construction, thus meeting the data-collection requirements.

Deflection data were collected within 6 months before and after construction, and at a frequency of every 2 years afterwards.

Distress surveys for the Colorado SPS-5 project were collected within 6 months before and every 2 years after the construction of the overlays. However, surveys were not taken within 6 months after the placement of the treatments.

Transverse profile data were collected within 6 months before and after the application of treatments; however, the long-term frequency requirements were not met.

Friction data were collected at a 2-year interval after the placement of the treatments, but not within 6 months before or after overlays were placed.

For the control section, there were 1,181 days of WIM and 4 out of the 5 years' worth of monitored traffic data had more than 45 days of AVC per year. For the treated sections, there were 1,058 days of WIM data. Among the 4 years of traffic data available for this project, 3 had more than 45 days of AVC per year.

Table 53 shows a summary of the testing material data collected on the Colorado SPS-5 project. It can be seen that most of the preconstruction testing had been completed. In addition, all of the available data were at Level E in the IMS. A similar observation can be made about the postconstruction testing. Only a few tests still needed to be done on the overlay AC and extracted aggregate, with the majority of the available data at Level E.

Table 52. Key project information for the Colorado SPS-5.

COLORADO SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	7.88	Construction Date:	10/8/91
Subgrade Type:	Fine/Coarse	Climatic Zone:	Dry-Freeze
Climatic Data Availability:	23 Years	Automated Vehicle Class:	1064 Days
Construction Problems:	Rut level-up on control	Weigh-In-Motion:	338 Days

Site Key Information Summary:

ID	Overlay Thickness, mm Design	Overlay Thickness, mm Actual	Material	Milled Design	Milled Actual	Original Pavement Structure Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	33.0		0		170	91	ATB*		
502	51	96.5	RAP	0		137	69	ATB		
503	127	137.2	RAP	0		127	53	ATB		
504	127	147.3	Virgin	0		114	89	ATB		
505	51	81.3	Virgin	0		163	76	ATB		
506	51	111.8	Virgin	51		165	86	ATB		
507	127	172.7	Virgin	51		147	25	ATB		
508	127	200.7	RAP	51		127	51	ATB		
509	51	106.7	RAP	51		130	69	ATB		
559	159	167.6	Virgin	0		163	99	ATB		
560	159	154.9	Modified	0		145	64	ATB		

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
501	9	6	5	2	6	1	5	4
502	9	6	5	2	6	1	4	4
503	9	6	5	2	6	1	4	4
504	9	6	5	2	6	1	4	4
505	9	6	5	2	6	1	4	4
506	9	7	5	2	6	1	4	4
507	9	6	5	2	6	1	4	4
508	9	6	5	2	6	1	4	4
509	9	6	5	2	6	1	4	4
559	9	6	5	2	3	1	4	4
560	9	5	5	2	3	1	4	4

ID	IRI Pre	IRI Post	Distress Pre	Distress Post	Transverse Pre	Transverse Post
501	5/28/91	11/13/91	5/3/91	7/12/94	8/19/91	2/27/92
502	5/28/91	11/13/91	5/1/91	7/12/94	8/19/91	2/27/92
503	5/28/91	11/13/91	5/2/91	7/12/94	8/19/91	2/27/92
504	5/28/91	11/13/91	5/3/91	7/12/94	8/19/91	2/27/92
505	5/28/91	11/13/91	5/3/91	7/12/94	8/19/91	2/27/92
506	5/28/91	11/13/91	5/3/91	7/12/94	8/19/91	2/27/92
507	5/28/91	11/13/91	5/3/91	7/12/94	8/19/91	2/27/92
508	5/28/91	11/13/91	5/2/91	7/12/94	8/19/91	2/27/92
509	5/28/91	11/13/91	5/1/91	7/12/94	8/19/91	2/27/92
559	5/28/91	11/13/91	5/3/91	7/12/94	5/3/91	4/25/96
560	5/28/91	11/13/91	5/3/91	7/12/94	5/3/91	4/25/96

*Asphalt-treated base

Table 53. Colorado SPS-5 materials testing summary.

	Test	Minimum No. Per Layer	Number Conducted	Percent at Level E
Colorado SPS-5 Materials Testing Summary—Preconstruction				
Subgrade:	Sieve Analysis	3	3	100.0
	Hydrometer Analysis	3	6	100.0
	Atterberg Limits	3	6	100.0
	Moisture-Density Relations	3	3	100.0
	Resilient Modulus	3	3	100.0
	Natural Moisture Content	3	5	100.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	0	0	0.0
	Atterberg Limits	0	0	0.0
	Moisture-Density Relations	0	0	0.0
	Resilient Modulus	0	0	0.0
	Permeability	0	0	0.0
	Natural Moisture Content	0	0	0.0
Bound Base:	Classification	3	3	100.0
Asphalt Surface:	Core Examination	26	26	100.0
	Bulk Specific Gravity	9	7	100.0
	Maximum Specific Gravity	3	3	100.0
	Asphalt Content	3	3	100.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	3	100.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	3	100.0
	Specific Gravity of Asphalt Cement	3	3	100.0
	Viscosity of Asphalt Cement	3	3	100.0
Colorado SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	62	74.2
	Bulk Specific Gravity	40	40	100.0
	Maximum Specific Gravity	6	4	100.0
	Asphalt Content	6	4	100.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity Fine Aggregate	6	4	100.0
	Bulk Specific Gravity Coarse Aggregate	6	4	100.0
	Aggregate Gradation	6	4	100.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	4	100.0
	Penetration of Asphalt Cement	6	4	100.0
	Specific Gravity	6	4	100.0
	Viscosity of Asphalt Cement	6	4	100.0

FLORIDA

The Florida SPS-5 is located in the wet-no-freeze environmental zone. The project is located on highway U.S. 1 in the southbound direction, about 70 km north of West Palm Beach. The original pavement was constructed on sand subgrade with approximately 305 mm of predominantly coarse soil aggregate mixture subbase, 203 mm of lime rock/caliche base, and about 89 mm of AC surface.

Florida elected to extend its SPS-5 project by adding six supplemental test sections to study the performance of other rehabilitation treatments of interest. Each of these treatments is identified in table 54. All of these test sections had been monitored, and the data collected were available to the DOT for evaluation.

Table 54. Florida SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
121030	None	Control section
120502	Minimum	51 mm RAP overlay
120503	Minimum	127 mm RAP overlay
120504	Minimum	127 mm virgin overlay
120505	Minimum	51 mm virgin overlay
120506	Intensive	51 mm virgin overlay with milling
120507	Intensive	127 mm virgin overlay with milling
120508	Intensive	127 mm RAP overlay with milling
120509	Intensive	51 mm RAP overlay with milling
120561	–	89 mm RAP overlay
120562	–	89 mm virgin overlay
120563	–	Mill/inlay (virgin)
120564	–	Mill/inlay (RAP)
120565	–	Mill/inlay, 89 mm RAP overlay
120566	–	Mill/inlay, 89 mm virgin overlay

Notes: SHRP Sections (120501-09; 121030 is a GPS section that corresponds to section 120501)
Florida DOT Sections (120561-66)

Preconstruction Monitoring

Each section was manually surveyed for distress before rehabilitation. The predominant distress for all the test sections was medium severity fatigue cracking. Surface profile measurements also were conducted before rehabilitation, along with FWD testing and materials sampling.

Construction Difficulties

The first 15 m of section 120502 received milling even though no milling was scheduled according to the experiment design. There was some evidence of segregation in the recycled mix placed during construction. There was a 460-mm swath of mix throughout the 120508 section that was not sufficiently tacked because the spray nozzles of the tack applicator were stuck.

Postconstruction Monitoring

Following construction, surface profile and deflection measurements were taken. In addition, materials sampling was performed 15 m from the approach and leave ends of each test section. Cores were taken as well as rod and level measurements for layer thickness information.

Data Completeness

Table 55 shows a summary of the key elements for the Florida SPS-5 project. It can be seen that layer thicknesses reported in the IMS were substantially larger than the design values for sections 120506 through 120509.

Longitudinal profile monitoring was conducted every 2 years after the placement of overlay on all sections except the control section. However, longitudinal profile data collection was not performed within 6 months before or after construction.

Deflection data were not collected within 6 months before and after construction, but they were collected at a frequency of every 2 years afterwards except for the control section.

Distress surveys for the Florida SPS-5 project were collected every 2 years after the construction of the overlays except for section 120501. However, no surveys were taken within 6 months before or after the placement of the treatments.

Transverse profile data were not collected within 6 months before or after the application of treatments; however, the long-term monitoring requirements were met for all sections with the exception of section 120501.

Friction data were collected at a 2-year interval after the placement of the treatments, and within 6 months before overlays were placed except for the control section. No friction data were collected within 6 months after construction of the overlays. No traffic data were available for the Florida project.

Table 56 shows a summary of the testing material data collected on the Florida SPS-5 project. It can be seen that the vast majority of the preconstruction testing had not been completed. In addition, many of the available preconstruction data were not at Level E in the IMS. The postconstruction testing data were almost complete. More than 50 percent of the postconstruction data were at Level E.

Table 55. Key project information for the Florida SPS-5.

FLORIDA SPS-5 PROJEC T SUMMARY			
Age as of Aug 1999:	4.32	Construction Date:	4/5/95
Subgrade Type:	Coarse	Climatic Zone:	WNF
Climatic Data Availability:	27 Years	Automated Vehicle Class:	None
Construction Problems:	Milling on 120502. Segregation in RAP.	Weigh-In-Motion:	None

Site Key Information Summary:

ID	Overlay Thickness, mm		Material	Milled		Original Pavement Structure				
	Design	Actual		Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	NA	–	0	0	–	–	–	–	–
502	51	63.5	RAP	0	0	79	269	DGAB*	292	Soil Agg
503	127	127.0	RAP	0	0	66	269	DGAB	292	Soil Agg
504	127	129.5	Virgin	0	0	71	213	DGAB	406	Soil Agg
505	51	50.8	Virgin	0	0	71	224	DGAB	457	Soil Agg
506	51	76.2	Virgin	51	35.1	76	213	DGAB	406	Soil Agg
507	127	165.1	Virgin	51	55.5	71	213	DGAB	406	Soil Agg
508	127	177.8	RAP	51	66.6	71	269	DGAB	292	Soil Agg
509	51	106.7	RAP	51	42.1	81	213	DGAB	406	Soil Agg
560	–	–	–	0	0	–	–	–	–	–
561	89	–	RAP	0	0	76	269	DGAB	292	Soil Agg
562	89	–	Virgin	0	0	66	224	DGAB	457	Soil Agg
563	–	–	Virgin	0	0	79	224	DGAB	457	Soil Agg
564	–	–	RAP	0	0	76	224	DGAB	457	Soil Agg
565	89	–	RAP	0	0	–	–	–	–	–
566	89	–	Virgin	0	0	–	–	–	–	–

Key monitoring data availability summary—Number of tests recorded in IMS to-date:

ID	IRI	FWD	Distress		Transverse Profile	Friction	Traffic	Adequacy Code
			Manual	Photographic				
501	0	0	0	0	0	0	0	2
502	3	2	4	1	3	2	0	2
503	3	2	4	1	3	2	0	2
504	3	2	4	1	3	2	0	2
505	3	2	4	1	3	2	0	2
506	3	2	4	1	3	2	0	2
507	3	2	4	1	3	2	0	2
508	4	4	4	1	3	2	0	2
509	3	0	4	1	3	2	0	2
560	0	0	0	0	0	0	0	2
561	3	2	4	1	3	2	0	2
562	3	2	4	1	3	2	0	2
563	3	2	4	1	3	2	0	2
564	3	2	4	1	3	2	0	2
565	3	2	4	1	3	2	0	2
566	3	2	4	1	3	2	0	2

* DGAB = dense-graded asphalt base

Table 55. Key project information for the Florida SPS-5, continued.

	IRI		Distress		Transverse	
ID	Pre	Post	Pre	Post	Pre	Post
502	5/25/94	11/1/95	9/26/94	1/21/96	–	1/21/96
503	5/25/94	11/1/95	9/26/94	1/21/96	–	1/21/96
504	5/25/94	11/2/95	9/28/94	1/22/96	–	1/21/96
505	5/25/94	11/2/95	9/29/94	1/22/96	–	1/21/96
506	5/25/94	11/2/95	9/28/94	1/21/96	–	1/21/96
507	5/25/94	11/2/95	9/28/94	1/22/96	–	1/21/96
508	5/25/94	11/1/95	9/27/94	1/21/96	–	1/21/96
509	5/25/94	11/2/95	9/28/94	1/21/96	–	1/21/96
560	–	–	–	–	–	–
561	5/25/94	11/1/95	–	1/21/96	–	1/21/96
562	5/25/94	11/2/95	–	9/29/94	–	1/21/96
563	5/26/94	11/2/95	–	9/29/94	–	1/21/96
564	5/26/94	11/2/95	–	9/29/94	–	1/21/96
565	5/25/94	11/2/95	–	9/28/94	–	1/21/96
566	5/25/94	11/2/95	–	9/28/94	–	1/21/96

Table 56. Florida SPS-5 materials testing summary.

	Test	Minimum No. Per Layer	Number Conducted	Percent at Level E
Florida SPS-5 Materials Testing Summary—Preconstruction				
Subgrade:	Sieve Analysis	3	1	0.0
	Hydrometer Analysis	3	1	0.0
	Atterberg Limits	3	1	0.0
	Moisture-Density Relations	3	1	0.0
	Resilient Modulus	3	1	0.0
	Natural Moisture Content	3	3	66.7
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	2	50.0
	Atterberg Limits	3	2	50.0
	Moisture-Density Relations	3	1	0.0
	Resilient Modulus	3	0	0.0
	Permeability	3	0	0.0
	Natural Moisture Content	3	3	66.7
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	40	34	64.7
	Bulk Specific Gravity	12	7	71.4
	Maximum Specific Gravity	3	0	0.0
	Asphalt Content	3	0	0.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	4	0	0.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	0	0.0
	Specific Gravity of Asphalt Cement	3	0	0.0
	Viscosity of Asphalt Cement	3	0	0.0
Florida SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	61	65	63.1
	Bulk Specific Gravity	61	64	62.5
	Maximum Specific Gravity	6	18	50.0
	Asphalt Content	6	18	50.0
	Moisture Susceptibility	6	17	47.1
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity Fine Aggregate	6	18	50.0
	Bulk Specific Gravity Coarse Aggregate	6	17	47.1
	Aggregate Gradation	6	18	50.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	18	50.0
	Specific Gravity	6	18	50.0
	Viscosity of Asphalt Cement	6	18	50.0

GEORGIA

The Georgia SPS-5 is located in the wet-no-freeze environmental zone. The project is located on Interstate Highway (IH) 75 in the northbound direction, about 96 km northwest of Atlanta. The original pavement was constructed on silty sand soil with approximately 356 mm of predominantly fine soil aggregate mixture subbase under 229 mm of asphalt-treated base (ATB), and about 147 mm of AC surface.

Georgia elected to extend its SPS-5 project by adding eight supplemental test sections to study the performance of other rehabilitation treatments of interest. Each of these treatments is identified in table 57. All test sections had been monitored, and the data collected were available to the DOT for evaluation.

Table 57. Georgia SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
130501	None	Control section
130502	Minimum	51 mm RAP overlay
130503	Minimum	127 mm RAP overlay
130504	Minimum	127 mm virgin overlay
130505	Minimum	51 mm virgin overlay
130506	Intensive	51 mm virgin overlay with milling
130507	Intensive	127 mm virgin overlay with milling
130508	Intensive	127 mm RAP overlay with milling
130509	Intensive	51 mm RAP overlay with milling
130560	–	Planned treatment
130561	–	89 mm RAP overlay
130562	–	89 mm virgin overlay
130563	Mill 51 mm	Inlay 51 mm virgin AC
130564	Mill 51 mm	Inlay 51 mm RAP
130565	Mill 89 mm	Inlay 89 mm RAP overlay
130566	Mill 89 mm	Inlay 89 mm overlay (virgin AC)
130567	Intensive	Control No. 2

Notes: SHRP Sections (130501-09)
Georgia DOT Sections (130560-67)

Preconstruction Monitoring

Pavement surface distress surveys were taken on all sections before construction of overlays. The predominant distress was low-severity longitudinal cracking in both wheel paths. Surface profile measurements were also performed with a profilometer. Transverse profiles were obtained manually using the Face Dipstick.

Deflection measurements were performed in conjunction with materials sampling. The deflection measurements were obtained using the FWD to evaluate the structural capacity of each test section.

Construction Difficulties

The preconstruction material sampling efforts revealed that the subgrade on the south end of the project yielded a subgrade material that is inconsistent with the subgrade material sampled on the north end of the project. The south end material was constructed with crushed gravel, while the north end was constructed with red sandy silt. Therefore, all the core sections were grouped on the north end while the supplemental sections were grouped on the south end.

Construction on section 130502 was delayed by approximately 45 minutes. This produced several surface anomalies could not be removed by the compaction process. Some surface anomalies also were observed on section 130562 that could not be removed by compaction.

Postconstruction Monitoring

After construction, all sections were profiled and rod and level measurements were taken. Transverse profile measurements were collected and deflection measurements were performed using FWD. Postconstruction materials sampling was performed in accordance with the SHRP guidelines.

Data Completeness

Table 58 shows a summary of the key elements for the Georgia SPS-5 project. It can be seen that layer thicknesses reported in the IMS were substantially larger than the design values for sections 130506 through 130509.

Longitudinal profile data were not available for the control section. For the treated sections, the monitoring of the longitudinal profile was performed 6 months before and every 2 years following the placement of overlay. However, collection of longitudinal profile was not completed within 6 months after construction.

Deflection data were collected within 6 months before and after construction, and the data were collected at a frequency of every 2 years afterwards. The exceptions were section 130501, which only met the requirement for within 6 months after construction, and section 130567, which did not meet the long-term monitoring requirement.

Distress surveys for the Georgia SPS-5 project were not collected within 6 months before the placement of the treatments for sections 130501, 130561 through 130563, and 130565 through 130567. Data were collected every 2 years after the construction of the overlays except for sections 130501 and 130567. However, no surveys were taken within 6 months after the placement of the treatments.

Transverse profile data were not collected within 6 months before or after the application of treatments, and the data were not collected at the required long-term frequency application of the treatments.

Friction data were collected at a 2-year interval after the placement of the treatments, but not within 6 months before or after overlays were placed. No traffic data were currently available for the Georgia project.

Table 59 shows a summary of the testing material data collected on the Georgia SPS-5 project. It can be seen that approximately half of the preconstruction testing was completed. More than half of the preconstruction available data were at Level E in the IMS. Very little of the postconstruction testing had been completed. Of the completed testing, approximately 70 percent of the data were at Level E in the IMS.

Table 58. Key project information for the Georgia SPS-5.

GEORGIA SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	6.17	Construction Date:	6/18/93
Subgrade Type:	Coarse	Climatic Zone:	Wet-Freeze
Climatic Data Availability:	19 Years	Automated Vehicle Class:	None
Construction Problems:	Supplemental sections on different subgrade. Surface anomalies on 130502.	Weigh-In-Motion:	None

Site Key Information Summary:

ID	Overlay Thickness, mm: Design	Overlay Thickness, mm: Actual	Material	Milled: Design	Milled: Actual	Original Pavement Structure: Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	NA	–	0		46	279	HMAC*	330	Soil Agg
502	51	40.6	RAP	0		46	279	HMAC	330	Soil Agg
503	127	129.5	RAP	0		51	290	HMAC	330	Soil Agg
504	127	134.6	Virgin	0		56	287	HMAC	330	Soil Agg
505	51	50.8	Virgin	0		61	287	HMAC	330	Soil Agg
506	51	106.7	Virgin	51		56	290	HMAC	330	Soil Agg
507	127	160.0	Virgin	51		61	295	HMAC	330	Soil Agg
508	127	170.2	RAP	51		41	290	HMAC	330	Soil Agg
509	51	96.5	RAP	51		46	284	HMAC	330	Soil Agg
560	–	55.9	–	0		41	386	HMAC	983	Soil Agg
561	89	73.7	RAP	0		46	396	HMAC	983	Soil Agg
562	89	88.9	Virgin	0		46	386	HMAC	394	Soil Agg
563	51	55.9	Virgin	51		56	384	HMAC	394	Soil Agg
564	51	58.4	RAP	51		41	386	HMAC	983	Soil Agg
565	89	127.0	RAP	89		51	396	HMAC	983	Soil Agg
566	89	137.2	Virgin	89		41	366	HMAC	394	Soil Agg
567	0	0	–	0		51	373	HMAC	394	Soil Agg

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress: Manual	Distress: Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
501	0	1	0	1	1	4	0	2
502	3	4	4	2	3	4	0	2
503	3	4	4	2	3	4	0	2
504	3	4	4	2	3	4	0	2
505	3	4	4	2	3	3	0	2
506	3	4	4	2	3	4	0	2
507	3	4	4	2	3	4	0	2
508	3	5	4	2	3	4	0	2
509	3	5	4	2	3	4	0	2
560	3	4	4	2	3	4	0	2
561	3	4	3	2	3	4	0	2
562	3	4	3	2	3	4	0	2
563	3	5	3	2	3	4	0	2
564	3	5	4	2	3	4	0	2
565	3	5	3	2	3	4	0	2
566	3	5	3	2	3	4	0	2
567	1	1	0	1	1	4	0	2

*Hot-mix asphalt concrete

Table 58. Key project information for the Georgia SPS-5, continued.

ID	IRI		Distress		Transverse	
	Pre	Post	Pre	Post	Pre	Post
501	–	–	–	4/7/94	–	4/7/94
502	3/1/93	5/7/96	2/24/93	4/7/94	–	4/7/94
503	3/1/93	5/7/96	2/23/93	4/7/94	–	4/7/94
504	3/1/93	5/6/96	2/22/93	4/7/94	–	4/7/94
505	3/1/93	5/6/96	2/22/93	4/7/94	–	4/7/94
506	3/1/93	5/6/96	2/22/93	4/7/94	–	4/7/94
507	3/1/93	5/6/96	2/22/93	4/7/94	–	4/7/94
508	3/1/93	5/7/96	2/23/93	4/7/94	–	4/7/94
509	3/1/93	5/7/96	2/23/93	4/7/94	–	4/7/94
560	3/8/93	5/8/96	3/1/93	4/7/94	–	4/7/94
561	3/8/93	5/8/96	–	4/7/94	–	4/7/94
562	3/1/93	5/8/96	–	4/7/94	–	4/7/94
563	3/1/93	5/8/96	–	4/7/94	–	4/7/94
564	3/8/93	5/8/96	3/1/93	4/7/94	–	4/7/94
565	3/8/93	5/8/96	–	4/7/94	–	4/7/94
566	3/1/93	5/8/96	–	4/7/94	–	4/7/94
567	3/1/93	5/8/96	–	4/7/94	–	4/7/94

Table 59. Georgia SPS-5 materials testing summary.

	Test	Minimum No. Per Layer	Number Conducted	Percent at Level E
Georgia SPS-5 Materials Testing Summary—Preconstruction				
Subgrade:	Sieve Analysis	4	2	100.0
	Hydrometer Analysis	4	2	100.0
	Atterberg Limits	4	2	100.0
	Moisture-Density Relations	4	2	100.0
	Resilient Modulus	4	3	66.7
	Natural Moisture Content	4	6	100.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	0	0	0.0
	Atterberg Limits	0	0	0.0
	Moisture-Density Relations	0	0	0.0
	Resilient Modulus	0	0	0.0
	Permeability	0	0	0.0
	Natural Moisture Content	0	0	0.0
Bound Base:	Classification	4	0	0.0
Asphalt Surface:	Core Examination	44	42	50.0
	Bulk Specific Gravity	12	42	50.0
	Maximum Specific Gravity	4	4	0.0
	Asphalt Content	4	3	66.7
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	4	3	66.7
	NAA Test for Fine Aggregate Particle Shape	4	0	0.0
	Penetration of Asphalt Cement	4	3	66.7
	Specific Gravity of Asphalt Cement	4	3	66.7
	Viscosity of Asphalt Cement	4	3	66.7
Georgia SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	68	66	75.8
	Bulk Specific Gravity	68	52	69.2
	Maximum Specific Gravity	6	0	0.0
	Asphalt Content	6	0	0.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	0	0.0
	Bulk Specific Gravity, Coarse Aggregate	6	0	0.0
	Aggregate Gradation	6	0	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	0	0.0
	Specific Gravity	6	0	0.0
	Viscosity of Asphalt Cement	6	0	0.0

MAINE

The Maine SPS-5 is located in the wet-freeze environmental zone. The project is located on IH-95 in the northbound direction, between Bangor and Howland. The original pavement had 216 mm to 241 mm of AC surface above 102 mm of gravel aggregate base course on a high fill of uncrushed gravel subbase layer.

Maine elected to extend its SPS-5 project by adding one supplemental test section to study the performance of another rehabilitation treatment of interest. This treatment is identified in table 60. This section was monitored, and the data collected were available to the DOT for evaluation.

Table 60. Maine SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
230501	None	Control section
230502	Minimum	51 mm RAP overlay
230503	Minimum	127 mm RAP overlay
230504	Minimum	127 mm virgin overlay
230505	Minimum	51 mm virgin overlay
230506	Intensive	51 mm virgin overlay with milling
230507	Intensive	127 mm virgin overlay with milling
230508	Intensive	127 mm RAP overlay with milling
230509	Intensive	51 mm RAP overlay with milling
230559	Intensive	32 mm virgin mix on 19 mm virgin shim AC layer

Notes: SHRP Sections (230501-09)
Maine DOT Section (230559)

Preconstruction Monitoring

Sampling for material testing was done before construction. In addition, longitudinal profile measurements using a profilometer also were taken. Deflection measurements using FWD were obtained as were manual distress surveys including Dipstick measurements of the transverse profile. The main distresses were high severity longitudinal cracks and high severity transverse cracks. The other major distresses observed were rutting and bleeding in the wheel paths.

Construction Difficulties

No leveling course was placed on the minimum preparation sections. In addition, cracks that were more than 19.1 mm wide were not repaired with patches. In some locations, the overlay thickness was adjusted to correct the cross-slope and remedy some of the rutting problem. Therefore, the overlay thickness was slightly thicker than stipulated by the experiment design. This difference in thickness was less than 10 mm, but still was larger than allowed by the construction requirements.

Postconstruction Monitoring

Longitudinal profile measurements were performed after construction of treatments using a profilometer. In addition, manual distress surveys were performed, including Dipstick measurements of the transverse profile. Deflection measurements also were obtained.

Data Completion

Table 61 shows a summary of the key elements for the Maine SPS-5 project. It can be seen that layer thicknesses reported in the IMS were substantially larger than the design values.

Longitudinal profile monitoring was performed within 6 months before and after overlay as well as at 2-year intervals after construction except for sections 230504 through 230506, 230508, and 230509. These sections did not meet the postconstruction requirement.

Deflection data, distress surveys, and transverse profile data were collected within 6 months before and after construction and at a frequency of every 2 years afterwards, thus meeting the data-collection requirements.

Friction data were collected at a 2-year interval after the placement of the treatments and within 6 months after construction. However, the friction data were not collected within 6 months before overlays were placed.

No traffic data were available for the Maine project.

Table 62 shows a summary of the testing material data collected on the Maine SPS-5 project. It can be seen that about 50 percent of the preconstruction testing had been completed. In addition, most of the available data were at Level E in the IMS. The vast majority of the postconstruction testing had been completed. Only a few tests still needed to be done, with the majority of the available data at Level E.

Table 61. Key project information for the Maine SPS-5.

MAINE SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	4.13	Construction Date:	6/27/95
Subgrade Type:	Coarse	Climatic Zone:	Wet-Freeze
Climatic Data Availability:	25 Years	Automated Vehicle Class:	None
Construction Problems:	Minimal preparation sections not pre-treated in accordance with guidelines.	Weigh-In-Motion:	None

Site Key Information Summary:

ID	Overlay Thickness, mm Design	Overlay Thickness, mm Actual	Material	Milled Design	Milled Actual	Original Pavement Structure: Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	0	–	0	0	211	112	DGAB	229	Gravel
502	51	91.4	RAP	0	0	213	112	DGAB	229	Gravel
503	127	139.7	RAP	0	0	218	112	DGAB	229	Gravel
504	127	144.8	Virgin	0	0	201	112	DGAB	229	Gravel
505	51	68.6	Virgin	0	0	201	112	DGAB	229	Gravel
506	51	104.1	Virgin	51	50.3	201	112	DGAB	229	Gravel
507	127	198.1	Virgin	51	57.2	211	112	DGAB	229	Gravel
508	127	172.7	RAP	51	52.0	221	112	DGAB	229	Gravel
509	51	96.5	RAP	51	43.4	203	112	DGAB	229	Gravel
559	51	–	Virgin	0	0	211	112	DGAB	229	Gravel

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
501	4	3	4	1	4	3	0	3
502	4	3	4	1	4	3	0	3
503	4	3	4	1	4	3	0	3
504	3	3	4	1	4	3	0	3
505	3	3	4	1	4	3	0	3
506	3	3	4	1	4	3	0	3
507	4	3	4	1	4	3	0	3
508	3	3	4	1	4	3	0	3
509	3	3	4	1	4	3	0	3
559	3	3	4	1	4	3	0	3

ID	IRI Pre	IRI Post	Distress Pre	Distress Post	Transverse Pre	Transverse Post
501	4/21/95	8/15/95	4/26/95	10/3/95	4/26/95	10/3/95
502	4/21/95	8/15/95	4/26/95	10/3/95	4/26/95	10/3/95
503	4/21/95	8/15/95	4/26/95	10/3/95	4/24/95	10/3/95
504	4/21/95	8/25/97	4/26/95	10/3/95	4/25/95	10/3/95
505	4/20/95	8/25/97	4/26/95	10/4/95	4/25/95	10/4/95
506	4/20/95	8/25/97	4/26/95	10/5/95	4/25/95	10/5/95
507	4/21/95	8/15/97	4/26/95	10/5/95	4/25/95	10/5/95
508	4/20/95	8/25/97	4/26/95	10/5/95	4/25/95	10/5/95
509	4/20/95	8/25/97	4/26/95	10/5/95	4/25/95	10/5/95
559	4/20/95	8/25/97	4/26/95	10/5/95	4/25/95	10/5/95

Table 62. Maine SPS-5 materials testing summary.

	Test	Minimum No. Per Layer	Number Conducted	Percent at Level E
Maine SPS-5 Materials Testing Summary—Preconstruction				
Subgrade:	Sieve Analysis	2	2	50.0
	Hydrometer Analysis	2	6	83.3
	Atterberg Limits	2	2	0.0
	Moisture-Density Relations	2	2	50.0
	Resilient Modulus	2	0	0.0
	Natural Moisture Content	4	8	87.5
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	2	8	87.5
	Atterberg Limits	2	2	0.0
	Moisture-Density Relations	2	2	0.0
	Resilient Modulus	2	0	0.0
	Permeability	2	0	0.0
	Natural Moisture Content	4	8	87.5
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	35	35	82.9
	Bulk Specific Gravity	35	35	82.9
	Maximum Specific Gravity	4	7	100.0
	Asphalt Content	4	7	100.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	4	7	85.7
	NAA Test for Fine Aggregate Particle Shape	4	0	0.0
	Penetration of Asphalt Cement	4	0	0.0
	Specific Gravity of Asphalt Cement	4	0	0.0
	Viscosity of Asphalt Cement	4	0	0.0
Maine SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	51	51	86.3
	Bulk Specific Gravity	51	44	97.7
	Maximum Specific Gravity	13	6	100.0
	Asphalt Content	13	6	100.0
	Moisture Susceptibility	13	6	0.0
	Resilient Modulus	5	0	0.0
	Tensile Strength	5	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	13	6	33.3
	Bulk Specific Gravity, Coarse Aggregate	13	6	66.7
	Aggregate Gradation	13	6	100.0
	NAA Test for Fine Aggregate Particle Shape	13	0	0.0
Asphalt Cement:	Abson Recovery	13	6	100.0
	Penetration of Asphalt Cement	13	5	100.0
	Specific Gravity	13	7	85.7
	Viscosity of Asphalt Cement	13	6	100.0

MARYLAND

The Maryland SPS-5 is located in the wet-freeze environmental zone. The project is located on U.S. 15 in the northbound direction, about 16 km south of Frederick, MD. The original pavement had a 114 mm AC surface resting on 102 mm of cement-treated base (CTB) over 152 mm of dense-graded aggregate subbase. The subbase lay above 152 mm of cement-modified subgrade. The original subgrade was silt.

Maryland elected to extend its SPS-5 project by adding five supplemental test sections to study the performance of other rehabilitation treatments of interest. Each of these treatments is identified in table 63. All of these test sections had been monitored, and the data collected were available to the DOT for evaluation.

Table 63. Maryland SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
240501	None	Control section
240502	Minimum	51 mm RAP overlay
240503	Minimum	127 mm RAP overlay
240504	Minimum	127 mm virgin overlay
240505	Minimum	51 mm virgin overlay
240506	Intensive	51 mm virgin overlay with milling
240507	Intensive	127 mm virgin overlay with milling
240508	Intensive	127 mm RAP overlay with milling
240509	Intensive	51 mm RAP overlay with milling
240559	Agency preparation	51 mm of agency mix design
240560	Agency preparation	64 mm of stone matrix asphalt, A (Arbocel)
240561	Agency preparation	64 mm of stone matrix asphalt, B (Vestoplast)
240562	Minimum (2 patches)	64 mm of stone matrix asphalt, B (Styrelf)
240563	Agency preparation	64 mm of stone matrix asphalt, A (Styrelf and Arbocel)

Notes: SHRP Sections (240501-09)
Maryland DOT Sections (240559-63)

Preconstruction Monitoring

Preconstruction materials sampling and testing were performed on the test sections. There was no documentation of other preconstruction monitoring in the construction report.

Construction Difficulties

No difficulties were documented in the construction report.

Postconstruction Monitoring

Postconstruction materials sampling and testing were performed on the test sections. In addition, initial inspection of the project after 4 months of traffic showed some flushing and rutting in the wheel paths in all of the recycled asphalt mixes.

Data Completeness

Table 64 shows a summary of the key elements for the Maryland SPS-5 project. It can be seen that layer thicknesses reported in the IMS were substantially larger than the design values for sections 240506 through 240509.

Longitudinal profile monitoring was completed 2 years after the placement of overlay except for section 240502. Longitudinal profile data were obtained and monitoring was done within 6 months after construction for all sections; however, collection of longitudinal profile data was not performed within 6 months before construction for sections 240504, 240508, and 240509.

Deflection data were collected within 6 months before and after construction, and at a frequency of every 2 years afterwards with the exception of two test sections. For sections 240562 and 240563, the deflection data were not taken within 6 months before construction.

Distress surveys for the Maryland SPS-5 project were collected 6 months before construction for all the sections except 240562. The distress data were collected within 6 months after construction only for sections 240503, 240559, 240562, and 240563. The distress data were not collected in accordance with the long-term monitoring requirements on any of the Maryland SPS-5 test sections.

Transverse profile data were collected within 6 months before construction. These data were collected within 6 months after construction only for section 240503. The transverse profile data were not collected every 2 years after construction on any section of the Maryland SPS-5 project.

Friction data were collected at a 2-year interval after the placement of the treatments. However, these data were only collected within 6 months before or after overlays were placed for section 240503, which collected data within 6 months after the overlay.

Traffic data were not available for the control section. For the treated sections, there were 155 days of WIM and 3 years worth of monitored traffic data. There were only 2 years with more than 45 days of AVC per year.

Table 65 summarizes the testing material data collected on the Maryland SPS-5 project. The vast majority of the preconstruction testing on the asphalt surface had been completed. However, the majority of the subgrade materials testing had not yet been completed. In addition, most available preconstruction data were at Level E in the IMS. The postconstruction testing data were almost complete. Less than 50 percent of the postconstruction data were at Level E.

Table 64. Key project information for the Maryland SPS-5.

MARYLAND SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	7.22	Construction Date:	6/1/92
Subgrade Type:	Fine	Climatic Zone:	Wet-Freeze
Climatic Data Availability:	26 Years	Automated Vehicle Class:	218 Days
Construction Problems:	None noted.	Weigh-In-Motion:	2 Days

Site Key Information Summary:

ID	Overlay Thickness, mm		Material	Milled		Original Pavement Structure				
	Design	Actual		Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	NA	–	0	0	91	107	CTB*	147	DGAB
502	51	53.3	RAP	0	0	81	107	CTB	150	DGAB
503	127	134.6	RAP	0	0	91	99	CTB	150	DGAB
504	127	134.6	Virgin	0	0	102	104	CTB	130	DGAB
505	51	53.3	Virgin	0	0	89	91	CTB	150	DGAB
506	51	91.4	Virgin	51	–	97	107	CTB	130	DGAB
507	127	190.5	Virgin	51	44.9	94	107	CTB	130	DGAB
508	127	167.6	RAP	51	–	94	107	CTB	130	DGAB
509	51	96.5	RAP	51	43.5	109	79	CTB	165	DGAB
559	51	–	Virgin	–	–	102	91	CTB	152	DGAB
560	64	–	Stone Mastic	–	–	76	104	CTB	147	DGAB
561	64	–	Stone Mastic	–	–	91	109	CTB	137	DGAB
562	64	–	Stone Mastic	–	–	91	109	CTB	137	DGAB
563	64	–	Stone Mastic	–	–	84	94	CTB	147	DGAB

Key monitoring data availability summary— Number of tests recorded in IMS to date

ID	IRI	FWD	Distress		Transverse Profile	Friction	Traffic	Adequacy Code
			Manual	Photographic				
501	10	5	5	2	8	4	0	4
502	8	6	6	2	9	3	3	4
503	10	6	6	2	9	3	3	4
504	9	6	5	2	8	3	3	4
505	9	5	5	2	8	3	3	4
506	10	5	5	2	8	3	3	4
507	10	5	5	2	8	3	3	4
508	8	6	6	2	9	3	3	4
509	8	5	5	2	8	3	3	4
559	8	5	4	2	6	4	3	4
560	6	5	4	2	8	3	3	4
561	5	5	4	2	7	3	3	4
562	5	4	4	2	5	3	3	4
563	6	4	4	2	5	3	3	4

ID	IRI		Distress		Transverse	
	Pre	Post	Pre	Post	Pre	Post
501	1/24/92	6/11/92	2/19/92	10/5/92	2/19/92	10/5/92
502	1/24/92	6/11/92	2/20/92	10/5/92	2/20/92	10/5/92
503	1/24/92	6/11/92	2/20/92	10/5/92	2/20/92	10/5/92
504	8/9/91	6/11/92	2/20/92	10/5/92	2/20/92	10/5/92
505	1/24/92	6/11/92	2/20/92	10/5/92	2/20/92	10/5/92
506	1/24/92	6/11/92	2/21/92	10/5/92	2/21/92	10/5/92
507	1/24/92	6/11/92	2/20/92	10/5/92	2/20/92	10/5/92
508	8/8/91	6/11/92	2/21/92	10/5/92	2/21/92	10/5/92
509	8/8/91	6/11/92	2/21/92	10/5/92	2/21/92	10/5/92
559	8/8/91	6/11/92	2/21/92	10/5/92	2/21/92	10/5/92
560	8/8/91	6/11/92	2/21/92	10/5/92	3/18/92	10/5/92
561	8/8/91	6/11/92	2/21/92	10/5/92	2/21/92	10/5/92
562	–	6/12/92	5/6/92	10/5/92	–	10/5/92
563	–	6/11/92	5/6/92	10/5/92	–	10/5/92

*Cement-treated base

Table 65. Maryland SPS-5 materials testing summary.

Maryland SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	0	0.0
	Hydrometer Analysis	3	0	0.0
	Atterberg Limits	3	0	0.0
	Moisture-Density Relations	3	0	0.0
	Resilient Modulus	3	0	0.0
	Natural Moisture Content	3	13	53.8
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	0	0	0.0
	Atterberg Limits	0	0	0.0
	Moisture-Density Relations	0	0	0.0
	Resilient Modulus	0	0	0.0
	Permeability	0	0	0.0
	Natural Moisture Content	0	0	0.0
Bound Base:	Classification	6	12	41.7
Asphalt Surface:	Core Examination	26	40	65.0
	Bulk Specific Gravity	9	40	65.0
	Maximum Specific Gravity	3	13	69.2
	Asphalt Content	3	13	69.2
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	26	26.9
	Aggregate Gradation	3	13	69.2
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	12	66.7
	Specific Gravity of Asphalt Cement	3	12	66.7
	Viscosity of Asphalt Cement	3	13	0.0
Maryland SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	76	105	53.3
	Bulk Specific Gravity	76	88	45.5
	Maximum Specific Gravity	12	10	30.0
	Asphalt Content	12	10	30.0
	Moisture Susceptibility	12	3	0.0
	Resilient Modulus	28	0	0.0
	Tensile Strength	28	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	12	5	100.0
	Bulk Specific Gravity, Coarse Aggregate	12	5	0.0
	Aggregate Gradation	12	10	30.0
	NAA Test for Fine Aggregate Particle Shape	12	0	0.0
Asphalt Cement:	Abson Recovery	5	9	33.3
	Penetration of Asphalt Cement	5	8	12.5
	Specific Gravity	5	8	37.5
	Viscosity of Asphalt Cement	5	8	25.0

MINNESOTA

The Minnesota SPS-5 is in the wet-freeze environmental zone. The project is located on U.S. 2 approximately 24 km west of Bemidji. According to the materials testing data, the original pavement had a surface course of 163 mm to 213 mm plant mix bituminous asphaltic concrete layer with a 305 mm to 325 mm crushed gravel subbase and a 119 mm to 137 mm uncrushed gravel base, resting on a subgrade of clayey soil material that varied from sandy clay to silty clay.

The SPS-5 project in Minnesota was constructed in 1990. Minnesota elected to extend its SPS-5 project by adding three supplemental test sections to study the performance of other rehabilitation treatments of interest. Each of these treatments is identified in table 66.

Table 66. Minnesota SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
270501	None	Control Section.
270502	Minimum	51 mm RAP overlay.
270503	Minimum	127 mm RAP overlay.
270504	Minimum	127 mm Virgin overlay.
270505	Minimum	51 mm Virgin overlay.
270506	Intensive	51 mm Virgin overlay with milling.
270507	Intensive	127 mm Virgin overlay with milling.
270508	Intensive	127 mm RAP overlay with milling.
270509	Intensive	51 mm RAP overlay with milling.
270559	Minimum	38 mm AC overlay.
270560	Intensive	Milling of transverse cracks only and 38 mm AC overlay.
270561	Minimum	Overlay consisting of two lifts; a type 41 mix on top of a type 31 mix.

Notes: SHRP Sections (270501-09)
MN/DOT Sections (270559-61)

All of these test sections had been monitored, and the data collected were available to the DOT for evaluation.

Preconstruction Monitoring

There was no recording of preconstruction monitoring in the construction report of the Minnesota SPS-5 project with the exception of the materials sampling and testing.

Construction Difficulties

Parts of the test sections were on fine-grained soils, while other parts were on coarse-grained soils. The materials sampled for pre- and postconstruction data were tested by the Minnesota Department of Transportation due to the delay of the SPS-5 guidelines. The project was located on either side of a small town along U.S. 2; four of the test sections were located east and the rest of the project was located west of the town. It was believed that this split between the test sections would cause no impact on the results because no change was anticipated in the traffic pattern.

Postconstruction Monitoring

There was no recording of postconstruction monitoring in the construction report of the Minnesota SPS-5 project except for the materials sampling and testing.

Data Completeness

Table 67 shows a summary of the key elements for the Minnesota SPS-5 project. It can be seen that layer thicknesses reported in the IMS are only available for three sections, 270502, 270505, and 270507.

Longitudinal profile monitoring was completed within 6 months before construction with the exception of section 270506. No longitudinal profile data were taken within 6 months after construction. The longitudinal profile data were collected every other year for all the sections after the placement of overlays.

Deflection data were collected in accordance with all of the monitoring requirements.

Distress surveys for the Minnesota SPS-5 project were collected within 6 months before construction except for sections 270501 (the control section), 270505, and 270559 through 270561. The distress data were obtained within 6 months after construction and every 2 years afterwards except for the control section.

Transverse profile data were not collected within 6 months before and after the application of treatments. However, the transverse profile data for the Minnesota SPS-5 section were collected in accordance with long-term monitoring requirements.

No friction data were in the IMS database for the Minnesota SPS-5 project.

There were 702 days of WIM and 3 years' worth of monitored traffic data. There were only 2 years with more than 45 days of AVC per year.

Table 68 shows a summary of the testing material data collected on the Minnesota SPS-5 project. It can be seen that the vast majority of the preconstruction and postconstruction testing had not been completed. In addition, none of the available data were at Level E in the IMS.

Table 67. Key project information for the Minnesota SPS-5.

MINNESOTA SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	NA	Construction Date:	9/15/90
Subgrade Type:	Fine	Climatic Zone:	Wet-Freeze
Climatic Data Availability:	28 Years	Automated Vehicle Class:	717 Days
Construction Problems:	Small town located within project limits.	Weigh-In-Motion:	702 Days

Site Key Information Summary:

	Overlay			Milled		Original Pavement Structure				
	Thickness, mm					Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
ID	Design	Actual	Material	Design	Actual					
501	0	NA	–	0		157	127	DGAB	325	Gravel
502	51	61.0	RAP	0		175	127	DGAB	325	Gravel
503	127	NA	RAP	0		165	127	DGAB	325	Gravel
504	127	NA	Virgin	0		170	132	DGAB	305	Gravel
505	51	48.3	Virgin	0		170	119	DGAB	320	Gravel
506	51	NA	Virgin	51		188	127	DGAB	318	Gravel
507	127	142.2	Virgin	51		175	132	DGAB	320	Gravel
508	127	NA	RAP	51		155	130	DGAB	315	Gravel
509	51	NA	RAP	51		190	127	DGAB	320	Gravel
559	38	NA	Virgin	0		175	137	DGAB	320	Gravel
560	38	NA	Virgin	0		188	137	DGAB	320	Gravel
561	–	NA	Virgin	0		213	137	DGAB	320	Gravel

Key monitoring data availability summary—Number of tests recorded in IMS to-date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
501	7	6	6	3	6	0	3	3
502	7	6	6	3	7	0	3	3
503	7	6	5	3	6	0	3	3
504	7	6	7	3	9	0	3	3
505	7	6	6	2	9	0	3	3
506	6	6	7	3	9	0	3	3
507	7	6	7	3	9	0	3	3
508	7	6	7	3	5	0	3	3
509	7	6	6	3	7	0	3	3
559	7	7	6	2	6	0	3	3
560	7	6	6	2	7	0	3	3
561	7	6	6	2	8	0	3	3

	IRI		Distress		Transverse	
ID	Pre	Post	Pre	Post	Pre	Post
501	5/24/90	7/13/91	5/29/90	11/5/90	–	6/16/92
502	7/13/91	10/31/92	5/29/90	11/9/90	–	11/9/90
503	7/13/91	10/31/92	5/29/90	11/9/90	–	11/9/90
504	7/13/91	10/31/92	5/29/90	11/6/90	–	11/6/90
505	7/13/91	10/31/92	5/29/90	11/6/90	–	11/6/90
506	7/13/91	10/31/92	5/29/90	11/6/90	–	11/6/90
507	7/13/91	10/31/92	5/29/90	11/5/90	–	6/16/92
508	7/13/91	10/31/92	5/29/90	11/5/90	–	11/9/90
509	7/13/91	10/31/92	5/29/90	11/6/90	–	11/6/90
559	7/13/91	10/31/92	–	11/5/90	–	6/16/92
560	7/13/91	10/31/92	–	11/5/90	–	6/16/92
561	7/13/91	10/31/92	–	11/5/90	–	6/16/92

Table 68. Minnesota SPS-5 materials testing summary.

	Test	Minimum No. Per Layer	Number Conducted	Percent at Level E
Minnesota SPS-5 Materials Testing Summary—Preconstruction				
Subgrade:	Sieve Analysis	3	4	0.0
	Hydrometer Analysis	3	0	0.0
	Atterberg Limits	3	4	100.0
	Moisture-Density Relations	3	4	0.0
	Resilient Modulus	3	0	0.0
	Natural Moisture Content	3	0	0.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	4	0.0
	Atterberg Limits	3	4	0.0
	Moisture-Density Relations	3	4	0.0
	Resilient Modulus	3	0	0.0
	Permeability	3	0	0.0
	Natural Moisture Content	3	0	0.0
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	26	3	0.0
	Bulk Specific Gravity	9	3	0.0
	Maximum Specific Gravity	3	4	0.0
	Asphalt Content	3	0	0.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	0	0.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	0	0.0
	Specific Gravity of Asphalt Cement	3	0	0.0
	Viscosity of Asphalt Cement	3	0	0.0
Minnesota SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	9	0.0
	Bulk Specific Gravity	40	12	0.0
	Maximum Specific Gravity	6	0	0.0
	Asphalt Content	6	0	0.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	0	0.0
	Bulk Specific Gravity, Coarse Aggregate	6	0	0.0
	Aggregate Gradation	6	0	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	0	0.0
	Specific Gravity	6	0	0.0
	Viscosity of Asphalt Cement	6	0	0.0

MISSISSIPPI

The Mississippi SPS-5 is in the wet-no-freeze environmental zone. The project is located on IH-55 in the northbound direction, north of Canton, MS. The original pavement was constructed on fine subgrade soil and consisted of approximately 216 mm of plant mix bituminous base over lime-treated subgrade soil in place.

Mississippi elected to extend its SPS-5 project by adding one supplemental test section to study the performance of other rehabilitation treatments of interest. This treatment is identified in table 69. This test section had been monitored, and the data collected were available to the DOT for evaluation.

Table 69. Mississippi SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
280501	None	Control section
280502	Minimum	51 mm RAP overlay
280503	Minimum	127 mm RAP overlay
280504	Minimum	127 mm virgin overlay
280505	Minimum	51 mm virgin overlay
280506	Intensive	51 mm virgin overlay with milling
280507	Intensive	127 mm virgin overlay with milling
280508	Intensive	127 mm RAP overlay with milling
280509	Intensive	51 mm RAP overlay with milling
280560	38 mm milling	76 mm virgin mix overlay with fabric underseal and slurry seal

Notes: SHRP Sections (280501-09)
Mississippi section (280560)

Preconstruction Monitoring

Pavement surface distress levels were taken by the photographic distress method. Profile data were obtained with the profilometer, showing IRI values that varied significantly among the different sections. Structural capacity was evaluated using FWD deflection data, which were taken 10 months before construction instead of the 6 months required. Material sampling activities at the project were completed.

Construction Difficulties

Construction occurred over a long period primarily because of problems associated with the asphalt concrete production plant, which had numerous breakdowns and had problems maintaining a consistent mix production.

Postconstruction Monitoring

Observations of pavement surface distress were obtained manually after construction for the Mississippi SPS-5 project. The profile measurements were collected using a profilometer. The FWD was used to collect deflection data to evaluate the pavement structural capacity. Materials sampling and testing were completed in accordance with the postconstruction sampling plan.

Data Completeness

Table 70 shows a summary of the key elements for the Mississippi SPS-5 project. It can be seen that layer thicknesses reported in the IMS were missing for sections 280506-9 as well as for section 280560.

Longitudinal profile monitoring was not completed in accordance with the long-term monitoring requirements for any of the Minnesota SPS-5 sections. However, monitoring of the longitudinal profile was performed within 6 months before and after construction for all sections.

Deflection data were not collected within 6 months before construction, but the data were collected within 6 months after construction and at a frequency of every 2 years afterwards.

Distress surveys for the Mississippi SPS-5 project were not taken within 6 months before construction. They were taken within 6 months after construction only for sections 280501, 280502, and 280503. The surveys were taken every 2 years after construction on all the sections.

Transverse profile data were collected within 6 months before the application of treatments. The data were not collected within 6 months after construction, but were collected every other year thereafter.

No friction data were in the IMS for the Mississippi SPS-5 project.

There were 89 days of WIM and 1 year of monitored traffic data. There were more than 45 days of AVC for that year.

Table 71 shows a summary of the testing material data collected on the Mississippi SPS-5 project. Preconstruction testing for the subgrade had been completed. However, the tests for the other layers had not been done. The majority of the completed preconstruction testing data were available at Level E in the IMS. Except for the core examinations, none of the postconstruction testing data had been completed.

Table 70. Key project information for the Mississippi SPS-5.

MISSISSIPPI SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	8.92	Construction Date:	9/25/90
Subgrade Type:	Fine	Climatic Zone:	Wet-No-Freeze
Climatic Data Availability:	26 Years	Automated Vehicle Class:	91 Days
Construction Problems:	Mix plant breakdown	Weigh-In-Motion:	89 Days

Site Key Information Summary:

	Overlay			Milled		Original Pavement Structure				
	Thickness, mm									
ID	Design	Actual	Material	Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	NA		0		104	193	HMAC	152	LTS*
502	51	50.8	RAP	0		109	180	HMAC	84	LTS
503	127	116.8	RAP	0		109	180	HMAC	84	LTS
504	127	124.5	Virgin	0		107	218	HMAC	152	LTS
505	51	50.8	Virgin	0		107	198	HMAC	114	LTS
506	51	NA	Virgin	51		107	198	HMAC	114	LTS
507	127	NA	Virgin	51		86	185	HMAC	234	LTS
508	127	NA	RAP	51		91	196	HMAC	0	LTS
509	51	NA	RAP	51		109	193	HMAC	102	LTS
560	76	NA	Virgin	38		91	203	HMAC	152	LTS

Key monitoring data availability summary—Number of tests recorded in IMS to date

			Distress		Transverse			Adequacy
ID	IRI	FWD	Manual	Photographic	Profile	Friction	Traffic	Code
501	6	6	4	3	5	0	1	3
502	6	6	4	3	5	0	1	3
503	6	6	4	3	5	0	1	3
504	6	6	3	3	4	0	1	3
505	6	6	3	3	5	0	1	3
506	6	7	3	3	5	0	1	3
507	6	6	3	3	5	0	1	3
508	6	6	3	3	5	0	1	3
509	6	7	3	3	5	0	1	3
560	4	6	3	2	2	0	1	3

	IRI		Distress		Transverse	
ID	Pre	Post	Pre	Post	Pre	Post
501	5/2/90	11/14/90	6/1/89	12/27/90	6/11/90	12/27/90
502	5/3/90	11/14/90	6/1/89	12/27/90	6/11/90	12/27/90
503	5/3/90	11/14/90	6/1/89	12/27/90	6/11/90	12/27/90
504	5/3/90	11/14/90	6/1/89	3/21/93	6/11/90	4/13/92
505	5/3/90	11/14/90	6/1/89	3/21/93	6/11/90	12/27/90
506	5/3/90	11/14/90	6/1/89	3/21/93	6/11/90	12/27/90
507	5/3/90	11/14/90	6/1/89	3/21/93	6/11/90	12/27/90
508	5/3/90	11/14/90	6/1/89	3/21/93	6/11/90	12/27/90
509	5/3/90	11/14/90	6/1/89	3/21/93	6/11/90	12/27/90
560	–	11/14/90	–	3/21/93	–	3/21/93

*Lime-treated subgrade

Table 71. Mississippi SPS-5 materials testing summary.

	Test	Minimum No. Per Layer	Number Conducted	Percent at Level E
Mississippi SPS-5 Materials Testing Summary—Preconstruction				
Subgrade:	Sieve Analysis	3	9	88.9
	Hydrometer Analysis	3	9	88.9
	Atterberg Limits	3	9	88.9
	Moisture-Density Relations	3	9	88.9
	Resilient Modulus	3	10	90.0
	Natural Moisture Content	3	7	85.7
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	0	0	0.0
	Atterberg Limits	0	0	0.0
	Moisture-Density Relations	0	0	0.0
	Resilient Modulus	0	0	0.0
	Permeability	0	0	0.0
	Natural Moisture Content	0	0	0.0
Bound Base:	Classification	3	0	0
Asphalt Surface:	Core Examination	26	28	100.0
	Bulk Specific Gravity	9	0	0.0
	Maximum Specific Gravity	3	0	0.0
	Asphalt Content	3	0	0.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	0	0.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	0	0.0
	Specific Gravity of Asphalt Cement	3	0	0.0
	Viscosity of Asphalt Cement	3	0	0.0
Mississippi SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	29	100.0
	Bulk Specific Gravity	40	0	0.0
	Maximum Specific Gravity	6	0	0.0
	Asphalt Content	6	0	0.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity Fine Aggregate	6	0	0.0
	Bulk Specific Gravity Coarse Aggregate	6	0	0.0
	Aggregate Gradation	6	0	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	0	0.0
	Specific Gravity	6	0	0.0
	Viscosity of Asphalt Cement	6	0	0.0

MISSOURI

Preconstruction Monitoring

The construction report was not available for review.

Construction Difficulties

The data in the IMS suggested that construction had not been completed.

Postconstruction Monitoring

The data in the IMS suggested that construction had not been completed.

Data Completeness

Table 72 shows a summary of the key elements for the Missouri SPS-5 project; very little information was available. Some data were available for FWD and manual distress. These data were taken before construction. No data were recorded for after construction, which suggests that construction had not been performed.

Table 73 shows a summary of the testing material data for the Missouri SPS-5 project. No data were available for either the preconstruction and postconstruction testing.

Table 72. Key project information for the Missouri SPS-5.

MISSOURI SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	0.93	Construction Date:	8/27/98
Subgrade Type:	NA	Climatic Zone:	NA
Climatic Data Availability:	NA	Automated Vehicle Class:	None
Construction Problems:		Weigh-In-Motion:	None

Site Key Information Summary:

	Overlay Thickness, mm			Milled		Original Pavement Structure				
ID	Design	Actual	Material	Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0		–	0						
502	51		RAP	0						
503	127		RAP	0						
504	127		Virgin	0						
505	51		Virgin	0						
506	51		Virgin	51						
507	127		Virgin	51						
508	127		RAP	51						
509	51		RAP	51						

Key monitoring data availability summary --- Number of tests recorded in IMS to-date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
501	0	1	2	0	2	0	0	0
502	0	1	2	0	2	0	0	0
503	0	1	2	0	2	0	0	0
504	0	2	2	0	2	0	0	0
505	0	2	2	0	2	0	0	0
506	0	2	2	0	2	0	0	0
507	0	1	2	0	2	0	0	0
508	0	1	2	0	2	0	0	0
509	0	1	2	0	1	0	0	0

ID	IRI Pre	IRI Post	Distress Pre	Distress Post	Transverse Pre	Transverse Post
501	–	–	7/22/98	12/17/98	7/22/98	12/17/98
502	–	–	7/23/98	12/17/98	7/23/98	12/17/98
503	–	–	7/23/98	1/20/99	7/23/98	1/20/99
504	–	–	6/10/98	12/16/98	6/10/98	12/6/98
505	–	–	6/10/98	12/16/98	6/6/98	12/6/98
506	–	–	6/10/98	12/16/98	6/10/98	12/6/98
507	–	–	7/22/98	1/19/99	7/22/98	1/19/99
508	–	–	7/22/98	12/15/98	7/22/98	12/15/98
509	–	–	7/22/98	1/16/99	7/22/98	–

Table 73. Missouri SPS-5 materials testing summary.

Missouri SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	0	0.0
	Hydrometer Analysis	3	0	0.0
	Atterberg Limits	3	0	0.0
	Moisture-Density Relations	3	0	0.0
	Resilient Modulus	3	0	0.0
	Natural Moisture Content	3	0	0.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	0	0.0
	Atterberg Limits	3	0	0.0
	Moisture-Density Relations	3	0	0.0
	Resilient Modulus	3	0	0.0
	Permeability	3	0	0.0
	Natural Moisture Content	3	0	0.0
Bound Base:	Classification	3	0	0.0
Asphalt Surface:	Core Examination	26	0	0.0
	Bulk Specific Gravity	9	0	0.0
	Maximum Specific Gravity	3	0	0.0
	Asphalt Content	3	0	0.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	0	0.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	0	0.0
	Specific Gravity of Asphalt Cement	3	0	0.0
	Viscosity of Asphalt Cement	3	0	0.0
Missouri SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	0	0.0
	Bulk Specific Gravity	40	0	0.0
	Maximum Specific Gravity	6	0	0.0
	Asphalt Content	6	0	0.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	0	0.0
	Bulk Specific Gravity, Coarse Aggregate	6	0	0.0
	Aggregate Gradation	6	0	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	0	0.0
	Specific Gravity	6	0	0.0
	Viscosity of Asphalt Cement	6	0	0.0

MONTANA

The Montana SPS-5 is in the dry-freeze environmental zone. The project is located on IH-90 in the westbound direction, west of Big Timber, MT. The original pavement was constructed on clayey gravel subgrade and had about 70 mm of predominantly fine soil aggregate mixture base, approximately 430 mm of predominantly fine soil aggregate mixture subbase, and 200 mm of AC surface.

Montana elected to extend its SPS-5 project by adding two supplemental test sections to study the performance of other rehabilitation treatments of interest. Each of these treatments is identified in table 74. All of these test sections had been monitored, and the data collected were available to the DOT for evaluation.

Table 74. Montana SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
307066	None	Control section, 51 mm HMAC overlay
300502	Minimum	51 mm RAP overlay
300503	Minimum	127 mm RAP overlay
300504	Minimum	127 mm virgin overlay
300505	Minimum	51 mm virgin overlay
300506	Intensive	51 mm virgin overlay with milling
300507	Intensive	127 mm virgin overlay with milling
300508	Intensive	127 mm RAP overlay with milling
300509	Intensive	51 mm RAP overlay with milling
300561	Mill open friction course	127 mm milling and inlay with Polybuilt additive in the mix
300560	Mill open friction course	51 mm milling and inlay with Kraton modified asphalt in the mix

Notes: SHRP Sections (300501-09; 307066 is a GPS section that is a substitute for section 300501)
Montana DOT Sections (300561-60)

Preconstruction Monitoring

The construction report lists the preconstruction requirements without confirming whether they were actually performed.

Construction Difficulties

Due to the deteriorating condition of the proposed 300501 control section, the Montana DOT proposed using the neighboring 307066 GPS section as a control. However, this GPS section was rehabilitated by removing the open-graded friction course (OGFC) and laying a 50-mm lift of HMA during the same period that the SPS sections were constructed. Therefore, a control section no longer existed.

Postconstruction Monitoring

The construction report lists the postconstruction requirements without confirming whether they were actually performed.

Data Completeness

Table 75 shows a summary of the key elements for the Montana SPS-5 project. It can be seen that layer thicknesses reported in the IMS were substantially larger than the design values for sections 300504 and 300506 through 300509.

Longitudinal profile monitoring was completed within 6 months before and after the application of treatments and every other year after the placement of overlay.

Deflection data were collected within 6 months before construction. The deflection data were collected within 6 months after construction for all the sections except section 300506. Deflection data were not collected at the required 2-year minimum frequency on any section after the application of treatment.

Distress surveys for the Montana SPS-5 project were collected within 6 months before construction and every 2 years after the construction of the overlays. The distress data were not collected within 6 months after construction.

Transverse profile data were collected within 6 months before the application of treatments. However, this monitoring was not performed within 6 months after or at the required long-term frequency after the treatments were applied.

Friction data were collected at a 2-year interval after the placement of the treatments. No friction data were collected within 6 months before construction of the overlays except for section 300506. No friction data were collected 6 months after construction.

There were zero days of WIM and 5 years of monitored traffic data. There were 3 years with more than 45 days of AVC per year, except for section 300501, which had 4 years with more than 45 days of AVC per year.

Table 76 shows a summary of the testing material data collected on the Montana SPS-5 project. It can be seen that the majority of the preconstruction testing had been completed. In addition, most of the available preconstruction data were at Level E in the IMS. The postconstruction testing data were almost complete with few exceptions. More than 90 percent of the available postconstruction data were at Level E.

Table 75. Key project information for the Montana SPS-5.

MONTANA SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	7.95	Construction Date:	9/12/91
Subgrade Type:	Coarse	Climatic Zone:	Dry-Freeze
Climatic Data Availability:	17 Years	Automated Vehicle Class:	930 Days
Construction Problems:	Control section overlaid. Paver hopper overloaded during placement of top lift. Malfunction of electronic grade control.	Weigh-In-Motion:	None

Site Key Information Summary:

	Overlay Thickness, mm			Milled		Original Pavement Structure				
ID	Design	Actual	Material	Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
7066	0	NA	–	0		124	76	Soil Agg	404	Soil Agg
502	51	66.0	RAP	0		112	71	Soil Agg	366	Soil Agg
503	127	116.8	RAP	0		119	109	Soil Agg	368	Soil Agg
504	127	142.2	Virgin	0		130	89	Soil Agg	396	Soil Agg
505	51	50.8	Virgin	0		122	71	Soil Agg	389	Soil Agg
506	51	106.7	Virgin	51		119	71	Soil Agg	389	Soil Agg
507	127	182.9	Virgin	51		112	89	Soil Agg	396	Soil Agg
508	127	180.3	RAP	51		112	109	Soil Agg	376	Soil Agg
509	51	114.3	RAP	51		119	97	Soil Agg	381	Soil Agg
560	127	NA	Modified	19		117	91	Soil Agg	366	Soil Agg
561	51	NA	Modified	19		117	91	Soil Agg	366	Soil Agg

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
7066	11	6	4	4	7	2	5	3
502	11	5	4	2	6	2	5	3
503	11	5	4	2	6	2	5	3
504	11	5	4	2	6	2	5	3
505	11	5	4	2	6	2	5	3
506	11	5	4	2	6	2	5	3
507	11	5	5	2	6	2	5	3
508	11	5	4	2	6	2	5	3
509	11	5	4	2	6	2	5	3
560	10	4	3	2	3	2	5	3
561	11	4	4	2	4	2	5	3

	IRI		Distress		Transverse	
ID	Pre	Post	Pre	Post	Pre	Post
7066	5/25/91	11/9/91	7/29/91	8/18/93	5/16/91	6/8/96
502	5/25/91	11/9/91	5/16/91	8/18/93	5/16/91	6/8/96
503	5/25/91	11/9/91	5/17/91	8/18/93	5/17/91	6/8/96
504	5/25/91	11/9/91	5/17/91	8/18/93	5/17/91	6/8/96
505	5/25/91	11/9/91	5/16/91	8/18/93	5/16/91	6/8/96
506	5/25/91	11/9/91	5/16/91	8/18/93	5/16/91	6/8/96
507	5/25/91	11/9/91	5/17/91	8/18/93	5/17/91	6/8/96
508	5/25/91	11/9/91	7/17/91	8/18/93	5/17/91	6/8/96
509	5/25/91	11/9/91	5/16/91	8/18/93	5/16/91	6/8/96
560	5/25/91	11/9/91	5/18/91	8/18/93	–	6/8/96
561	5/25/91	11/9/91	5/18/91	8/18/93	–	6/8/96

Table 76. Montana SPS-5 materials testing summary.

Montana SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	7	85.7
	Hydrometer Analysis	3	5	80.0
	Atterberg Limits	3	5	80.0
	Moisture-Density Relations	3	5	80.0
	Resilient Modulus	3	1	100.0
	Natural Moisture Content	3	15	80.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	5	80.0
	Atterberg Limits	3	4	75.0
	Moisture-Density Relations	3	4	75.0
	Resilient Modulus	3	0	0.0
	Permeability	3	0	0.0
	Natural Moisture Content	3	8	62.5
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	26	49	81.6
	Bulk Specific Gravity	9	17	82.4
	Maximum Specific Gravity	3	5	80.0
	Asphalt Content	3	5	80.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	5	80.0
	NAA Test for Fine Aggregate Particle Shape	3	2	100.0
	Penetration of Asphalt Cement	3	3	66.7
	Specific Gravity of Asphalt Cement	3	3	66.7
	Viscosity of Asphalt Cement	3	3	66.7
Montana SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	66	78.8
	Bulk Specific Gravity	40	28	100.0
	Maximum Specific Gravity	6	8	100.0
	Asphalt Content	6	8	100.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	5	100.0
	Bulk Specific Gravity, Coarse Aggregate	6	6	100.0
	Aggregate Gradation	6	8	100.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	6	100.0
	Penetration of Asphalt Cement	6	6	100.0
	Specific Gravity	6	6	100.0
	Viscosity of Asphalt Cement	6	6	100.0

NEW JERSEY

The New Jersey SPS-5 is in the wet-freeze environmental zone. The project is located on IH-194 in the westbound direction, east of Trenton, NJ. The original pavement was constructed on silty to clayey sand soil, and had about 267 mm of uncrushed gravel base above a variable-depth soil aggregate mixture subbase, and about 216 mm of AC surface.

New Jersey elected to extend its SPS-5 project by adding two supplemental test sections to study the performance of other rehabilitation treatments of interest. Each of these treatments is identified in table 77. All of these test sections had been monitored, and the data collected were available to the DOT for evaluation.

Table 77. New Jersey SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
340501	None	Control section
340502	Minimum	51 mm RAP overlay
340503	Minimum	127 mm RAP overlay
340504	Minimum	127 mm virgin overlay
340505	Minimum	51 mm virgin overlay
340506	Intensive	51 mm virgin overlay with milling
340507	Intensive	127 mm virgin overlay with milling
340508	Intensive	127 mm RAP overlay with milling
340509	Intensive	51 mm RAP overlay with milling
340559	Intensive	51 mm milling with 51 mm RAP overlay above 64 mm virgin mix binder
340560	Intensive	51 mm milling with 25 mm rubblized wearing course above a 64 mm virgin mix overlay

Notes: SHRP Sections (340501-09)
New Jersey DOT Sections (340559-60)

Preconstruction Monitoring

Materials sampling and testing were performed before construction.

Construction Difficulties

The original outside shoulder of section 340559 consisted of 51 mm of bituminous stabilized base course over a pit run gravel base. The 51-mm milling exposed some gravel areas (about 25 percent of the surface area). The milling of the driving lane extended 0.02 m into the outside shoulder. Therefore, the pavement's outside lane milled depths could not be measured. The milling machine also cut 51 to 102 mm into the passing lane's replacement layer. The milled pavement had a fine macro texture, whereas the milled shoulder had a coarse macro texture due to the large aggregate of the bituminous stabilized base course.

Aggregate fracturing was observed at the center longitudinal joint and the shoulder joint on both the binder course and the surface course overlay paving. This was caused by the overlap of the vibratory roller.

Postconstruction Monitoring

Quality control and data collection were performed on the same day the overlay was placed and then at two weeks after construction on either side of each test section.

Data Completeness

Table 78 shows a summary of the key elements for the New Jersey SPS-5 project. The layer thicknesses for sections 340502 through 340505 were smaller than the design values, whereas the layer thicknesses were substantially larger than the design values for sections 340506 through 340509.

Longitudinal profile monitoring was performed within 6 months after the overlay construction on all test sections. However, data for the first five sections were not collected within 6 months before construction. Longitudinal profile data had been collected in accordance with long-term frequency requirements with the exception of test section 340506.

Deflection data were collected within 6 months before the overlay construction on all test sections. With the exception of sections 340503 and 340507, no sections met either the postconstruction or the long-term data collection frequency requirements.

Both the distress survey and transverse profile data were collected within 6 months prior and every other year after construction, but no data were collected within 6 months after construction.

Friction data were collected within 6 months after and every other year after construction, but no data were collected within 6 months before construction.

There were 1,466 days of WIM and 5 years of monitored traffic data except for the first 3 sections, which had 1,491 days of WIM and 6 years of monitored traffic data. All sections had 5 years with more than 45 days of AVC data per year.

Table 79 summarizes the testing material data collected on the New Jersey SPS-5 project. The majority of the preconstruction testing had not been completed. Most of the available preconstruction data were at Level E in the IMS. Most of the postconstruction testing had been completed, and about 60 percent of the data were at Level E.

Table 78. Key project information for the New Jersey SPS-5.

NEW JERSEY SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	7.00	Construction Date:	8/21/92
Subgrade Type:	Coarse	Climatic Zone:	Wet-Freeze
Climatic Data Availability:	29 Years	Automated Vehicle Class:	1395 Days
Construction Problems:	Some areas of HMAC completely milled off. Aggregate fracture observed along center longitudinal joint.	Weigh-In-Motion:	1491 Days

Site Key Information Summary:

	Overlay Thickness, mm			Milled		Original Pavement Structure				
ID	Design	Actual	Material	Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	NA	–	0	NA	241	254	Gravel	1676	Soil Agg
502	51	48.3	RAP	0	NA	226	264	Gravel	1042	Soil Agg
503	127	119.4	RAP	0	NA	229	287	Gravel	559	Soil Agg
504	127	119.4	Virgin	0	NA	216	272	Gravel	533	Soil Agg
505	51	45.7	Virgin	0	NA	229	254	Gravel	508	Soil Agg
506	51	106.7	Virgin	51	53.8	241	254	Gravel	0	Soil Agg
507	127	198.1	Virgin	51	55.7	213	254	Gravel	1372	Soil Agg
508	127	198.1	RAP	51	55.3	231	287	Gravel	559	Soil Agg
509	51	109.2	RAP	51	63.7	241	287	Gravel	559	Soil Agg
559	115	NA	RAP	51	NA	218	267	Gravel	762	Soil Agg
560	89	NA	RAP	51	NA	216	267	Gravel	102	Soil Agg

Key monitoring data availability summary—Number of tests recorded in IMS to date

			Distress		Transverse			Adequacy
ID	IRI	FWD	Manual	Photographic	Profile	Friction	Traffic	Code
501	7	4	3	2	6	2	6	4
502	7	5	3	2	6	2	6	4
503	6	7	4	2	7	2	6	4
504	7	4	3	2	6	2	5	4
505	7	5	3	2	6	2	5	4
506	5	5	3	2	6	2	5	4
507	6	6	4	2	7	2	5	4
508	7	5	4	2	7	2	5	4
509	7	5	3	2	6	2	5	4
559	5	4	3	2	5	2	5	4
560	5	5	3	2	5	2	5	4

	IRI		Distress		Transverse	
ID	Pre	Post	Pre	Post	Pre	Post
501	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
502	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
503	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
504	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
505	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
506	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
507	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
508	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
509	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
559	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93
560	1/25/92	10/30/92	4/2/92	2/24/93	4/6/92	2/24/93

Table 79. New Jersey SPS-5 materials testing summary.

	Test	Minimum No. Per Layer	Number Conducted	Percent at Level E
New Jersey SPS-5 Materials Testing Summary—Preconstruction				
Subgrade:	Sieve Analysis	3	2	50.0
	Hydrometer Analysis	3	4	75.0
	Atterberg Limits	3	4	0.0
	Moisture-Density Relations	3	4	75.0
	Resilient Modulus	3	2	100.0
	Natural Moisture Content	3	0	0.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	2	100.0
	Atterberg Limits	3	4	0.0
	Moisture-Density Relations	3	4	75.0
	Resilient Modulus	3	0	0.0
	Permeability	3	0	0.0
	Natural Moisture Content	3	0	0.0
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	26	46	69.6
	Bulk Specific Gravity	9	19	73.7
	Maximum Specific Gravity	3	0	0.0
	Asphalt Content	3	0	0.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	0	0.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	0	0.0
	Specific Gravity of Asphalt Cement	3	0	0.0
	Viscosity of Asphalt Cement	3	0	0.0
New Jersey SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	178	56.2
	Bulk Specific Gravity	40	78	61.5
	Maximum Specific Gravity	6	9	66.7
	Asphalt Content	6	9	66.7
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity Fine Aggregate	6	9	66.7
	Bulk Specific Gravity Coarse Aggregate	6	9	44.5
	Aggregate Gradation	6	9	66.7
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	3	66.7
	Penetration of Asphalt Cement	6	3	33.3
	Specific Gravity	6	3	66.7
	Viscosity of Asphalt Cement	6	3	66.7

NEW MEXICO

The New Mexico SPS-5 is in the dry-no-freeze environmental zone. The project is located on IH-10 in the eastbound direction, between Lordsburg and Deming, NM. The original pavement was constructed on silty sand subgrade and had about 305 mm of sand granular base with approximately 241 mm of AC surface. Each of the New Mexico SPS-5 treatments is identified in table 80.

Table 80. New Mexico SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
350501	None	Control section, 51mm milling and 51mm inlay
350502	Minimum	51 mm RAP overlay
350503	Minimum	127 mm RAP overlay
350504	Minimum	127 mm virgin overlay
350505	Minimum	51 mm virgin overlay
350506	Intensive	51 mm virgin overlay with milling
350507	Intensive	127 mm virgin overlay with milling
350508	Intensive	127 mm RAP overlay with milling
350509	Intensive	51 mm RAP overlay with milling

Preconstruction Monitoring

Before rehabilitation, a manual surface distress survey was performed on each test section. The predominant distress found was low severity longitudinal cracking outside the wheel path. Deflection measurements were performed using the FWD. Materials sampling and testing were performed.

Construction Difficulties

There were some high air voids in the RAP mix, and oil was boosted to reduce this problem in time for the RAP overlay of sections 350508 and 350509. Section 350501 received a 51-mm cold mill and a 51-mm inlay; this section was supposed to be the control section with no treatments applied.

Postconstruction Monitoring

Postconstruction sampling and testing were performed the day after construction of each section. Coring was obtained from the approach and leave end of each test section, and sampling was conducted by the State’s subcontracted laboratory.

Data Completeness

Table 81 shows a summary of the key elements for the New Mexico SPS-5 project. It can be seen that layer thicknesses were not available in the IMS from the testing data.

Longitudinal profile monitoring was not performed 6 months before construction except for sections 350501, 350505, and 350506.

Deflection data were collected within 6 months before and after construction, and at a frequency of every 2 years afterwards.

Distress surveys for the New Mexico SPS-5 project were collected within 6 months before and every 2 years after the construction of the overlays. However, no surveys were taken within 6 months after the placement of the treatments.

Transverse profile data were not collected within 6 months before or after the application of treatments. However, these data were collected in accordance with long-term monitoring requirements.

The friction and the traffic data were unavailable for the New Mexico SPS-5 project.

Table 82 shows a summary of the testing material data collected on the New Mexico SPS-5 project. A majority of the preconstruction testing had not been completed. The available preconstruction data were all at Level E in the IMS. The postconstruction testing data were not available.

Table 81. Key project information for the New Mexico SPS-5.

NEW MEXICO SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	2.89	Construction Date:	9/17/96
Subgrade Type:	Coarse	Climatic Zone:	Dry-No-Freeze
Climatic Data Availability:	26 Years	Automated Vehicle Class:	None
Construction Problems:	Control section was milled and overlaid	Weigh-In-Motion:	None

Site Key Information Summary:

ID	Overlay Thickness, mm Design	Overlay Thickness, mm Actual	Material	Milled Design	Milled Actual	Original Pavement Structure: Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	NA	–	0	51					
502	51	NA	Rap	0	0					
503	127	NA	Rap	0	0					
504	127	NA	Virgin	0	0					
505	51	NA	Virgin	0	0					
506	51	NA	Virgin	51	54.2					
507	127	NA	Virgin	51	55.7					
508	127	NA	RAP	51	55.8					
509	51	NA	RAP	51	52.8					

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
501	2	2	2	0	2	0	0	1
502	1	2	2	0	2	0	0	1
503	1	3	2	0	2	0	0	1
504	1	2	2	0	2	0	0	1
505	2	2	0	2	2	0	0	1
506	2	2	2	0	2	0	0	1
507	1	2	2	0	2	0	0	1
508	1	2	2	0	2	0	0	1
509	1	2	2	0	2	0	0	1

ID	IRI Pre	IRI Post	Distress Pre	Distress Post	Transverse Pre	Transverse Post
501	8/31/96	3/9/97	5/30/96	1/6/99	5/30/96	1/6/99
502	–	3/9/97	5/30/96	1/6/99	5/30/96	3/19/99
503	–	3/9/97	5/30/96	1/6/99	5/30/96	1/6/99
504	–	3/9/97	5/30/96	1/6/99	5/30/96	1/6/99
505	8/31/96	3/9/97	5/30/96	1/6/99	5/30/96	1/6/99
506	8/31/96	3/9/97	5/30/96	1/6/99	5/30/96	1/6/99
507	–	3/9/97	5/30/96	1/6/99	5/30/96	1/6/99
508	–	3/9/97	5/30/96	1/6/99	5/30/96	3/6/99
509	–	3/9/97	5/30/96	1/6/99	5/30/96	3/19/99

Table 82. New Mexico SPS-5 material testing summary.

New Mexico SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	0	0.0
	Hydrometer Analysis	3	0	0.0
	Atterberg Limits	3	0	0.0
	Moisture-Density Relations	3	0	0.0
	Resilient Modulus	3	0	0.0
	Natural Moisture Content	3	0	0.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	0	0.0
	Atterberg Limits	3	0	0.0
	Moisture-Density Relations	3	0	0.0
	Resilient Modulus	3	0	0.0
	Permeability	3	0	0.0
	Natural Moisture Content	3	0	0.0
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	26	0	0.0
	Bulk Specific Gravity	12	0	0.0
	Maximum Specific Gravity	3	7	100.0
	Asphalt Content	3	7	100.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	13	100.0
	Aggregate Gradation	3	6	100.0
	NAA Test for Fine Aggregate Particle Shape	3	6	100.0
	Penetration of Asphalt Cement	3	6	100.0
	Specific Gravity of Asphalt Cement	3	6	100.0
	Viscosity of Asphalt Cement	3	6	100.0
New Mexico SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	0	0.0
	Bulk Specific Gravity	40	0	0.0
	Maximum Specific Gravity	6	0	0.0
	Asphalt Content	6	0	0.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	12	0	0.0
	Tensile Strength	16	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	0	0.0
	Bulk Specific Gravity, Coarse Aggregate	6	0	0.0
	Aggregate Gradation	6	0	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	0	0.0
	Specific Gravity	6	0	0.0
	Viscosity of Asphalt Cement	6	0	0.0

OKLAHOMA

The Oklahoma SPS-5 is in the wet-no-freeze environmental zone. The project is located on U.S. 62 in the westbound direction, near Lawton, OK. The original pavement was constructed on sandy clay subgrade, and had about 203 mm of HMAC base and about 114 mm of AC surface. The treatment sections are detailed in table 83. The State agency opted to incorporate one supplemental section.

Table 83. Oklahoma SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
400501	None	Control section
400502	Minimum	51 mm RAP overlay
400503	Minimum	127 mm RAP overlay
400504	Minimum	127 mm virgin overlay
400505	Minimum	51 mm virgin overlay
400506	Intensive	51 mm virgin overlay with milling
400507	Intensive	127 mm virgin overlay with milling
400508	Intensive	127 mm RAP overlay with milling
400509	Intensive	51 mm RAP overlay with milling
400560	Mill/inlay	89 mm virgin overlay

Preconstruction Monitoring

Before rehabilitation, a manual distress survey was performed on each test section. The predominant distresses found were bleeding in the wheel paths and moderate severity transverse cracking. Deflection measurements were performed using the FWD to evaluate structural capacity. Profilometer measurements were taken both inside and outside wheel paths. Materials sampling also was performed.

Construction Difficulties

No major problems were encountered during construction, except that the initial batch of recycled mix laid on the test strip contained too much asphalt cement.

Postconstruction Monitoring

Following the completion of construction, monitoring activities similar to those performed before construction were initiated.

Data Completeness

Table 84 shows a summary of the key elements for the Oklahoma SPS-5 project. The layer thicknesses were not available in the IMS from the testing data.

Monitoring data collection was required within 6 months before and after construction, and then the data were to be collected every other year.

The longitudinal and transverse profile data collection did not meet the postconstruction requirement.

Both the FWD and distress data were collected and met the frequency requirements.

The friction data collection did not meet the preconstruction requirement.

No traffic data were available.

Table 85 summarizes the material testing performed on the Oklahoma SPS-5 project. The majority of both the preconstruction and postconstruction testing had not been completed. All the available testing data were at Level E.

Table 84. Key project information for the Oklahoma SPS-5.

OKLAHOMA SPS-5 PROJECT SUMMARY

Age as of Aug 1999:	2.06	Construction Date:	7/16/97
Subgrade Type:	Fine	Climatic Zone:	Wet-No-Freeze
Climatic Data Availability:	24 Years	Automated Vehicle Class:	None
Construction Problems:		Weigh-In-Motion:	None

Site Key Information Summary:

	Overlay Thickness, mm			Milled		Original Pavement Structure				
ID	Design	Actual	Material	Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0		–	0						
502	51		Rap	0						
503	127		Rap	0						
504	127		Virgin	0						
505	51		Virgin	0						
506	51		Virgin	51						
507	127		Virgin	51						
508	127		RAP	51						
509	51		RAP	51						
560	89		NA	51						

Key monitoring data availability summary—Number of tests recorded in IMS to date

			Distress		Transverse			Adequacy
ID	IRI	FWD	Manual	Photographic	Profile	Friction	Traffic	Code
501	2	3	2	0	1	1	0	1
502	2	3	2	0	1	1	0	1
503	2	3	2	0	1	1	0	1
504	2	3	2	0	1	1	0	1
505	2	3	2	0	1	1	0	1
506	2	3	2	0	1	1	0	1
507	2	3	2	0	1	1	0	1
508	2	3	2	0	1	1	0	1
509	2	3	2	0	1	1	0	1
560	1	3	2	0	0	1	0	1

	IRI		Distress		Transverse	
ID	Pre	Post	Pre	Post	Pre	Post
501	6/4/97	1/14/98	6/16/97	7/22/97	6/16/97	–
502	6/4/97	1/14/98	6/16/97	7/22/97	6/16/97	–
503	6/4/97	1/14/98	6/16/97	7/22/97	6/17/97	–
504	6/4/97	1/14/98	6/17/97	7/23/97	6/17/97	–
505	6/4/97	1/14/98	6/17/97	7/23/97	6/17/97	–
506	6/4/97	1/14/98	6/17/97	7/23/97	6/17/97	–
507	6/4/97	1/14/98	6/17/97	7/23/97	6/17/97	–
508	6/4/97	1/14/98	6/16/97	7/22/97	6/17/97	–
509	6/4/97	1/14/98	6/17/97	7/23/97	6/17/97	–
560	–	1/14/98	6/17/97	7/23/97	–	–

Table 85. Oklahoma SPS-5 materials testing summary.

Oklahoma SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	0	0.0
	Hydrometer Analysis	3	0	0.0
	Atterberg Limits	3	0	0.0
	Moisture-Density Relations	3	0	0.0
	Resilient Modulus	3	0	0.0
	Natural Moisture Content	3	0	0.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	0	0	0.0
	Atterberg Limits	0	0	0.0
	Moisture-Density Relations	0	0	0.0
	Resilient Modulus	0	0	0.0
	Permeability	0	0	0.0
	Natural Moisture Content	0	0	0.0
Bound Base:	Classification	3	0	0.0
Asphalt Surface:	Core Examination	28	31	0.0
	Bulk Specific Gravity	12	2	0.0
	Maximum Specific Gravity	3	7	100.0
	Asphalt Content	3	7	100.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	7	100.0
	NAA Test for Fine Aggregate Particle Shape	3	6	100.0
	Penetration of Asphalt Cement	3	7	100.0
	Specific Gravity of Asphalt Cement	3	7	100.0
	Viscosity of Asphalt Cement	3	7	100.0
Oklahoma SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	44	38	0.0
	Bulk Specific Gravity	44	11	0.0
	Maximum Specific Gravity	6	3	100.0
	Asphalt Content	6	10	0.0
	Moisture Susceptibility	6	6	100.0
	Resilient Modulus	12	0	0.0
	Tensile Strength	16	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	6	0.0
	Bulk Specific Gravity, Coarse Aggregate	6	6	0.0
	Aggregate Gradation	6	6	0.0
	NAA Test for Fine Aggregate Particle Shape	6	6	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	5	0.0
	Specific Gravity	6	6	0.0
	Viscosity of Asphalt Cement	6	6	0.0

TEXAS

The Texas SPS-5 project is in the wet-no-freeze environmental zone, but is only about 20 miles east of IH-35, which is the boundary established between the dry-no-freeze and wet-no-freeze environmental zones. This project is located on U.S. 175 in Kaufman County. The original pavement was placed on a fat clay subgrade, had 152 mm to 203 mm of lime-treated subgrade as a subbase, and 203 mm to 356 mm of crushed stone treated with 3 percent of lime, and 218 mm to 244 mm of AC. The treated base "set up" sufficiently that it could be cored; therefore, it represents a relatively stiff base course.

There are two nearby control sections for this project. One is the GPS-1 test section 481069 and the other is the control section for the Maintenance Effectiveness Study (SPS-3), 48B340. As these are adjacent to the SPS-5 project, no specific test section was designated as 48A501. GPS-1 test sections can have specific maintenance treatments under certain circumstances, while an SPS-3 project control section can have none, so there is some additional contrast available from the two control sections. The treatment sections for the SPS-5 sections in Texas are shown in table 86.

Table 86. Texas SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
481069	None	Control section
48A502	Minimum	51 mm RAP overlay
48A503	Minimum	127 mm RAP overlay
48A504	Minimum	127 mm virgin overlay
48A505	Minimum	51 mm virgin overlay
48A506	Intensive	51 mm virgin overlay with milling
48A507	Intensive	127 mm virgin overlay with milling
48A508	Intensive	127 mm RAP overlay with milling
48A509	Intensive	51 mm RAP overlay with milling

Note: Section 481069 is a substitute for 48A501.

Preconstruction Monitoring

Before rehabilitation, pavement surface distress was collected by a photographic distress survey. The predominant distresses found were longitudinal and transverse cracking. Deflection measurements were performed using the FWD to evaluate structural capacity. Profilometer measurements were taken at 150-mm increments on the travel lane for each section. Materials sampling and testing also were performed.

Construction Difficulties

The overlay construction was delayed due to a combination of rain, mix design problems, and delays in the receipt of plant parts.

Postconstruction Monitoring

Postconstruction monitoring activities were identical to those conducted before the treatment applications. These activities include pavement surface distress survey, surface profile, structural capacity, and materials sampling and testing.

Data Completeness

Table 87 shows a summary of the key elements for the Texas SPS-5 project. The layer thicknesses reported in the IMS were substantially larger than the design values for sections 48A506 through 48A509.

Longitudinal profile monitoring was performed every other year after construction on all test sections. Sections 48A502 through 48A505 did not meet the preconstruction requirement. Control section 481069 did not meet either the preconstruction or the postconstruction requirement.

Deflection data were collected within 6 months before construction on all sections except the control section. For the postconstruction requirement, deflection data were collected only on test sections 48A502 through 48A505. Only the control section had met the long-term collection requirement.

No distress data were collected within 6 months before construction on all sections. Data were collected only on the control section within 6 months after construction. The long-term data-collection requirement was met for all test sections.

Transverse profile data were collected within 6 months before construction on sections 48A506 through 48A509 only. Data were collected within 6 months after construction on all sections except sections 48A508 and 48A509. The long-term data-collection requirement was not met for all test sections.

None of the friction data collection requirements were met for all test sections except the control section, for which data were collected within 6 months after construction.

There were 7 days of WIM and 7 years' worth of monitored traffic data except for the control section, which had 8 years' worth of monitored data. There were 6 years with more than 45 days of AVC per year for all sections except the control section, which had 1 more year than the other sections.

Table 88 shows a summary of the materials testing data collected for the Texas SPS-5 project. All of the preconstruction testing had been completed and the data were all at Level E in the

IMS. About 50 percent of the postconstruction testing had been completed and the data were at Level E.

Table 87. Key project information for the Texas SPS-5.

TEXAS SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	7.84	Construction Date:	10/21/91
Subgrade Type:	Fine	Climatic Zone:	Wet-No-Freeze
Climatic Data Availability:	20 Years	Automated Vehicle Class:	385 Days
Construction Problems:	Weather and production plant delays.	Weigh-In-Motion:	7 Days

Site Key Information Summary:

ID	Overlay Thickness, mm Design	Overlay Thickness, mm Actual	Material	Milled Design	Milled Actual	Original Pavement Structure: Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
1069	0	0	–	0	0	241	386	LTB*	165	LTS
A502	51	55.4	Rap	0	0	231	376	LTB	203	LTS
A503	127	134.6	Rap	0	0	239	254	LTB	203	LTS
A504	127	134.6	Virgin	0	0	221	269	LTB	203	LTS
A505	51	50.8	Virgin	0	0	244	224	LTB	147	LTS
A506	51	99.1	Virgin	51	56.5	229	224	LTB	147	LTS
A507	127	17.8	Virgin	51	55.3	229	224	LTB	147	LTS
A508	127	185.4	RAP	51	52.6	244	356	LTB	203	LTS
A509	51	109.2	RAP	51	46.9	226	376	LTB	203	LTS

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
1069	5	4	6	6	9	7	8	5
A502	5	6	3	2	5	5	7	5
A503	5	5	3	2	5	4	7	5
A504	5	5	3	2	5	4	7	5
A505	5	5	3	2	5	4	7	5
A506	5	5	3	2	5	4	7	5
A507	5	5	3	2	5	4	7	5
A508	5	5	3	2	5	4	7	5
A509	5	6	3	2	5	4	7	5

ID	IRI Pre	IRI Post	Distress Pre	Distress Post	Transverse Pre	Transverse Post
1069	3/18/91	2/11/93	7/17/91	1/28/92	7/17/91	1/28/92
A502	3/19/91	1/20/92	–	3/3/93	3/10/91	1/28/92
A503	3/19/91	1/21/92	–	3/3/93	3/10/91	1/28/92
A504	3/19/91	1/21/92	–	3/3/93	3/10/91	1/28/92
A505	3/20/91	1/22/91	–	3/3/93	3/10/91	1/28/92
A506	3/19/91	1/21/92	–	3/3/93	3/10/91	1/28/92
A507	3/19/91	1/21/92	–	3/3/93	3/10/91	1/28/92
A508	3/19/91	1/20/92	–	3/3/93	3/10/91	1/28/92
A509	3/19/91	1/20/92	–	3/3/93	3/10/91	1/28/92

* LTB—lime-treated base

Table 88. Texas SPS-5 materials testing summary.

Texas SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	5	100.0
	Hydrometer Analysis	3	5	100.0
	Atterberg Limits	3	5	100.0
	Moisture-Density Relations	3	5	100.0
	Resilient Modulus	3	3	100.0
	Natural Moisture Content	3	6	100.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	0	0	0.0
	Atterberg Limits	0	0	0.0
	Moisture-Density Relations	0	0	0.0
	Resilient Modulus	0	0	0.0
	Permeability	0	0	0.0
	Natural Moisture Content	0	0	0.0
Bound Base:	Classification	3	4	100.0
Asphalt Surface:	Core Examination	31	54	100.0
	Bulk Specific Gravity	9	14	100.0
	Maximum Specific Gravity	3	5	100.0
	Asphalt Content	3	5	100.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	5	100.0
	NAA Test for Fine Aggregate Particle Shape	3	2	100.0
	Penetration of Asphalt Cement	3	3	100.0
	Specific Gravity of Asphalt Cement	3	3	100.0
	Viscosity of Asphalt Cement	3	3	100.0
Texas SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	36	37	100.0
	Bulk Specific Gravity	36	34	100.0
	Maximum Specific Gravity	6	3	100.0
	Asphalt Content	6	3	100.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	6	100.0
	Bulk Specific Gravity, Coarse Aggregate	6	6	100.0
	Aggregate Gradation	6	6	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	3	100.0
	Penetration of Asphalt Cement	6	3	100.0
	Specific Gravity	6	3	100.0
	Viscosity of Asphalt Cement	6	3	100.0

ALBERTA

The Alberta SPS-5 is in the wet-freeze environmental zone. The project is located on Trans-Canada Highway 16 in the westbound direction, near Edson, Alberta. The original pavement was constructed on sandy clay subgrade and had about 152 mm of gravel subbase, about 89 mm of crushed stone base, and approximately 200 mm of AC surface. The treatment sections are shown in table 89.

Table 89. Alberta SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
810501	None	Control section
810502	Minimum	51 mm RAP overlay
810503	Minimum	127 mm RAP overlay
810504	Minimum	127 mm virgin overlay
810505	Minimum	51 mm virgin overlay
810506	Intensive	51 mm virgin overlay with milling
810507	Intensive	127 mm virgin overlay with milling
810508	Intensive	127 mm RAP overlay with milling
810509	Intensive	51 mm RAP overlay with milling

Preconstruction Monitoring

Before rehabilitation, materials sampling and testing were performed.

Construction Difficulties

Overall, the construction was completed without any major problems. A few minor problems were noted. Some problems with tack coat bubbling through surface course lift on the SHRP lane was encountered on section 810502. Near the middle of section 810505 on the SHRP lane, one of the pneumatic rollers spun its wheels, leaving a slight depression. On the SHRP lane of section 810509, the inlay that overlaps the shoulder had a 4.6-m crack that was 25 mm wide, centered at station 0+25.

Postconstruction Monitoring

Material sampling and testing were performed after construction. In addition, a distress survey was performed 7 months after construction.

Data Completeness

Table 90 summarizes the key elements for the Alberta SPS-5 project. The layer thicknesses reported in the IMS were substantially larger than the design values for sections 810506 through 810509. The layer thickness for section 810505 was not available.

Longitudinal profile monitoring was completed within 6 months before and after construction, and then every other year after construction on all test sections.

Deflection data were collected within 6 months before and after construction and then every other year after construction on all test sections except section 810502, which did not meet the postconstruction requirement.

Distress data were collected within 6 months before construction and then every other year on all test sections. However, no data were collected within 6 months after construction on all sections.

Transverse profile data collection did not meet any of the frequency requirements.

None of the friction data collection requirements was met for all test sections except the control section, which had data collected every other year after construction.

Traffic data were not available for the Alberta SPS-5 project.

Table 91 summarizes the testing material data collected for the Alberta SPS-5 project. Most of the preconstruction testing had been completed, and almost all the data were at Level E in the IMS. The majority of the postconstruction testing had been completed, and the data were at Level E.

Table 90. Key project information for the Alberta SPS-5.

ALBERTA SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	8.88	Construction Date:	10/10/90
Subgrade Type:	Coarse	Climatic Zone:	Wet-Freeze
Climatic Data Availability:	57 Years	Automated Vehicle Class:	None
Construction Problems:	Tack coat bubbling through surface course lift on 810502.	Weigh-In-Motion:	None

Site Key Information Summary:

ID	Overlay Thickness, mm		Material	Milled		Original Pavement Structure				
	Design	Actual		Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	0	–	0		160	74	ATB	295	Soil Agg
502	51	53.3	Rap	0		132	0	ATB	381	Soil Agg
503	127	127.0	Rap	0		157	76	ATB	328	Soil Agg
504	127	121.9	Virgin	0		160	30	ATB	279	Soil Agg
505	51	NA	Virgin	0		152	64	ATB	295	Soil Agg
506	51	94.0	Virgin	51		152	46	ATB	330	Soil Agg
507	127	162.6	Virgin	51		157	41	ATB	330	Soil Agg
508	127	177.8	RAP	51		163	0	ATB	378	Soil Agg
509	51	83.8	RAP	51		175	0	ATB	343	Soil Agg

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress		Transverse Profile	Friction	Traffic	Adequacy Code
			Manual	Photographic				
501	10	5	5	3	5	2	0	3
502	10	4	5	3	5	2	0	3
503	10	5	5	3	5	2	0	3
504	10	5	5	3	5	2	0	3
505	10	5	5	3	5	2	0	3
506	10	5	5	3	5	2	0	3
507	10	5	5	3	5	2	0	3
508	10	5	5	3	5	2	0	3
509	10	6	5	3	5	2	0	3

ID	IRI		Distress		Transverse	
	Pre	Post	Pre	Post	Pre	Post
501	5/12/90	10/15/90	5/17/90	5/7/91	–	6/26/91
502	5/12/90	10/15/90	5/17/90	5/8/91	–	6/26/91
503	5/12/90	10/15/90	5/17/90	5/8/91	–	6/26/91
504	5/12/90	10/15/90	5/17/90	5/8/91	–	6/26/91
505	5/12/90	10/15/90	5/17/90	5/7/91	–	6/26/91
506	5/12/90	10/15/90	5/17/90	5/7/91	–	6/26/91
507	5/12/90	10/15/90	5/17/90	5/7/91	–	6/26/91
508	5/12/90	10/15/90	5/17/90	5/8/91	–	6/26/91
509	5/12/90	10/15/90	5/17/90	5/8/91	–	6/26/91

Table 91. Alberta SPS-5 materials testing summary.

Alberta SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	3	100.0
	Hydrometer Analysis	3	3	100.0
	Atterberg Limits	3	3	100.0
	Moisture-Density Relations	3	3	100.0
	Resilient Modulus	3	2	0.0
	Natural Moisture Content	3	7	100.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	0	0	0.0
	Atterberg Limits	0	0	0.0
	Moisture-Density Relations	0	0	0.0
	Resilient Modulus	0	0	0.0
	Permeability	0	0	0.0
	Natural Moisture Content	0	0	0.0
Bound Base:	Classification	3	3	100.0
Asphalt Surface:	Core Examination	26	26	100.0
	Bulk Specific Gravity	9	9	100.0
	Maximum Specific Gravity	3	3	100.0
	Asphalt Content	3	3	100.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	3	100.0
	NAA Test for Fine Aggregate Particle Shape	3	0	0.0
	Penetration of Asphalt Cement	3	3	100.0
	Specific Gravity of Asphalt Cement	3	3	100.0
	Viscosity of Asphalt Cement	3	3	100.0
Alberta SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	40	100.0
	Bulk Specific Gravity	40	40	100.0
	Maximum Specific Gravity	6	6	100.0
	Asphalt Content	6	6	100.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	6	100.0
	Bulk Specific Gravity, Coarse Aggregate	6	6	100.0
	Aggregate Gradation	6	6	100.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	6	100.0
	Penetration of Asphalt Cement	6	6	100.0
	Specific Gravity	6	6	100.0
	Viscosity of Asphalt Cement	6	6	100.0

MANITOBA

The Manitoba SPS-5 is in the wet-freeze environmental zone. The project is located on Trans-Canada Highway 1 in the westbound direction, 80 km east of Winnipeg. The original pavement was constructed on sandy silt subgrade and had about 229 mm of crushed stone subbase, about 102 mm of crushed stone base, and about 102 mm of AC surface. The details of the structure are shown in table 92.

Table 92. Manitoba SPS-5 test section layout.

SECTION NO.	SURFACE PREPARATION	OVERLAY MATERIAL AND THICKNESS
810501	None	Control section, 51 mm recycled asphalt pavement (rap) overlay
810502	Minimum	51 mm RAP overlay
810503	Minimum	127 mm RAP overlay
810504	Minimum	127 mm virgin overlay
810505	Minimum	51 mm virgin overlay
810506	Intensive	51 mm virgin overlay with milling
810507	Intensive	127 mm virgin overlay with milling
810508	Intensive	127 mm RAP overlay with milling
810509	Intensive	51 mm RAP overlay with milling

Preconstruction Monitoring

Before rehabilitation, measurements for the FWD, profile, and distress were taken. Materials sampling and testing were also performed.

Construction Difficulties

The project contractor did not have any recycling experience.

The guidelines were still being developed during construction, causing significant construction deviations. The field sampling data were not collected in accordance with the updated guidelines.

The Manitoba SPS-5 project was nominated as a fine-grained subgrade classification. Laboratory test results suggested a coarse-grained soil instead.

The addition of a centerline crown and the milling operation may have caused the overlay thicknesses to vary by more than 25 mm on some test sections. Additional full-depth cores were taken by personnel from Manitoba Highways and Transportation to document the possible variation, but these did not answer all the questions on the asphalt thickness.

Postconstruction Monitoring

The same monitoring activities as those conducted during the preconstruction monitoring were performed. Material sampling and testing were performed after construction.

Data Completeness

Table 93 summarizes the key elements for the Manitoba SPS-5 project. The layer thicknesses reported in the IMS were substantially larger than the design values for sections 830506 through 830509. The layer thickness for section 830505 was not available.

Longitudinal profile monitoring was not performed within 6 months before construction, but data were collected within 6 months and then every other year after construction on all test sections.

Deflection data were collected within 6 months before and after construction and then every other year after construction on all test sections.

Distress data were collected within 6 months before construction and then every other year on all test sections. However, no data were collected within 6 months after construction on all sections.

Transverse profile data collection was not completed within 6 months before or after construction. Data were collected every other year after construction except for the control section.

Friction data collection was performed within 6 months before construction except for section 830509. Data were not collected within 6 months after construction, but data were collected every other year after construction.

Traffic data were available for all sections of this project. There were 0 days of WIM and 1 year of monitored traffic data with more than 45 days of AVC per year.

Table 94 summarizes the materials testing data collected for the Manitoba SPS-5 project. A majority of the preconstruction testing and almost all of the postconstruction testing was incomplete. Most of the available data were at Level E in the IMS.

Table 93. Key project information for the Manitoba SPS-5.

MANITOBA SPS-5 PROJECT SUMMARY			
Age as of Aug 1999:	9.96	Construction Date:	9/13/89
Subgrade Type:	Fine-Coarse	Climatic Zone:	Wet-Freeze
Climatic Data Availability:	26 Years	Automated Vehicle Class:	None
Construction Problems:	Entrance to gravel mining operation located in the middle of the project.	Weigh-In-Motion:	None

Site Key Information Summary:

ID	Overlay Thickness, mm			Milled		Original Pavement Structure				
	Design	Actual	Material	Design	Actual	Surface Thickness, mm	Base Thickness, mm	Base Type	Subbase Thickness, mm	Subbase Type
501	0	0	–	0		119	130	Gravel	127	Gravel
502	51	68.6	Rap	0		107	127	Gravel	102	Gravel
503	127	124.5	Rap	0		107	178	Gravel	127	Gravel
504	127	142.2	Virgin	0		97	130	Gravel	127	Gravel
505	51	78.7	Virgin	0		122	130	Gravel	127	Gravel
506	51	81.3	Virgin	51		137	89	Gravel	254	Gravel
507	127	165.1	Virgin	51		119	89	Gravel	254	Gravel
508	127	165.1	RAP	51		102	175	Gravel	127	Gravel
509	51	94.0	RAP	51		132	175	Gravel	127	Gravel

Key monitoring data availability summary—Number of tests recorded in IMS to date

ID	IRI	FWD	Distress Manual	Distress Photographic	Transverse Profile	Friction	Traffic	Adequacy Code
501	8	7	6	3	5	4	1	2
502	9	7	6	3	6	4	1	2
503	9	7	6	3	6	4	0	2
504	9	7	6	3	6	4	0	2
505	9	7	6	3	5	4	0	2
506	9	7	7	3	6	4	0	2
507	8	7	5	3	5	4	0	2
508	9	7	6	3	6	4	0	2
509	10	7	6	3	5	3	0	2

ID	IRI Pre	IRI Post	Distress Pre	Distress Post	Transverse Pre	Transverse Post
501	–	10/18/89	5/19/89	5/25/90	–	7/12/92
502	–	10/19/89	5/19/89	5/25/90	–	7/21/92
503	–	10/19/89	5/19/89	5/25/90	–	7/21/92
504	–	10/20/89	5/19/89	5/25/90	–	7/21/92
505	–	10/20/89	5/19/89	5/25/90	–	7/21/92
506	–	10/19/89	8/22/89	5/25/90	–	7/21/92
507	–	10/20/89	8/22/89	5/25/90	–	7/21/92
508	–	10/19/89	8/22/89	5/25/90	–	7/21/92
509	–	10/19/89	8/22/89	5/25/90	–	7/21/92

Table 94. Manitoba SPS-5 materials testing summary.

Manitoba SPS-5 Materials Testing Summary—Preconstruction				
	Test	**Minimum No. Per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:	Sieve Analysis	3	5	80.0
	Hydrometer Analysis	3	5	100.0
	Atterberg Limits	3	0	0.0
	Moisture-Density Relations	3	5	100.0
	Resilient Modulus	3	0	0.0
	Natural Moisture Content	3	5	80.0
	Permeability	0	0	0.0
Unbound Base:	Sieve Analysis	3	5	100.0
	Atterberg Limits	3	5	100.0
	Moisture-Density Relations	3	6	100.0
	Resilient Modulus	3	0	0.0
	Permeability	3	0	0.0
	Natural Moisture Content	3	5	100.0
Bound Base:	Classification	0	0	0.0
Asphalt Surface:	Core Examination	26	0	0.0
	Bulk Specific Gravity	9	0	0.0
	Maximum Specific Gravity	3	0	0.0
	Asphalt Content	3	0	0.0
	Moisture Susceptibility	0	0	0.0
	Specific Gravity of Aggregate	0	0	0.0
	Aggregate Gradation	3	0	0.0
	NAA Test for Fine Aggregate Particle Shape	3	2	100.0
	Penetration of Asphalt Cement	3	0	0.0
	Specific Gravity of Asphalt Cement	3	0	0.0
	Viscosity of Asphalt Cement	3	0	0.0
Manitoba SPS-5 Materials Testing Summary—Postconstruction				
Asphalt Concrete:	Core Examination	40	52	100.0
	Bulk Specific Gravity	40	52	0.0
	Maximum Specific Gravity	6	0	0.0
	Asphalt Content	6	0	0.0
	Moisture Susceptibility	6	0	0.0
	Resilient Modulus	6	0	0.0
	Tensile Strength	18	0	0.0
Extracted Aggregate:	Bulk Specific Gravity, Fine Aggregate	6	0	0.0
	Bulk Specific Gravity, Coarse Aggregate	6	0	0.0
	Aggregate Gradation	6	0	0.0
	NAA Test for Fine Aggregate Particle Shape	6	0	0.0
Asphalt Cement:	Abson Recovery	6	0	0.0
	Penetration of Asphalt Cement	6	0	0.0
	Specific Gravity	6	0	0.0
	Viscosity of Asphalt Cement	6	0	0.0

APPENDIX B. CONSTRUCTION DATA SUMMARY

Appendix B contains a summary of the construction data available for each project as of the approximate time of this report, which was 1999-2000. Thickness data were from three sources. The first source was the **TST_L05B** table, which contained the values most representative of the material that was actually placed on the test section and the pre-existing pavement structure. The second was the **SPS5_LAYER** table, which included thicknesses that should be the same as those provided in the **TST_L05B** table. However, in most of the data shown, these thicknesses were not the same. The third source was the **SPS5_LAYER_ THICKNESS** table. These data were obtained from elevation measurements taken on the projects after the placement of each layer of overlay.

Table 95. Summary of construction data for Alabama.

Alabama (1)	501	502	503	504	505	506	507	508	509	563	564
Required Thickness											
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51		
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50		
L05B Thickness											
AC OVERLAY (mm)											
MILLING (mm)											
SPS Construction Thickness											
AC OVERLAY (mm)		33	102	112	36	76	142	145	81	36	28
Rod & Level											
AC OVERLAY (mm)		33	100	110	35	52	123	114	45		30
MILLING (mm)						25	18	29	35	36	
Rod & Level Std Dev											
AC OVERLAY (mm)		8	9	10	9	6	7	4	5		7
MILLING (mm)						7	7	5	8	6	
Rod & Level Min											
AC OVERLAY (mm)		18	84	89	18	41	104	104	33		15
MILLING (mm)						10	3	20	18	18	
Rod & Level Max											
AC OVERLAY (mm)		51	127	137	56	64	137	122	58		51
MILLING (mm)						43	30	41	56	48	
MILLING (mm)						42	32	23	25	33	30
Lift Thicknesses											
Maximum Lift Thickness <= 75 mm		41	64	76	43	64	89	79	56	46	38
AC Material Requirements											
Hveem Stability (minimum 37)											
Air Voids 3-5 %		3.9	4.2	3.6	3.6	3.6	3.6	4.2	4.2	3.6	3.9
Virgin Mix											
Aggregate Pass #4 <40%											
RAP											
TOTAL AC											
NEW AC											
%AC OF SALVAGED MIX											
% NEW AGG. MATERIAL											
% RAP											
New Aggregate											
Aggregate Pass #4 <40%											

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 96. Summary of construction data for Arizona.

Arizona (4)	501	502	503	504	505	506	507	508	509	559	560
Required Thickness											
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51		
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50		
L05B Thickness											
AC OVERLAY (mm)		69	119	122	71	132	173	165	99	152	56
MILLING (mm)		23	20	18	23	48	66	69	71	86	23
SPS Construction Thickness											
AC OVERLAY (mm)		69	119	122	71	43	104	104	38	76	56
Rod & Level											
AC OVERLAY (mm)											
MILLING (mm)											
Rod & Level Std Dev											
AC OVERLAY (mm)											
MILLING (mm)											
Rod & Level Min											
AC OVERLAY (mm)											
MILLING (mm)											
Rod & Level Max											
AC OVERLAY (mm)											
MILLING (mm)											
MILLING (mm)		27	18	27	33	72	69	69	64	99	25
Lift Thicknesses											
Maximum Lift Thickness <= 75 mm		64	76	74	74	74	81	76	71	109	66
AC Material Requirements											
Hveem Stability (minimum 37)											
Air Voids 3-5 %											
Virgin Mix											
Aggregate Pass #4 <40%		64			57						
RAP											
TOTAL AC											
NEW AC											
%AC OF SALVAGED MIX											
% NEW AGG. MATERIAL											
% RAP											
New Aggregate											
Aggregate Pass #4 <40%		53	53					53	53	53	

Note: The number after the state name is the state's numeric code in the LTPP date base.

Table 97. Summary of construction data for California.

California (6)	501	502	503	504	505	506	507	508	509	559	560	561	562	563	564	565	566	567	568	569	570	571
Required Thickness																						
AC OVERLAY(mm)	0	51	127	127	51	51	127	127	51													
MILLING(mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50													
L05B Thickness																						
AC OVERLAY(mm)	46	76	165	145	91	109	170	168	112	203	109	107	112	102	109	109	109	102	152	183	183	248
MILLING(mm)		30	36	36	30	43	48	46	51	76	58	58	53	58	66	53	53	56	58	66	91	91
SPS Construction Thickness																						
AC OVERLAY(mm)	46	76	165	145	91	109	170	114	112	152	109	107	107	102	102	109	109	102	152	183	183	244
Rod & Level																						
AC OVERLAY(mm)																						
MILLING(mm)																						
Rod & Level Std Dev																						
AC OVERLAY(mm)																						
MILLING(mm)																						
Rod & Level Min																						
AC OVERLAY(mm)																						
MILLING(mm)																						
Rod & Level Max																						
AC OVERLAY(mm)																						
MILLING(mm)																						
MILLING(mm)																						
Lift Thicknesses																						
Maximum Lift Thickness <= 75 mm	64	69	107	102	71	81	69	74	71	122	0	71	71	81	89	74	76	71	157	53	51	46
AC Material Requirements																						
Hveem Stability (minimum 37)																						
Air Voids 3-5 %																						
Virgin Mix																						
Aggregate Pass #4<40%																						
RAP																						
TOTAL AC																						
NEW AC																						
%AC OF SALVAGED MIX																						
% NEW AGG. MATERIAL																						
% RAP																						
New Aggregate																						
Aggregate Pass #4 <40%	48	48	48					48														

Note: The number after the state name is the state's numeric code in the LTPP date base.

Table 98. Summary of construction data for Colorado.

Colorado (8)	501	502	503	504	505	506	507	508	509	559	560
Required Thickness											
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51		
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50		
L05B Thickness											
AC OVERLAY (mm)	33	97	137	147	81	112	173	201	107	168	155
MILLING (mm)	0	0	0	0	0	51	51	71	51	0	0
SPS Construction Thickness											
AC OVERLAY (mm)	33	97	145	147	81	94	175	201	109	175	157
Rod & Level											
AC OVERLAY (mm)		89	135	154	74	65	149	132	65	172	151
MILLING (mm)											
Rod & Level Std Dev											
AC OVERLAY (mm)		13	18	17	21	28	19	25	16	30	20
MILLING (mm)											
Rod & Level Min											
AC OVERLAY (mm)		66	97	94	0	0	97	0	20	76	117
MILLING (mm)											
Rod & Level Max											
AC OVERLAY (mm)		112	196	180	109	102	188	168	97	234	196
MILLING (mm)											
MILLING (mm)						52	52	55	52		
Lift Thicknesses											
Maximum Lift Thickness <= 75 mm	30	79	89	107	74	64	71	84	64	114	64
AC Material Requirements											
Hveem Stability (minimum 37)											
Air Voids 3-5 %											
Virgin Mix											
Aggregate Pass #4 <40%							60		62		
RAP											
TOTAL AC											
NEW AC											
%AC OF SALVAGED MIX											
% NEW AGG. MATERIAL											
% RAP											
New Aggregate											
Aggregate Pass #4 <40%		58	58					58	58		

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 99. Summary of construction data for Florida.

Florida (12)	501	502	503	504	505	506	507	508	509	560	561	562	563	564	565	566
Required Thickness																
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51							
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50							
L05B Thickness																
AC OVERLAY (mm)		64	127	130	51	76	165	178	107							
MILLING (mm)		38				36			64							
SPS Construction Thickness																
AC OVERLAY (mm)		53	135	122	48	102	168	180	107							
Rod & Level																
AC OVERLAY (mm)		50	134	123	50	65	111	113	65							
MILLING (mm)		.	.	.	.	35	55	67	42							
Rod & Level Std Dev																
AC OVERLAY (mm)		9	7	8	4	4	6	7	5							
MILLING (mm)		.	.	.	.	6	5	4	10							
Rod & Level Min																
AC OVERLAY (mm)		25	112	102	38	58	102	94	53							
MILLING (mm)		.	.	.	.	20	46	61	20							
Rod & Level Max																
AC OVERLAY (mm)		61	150	145	58	74	122	124	71							
MILLING (mm)		.	.	.	.	43	66	76	71							
MILLING (mm)		22		11	25	69	62	70	72							
Lift Thicknesses																
Maximum Lift Thickness <= 75 mm		38	69	56	38	81	76	84	53							
AC Material Requirements																
Hveem Stability (minimum 37)																
Air Voids 3-5 %																
Virgin Mix																
Aggregate Pass #4 <40%					79		60		69							
RAP																
TOTAL AC																
NEW AC																
%AC OF SALVAGED MIX																
% NEW AGG. MATERIAL																
% RAP																
New Aggregate																
Aggregate Pass #4 <40%		72	62					62	72							

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 100. Summary of construction data for Georgia.

Georgia (13)	501	502	503	504	505	506	507	508	509	560	561	562	563	564	565	566	567
Required Thickness																	
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51								
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50								
L05B Thickness																	
AC OVERLAY (mm)		41	130	135	51	107	160	170	97	56	74	89	56	58	127	137	
MILLING (mm)		30	38	41	46	74	53	53	58	30	20	25	76	58	25	56	
SPS Construction Thickness																	
AC OVERLAY (mm)		23	127	130	41	99	168	175	99								
Rod & Level																	
AC OVERLAY (mm)		23	125	128	42	48	119	123	43								
MILLING (mm)																	
Rod & Level Std Dev																	
AC OVERLAY (mm)		8	4	7	9	4	15	5	6								
MILLING (mm)		.	.	.	.	52	47	49	57								
Rod & Level Min																	
AC OVERLAY (mm)		5	119	119	33	43	109	109	30								
MILLING (mm)		.	.	.	.	7	12	3	6								
Rod & Level Max																	
AC OVERLAY (mm)		36	132	142	81	58	185	132	51								
MILLING (mm)		.	.	.	.	41	0	41	48								
MILLING (mm)			18	27	30	61	38	65	41								
Lift Thicknesses																	
Maximum Lit Thickness <= 75 mm		28	64	58	46	64	114	114	71								
AC Material Requirements																	
Hveem Stability (minimum 37)																	
Air Voids 3-5 %																	
Virgin Mix																	
Aggregate Pass #4 <40%							64		66								
RAP																	
TOTAL AC																	
NEW AC																	
%AC OF SALVAGED MIX																	
% NEW AGG. MATERIAL																	
% RAP																	
New Aggregate																	
Aggregate Pass #4 <40%																	

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 101. Summary of construction data for Maine.

Maine (23)	501	502	503	504	505	506	507	508	509	559
Required Thickness										
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51	
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50	
L05B Thickness										
AC OVERLAY (mm)		91	140	145	69	104	198	173	97	
MILLING (mm)						38	43	30	38	
SPS Construction Thickness										
AC OVERLAY (mm)		86	142	142	61	102	183	175	94	
Rod & Level										
AC OVERLAY (mm)		91	140	144	69	54	133	121	52	
MILLING (mm)		.	.	.	.	50	57	52	43	
Rod & Level Std Dev										
AC OVERLAY (mm)		9	9	10	9	6	6	6	5	
MILLING (mm)		.	.	.	.	7	7	5	6	
Rod & Level Min										
AC OVERLAY (mm)		76	122	122	51	41	122	107	36	
MILLING (mm)		.	.	.	.	30	46	41	30	
Rod & Level Max										
AC OVERLAY (mm)		114	155	165	84	66	145	140	66	
MILLING (mm)		.	.	.	.	66	76	61	56	
MILLING (mm)						43	47	37	38	
Lift Thicknesses										
Maximum Lift Thickness <= 75 mm		61	58	58	38	58	89	81	58	
AC Material Requirements										
Hveem Stability (minimum 37)										
Air Voids 3-5 %										
Virgin Mix										
Aggregate Pass #4 <40%			45	52		46	52	48	44	
RAP										
TOTAL AC										
NEW AC										
%AC OF SALVAGED MIX										
% NEW AGG. MATERIAL										
% RAP										
New Aggregate										
Aggregate Pass #4 <40%		47	39					39	39	

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 102. Summary of construction data for Maryland.

Maryland (24)	501	502	503	504	505	506	507	508	509	559	560	561	562	563
Required Thickness														
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51					
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50					
L05B Thickness														
AC OVERLAY (mm)		53	135	135	53	91	191	168	97					
MILLING (mm)						38	36	36	38					
SPS Construction Thickness														
AC OVERLAY (mm)		53	124	114	51	91	188	140	89					
Rod & Level														
AC OVERLAY (mm)		46	124	116	48	55	108	139	45					
MILLING (mm)							45		44					
Rod & Level Std Dev														
AC OVERLAY (mm)		7	8	9	6	5	6	6	4					
MILLING (mm)							9		8					
Rod & Level Min														
AC OVERLAY (mm)		28	109	97	36	46	97	127	33					
MILLING (mm)							33		25					
Rod & Level Max														
AC OVERLAY (mm)		58	140	140	64	66	124	150	51					
MILLING (mm)							71		64					
MILLING (mm)						39	39	39	39					
Lift Thicknesses														
Maximum Lift Thickness <= 75 mm		61	61	66	64	64	64	57	64					
AC Material Requirements														
Hveem Stability (minimum 37)														
Air Voids 3-5 %														
Virgin Mix														
Aggregate Pass #4 <40 %				41	49									
RAP														
TOTAL AC														
NEW AC														
%AC OF SALVAGED MIX														
% NEW AGG. MATERIAL														
% RAP														
New Aggregate														
Aggregate Pass #4 <40 %														

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 103. Summary of construction data for Minnesota.

Minnesota (27)	501	502	503	504	505	506	507	508	509	559	560	561
Required Thickness												
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51			
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50			
L05B Thickness												
AC OVERLAY (mm)		61			48		142					
MILLING (mm)												
SPS Construction Thickness												
AC OVERLAY (mm)												
Rod & Level												
AC OVERLAY (mm)												
MILLING (mm)												
Rod & Level Std Dev												
AC OVERLAY (mm)												
MILLING (mm)												
Rod & Level Min												
AC OVERLAY (mm)												
MILLING (mm)												
Rod & Level Max												
AC OVERLAY (mm)												
MILLING (mm)												
MILLING (mm)												
Lift Thicknesses												
Maximum Lift Thickness <= 75 mm												
AC Material Requirements												
Hveem Stability (minimum 37)												
Air Voids 3-5 %												
Virgin Mix												
Aggregate Pass #4 <40%												
RAP												
TOTAL AC												
NEW AC												
%AC OF SALVAGED MIX												
% NEW AGG. MATERIAL												
% RAP												
New Aggregate												
Aggregate Pass #4 <40%												

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 104. Summary of construction data for Mississippi.

Mississippi (28)	501	502	503	504	505	506	507	508	509	560
Required Thickness										
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51	
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50	
L05B Thickness										
AC OVERLAY (mm)		51	117	124	51					
MILLING (mm)		0	0	0	0					
SPS Construction Thickness										
AC OVERLAY (mm)		51	127	127	51	89	165	165	89	
Rod & Level										
AC OVERLAY (mm)										
MILL REPLACEMENT (mm)										
Rod & Level Std Dev										
AC OVERLAY (mm)										
MILL REPLACEMENT (mm)										
Rod & Level Min										
AC OVERLAY (mm)										
MILL REPLACEMENT (mm)										
Rod & Level Max										
AC OVERLAY (mm)										
MILL REPLACEMENT (mm)										
MILLING (mm)						38	38	38	38	
Lift Thicknesses										
Maximum Lift Thickness <= 75 mm		56	51	51	51	51	51	51	51	
AC Material Requirements										
Hveem Stability (minimum 37)										
Air Voids 3-5 %										
Virgin Mix										
Aggregate Pass #4 <40 %										
RAP										
TOTAL AC										
NEW AC		4	4					4	4	
% AC OF SALVAGED MIX										
% NEW AGG. MATERIAL		70	70					70	70	
% RAP										
New Aggregate										
Aggregate Pass #4 <40 %		67	67					67	67	

Note: The number after the state name is the state's numeric code in the LTPP data base.

Tab1e 105. Summary of construction data for Missouri.

Missouri (29)	501	502	503	504	505	506	507	508	509
Required Thickness									
AC OVERLAY(mm)	0	51	127	127	51	51	127	127	51
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50
L05B Thickness									
AC OVERLAY(mm)									
MILLING (mm)									
SPS Construction Thickness									
AC OVERLAY(mm)									
Rod & Level									
AC OVERLAY(mm)									
MILLING (mm)									
Rod & Level Std Dev									
AC OVERLAY(mm)									
MILLING (mm)									
Rod & Level Min									
AC OVERLAY(mm)									
MILLING (mm)									
Rod & Level Max									
AC OVERLAY(mm)									
MILLING (mm)									
MILLING (mm)									
Lift Thicknesses									
Maximum Lift Thickness <= 75 mm									
AC Material Requirements									
Hveem Stability (minimum 37)									
Air Voids 3-5 %									
Virgin Mix									
Aggregate Pass #4 <40%									
RAP									
TOTAL AC									
NEW AC									
%AC OF SALVAGED MIX									
% NEW AGG. MATERIAL									
% RAP									
New Aggregate									
Aggregate Pass #4 <40%									

Note: The number after the state name is the state’s numeric code in the LTPP data base.

Table 106. Summary of construction data for Montana.

Montana (30)	501	502	503	504	505	506	507	508	509	560	561
Required Thickness											
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51		
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50		
L05B Thickness											
AC OVERLAY (mm)		66	117	142	51	107	183	180	114		
MILLING (mm)		20	28	33	15	69	71	71	66		
SPS Construction Thickness											
AC OVERLAY (mm)		66	117	142	51	107	191	180	114		
Rod & Level											
AC OVERLAY (mm)		27	101	92	37	28	95	89	28		
MILL REPLACEMENT (mm)											
Rod & Level Std Dev											
AC OVERLAY (mm)		8	10	10	9	9	9	11	8		
MILL REPLACEMENT (mm)											
Rod & Level Min											
AC OVERLAY (mm)		10	79	74	13	13	74	51	13		
MILL REPLACEMENT (mm)											
Rod & Level Max											
AC OVERLAY (mm)		46	119	127	64	48	122	117	46		
MILL REPLACEMENT (mm)											
MILLING (mm)		25	25	25	25	79	77	77	76		
Lift Thicknesses											
Maximum Lift Thickness <= 75 mm		61	94	89	64	74	94	94	71		
AC Material Requirements											
Hveem Stability (minimum 37)											
Air Voids 3-5 %											
Virgin Mix											
Aggregate Pass #4 <40%		51			55						
RAP											
TOTAL AC											
NEW AC											
%AC OF SALVAGED MIX											
% NEW AGG. MATERIAL											
% RAP											
New Aggregate											
Aggregate Pass #4 <40%		51	51					51	51		

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 107. Summary of construction data for New Jersey.

New Jersey (34)	501	502	503	504	505	506	507	508	509	559	560
Required Thickness											
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51		
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50		
L05B Thickness											
AC OVERLAY (mm)		48	119	119	46	107	198	198	109		
MILLING (mm)		0	0	0	0	51	51	51	51		
SPS Construction Thickness											
AC OVERLAY (mm)		51	127	127	127	102	178	178	102		
Rod & Level											
AC OVERLAY (mm)		43	114	118	53	49	56	123	41		
MILL REPLACEMENT (mm)						54	56	55	64		
Rod & Level Std Dev											
AC OVERLAY (mm)		12	9	8	9	6	6	14	6		
MILL REPLACEMENT (mm)						9	10	8	11		
Rod & Level Min											
AC OVERLAY (mm)		18	99	102	28	28	43	81	23		
MILL REPLACEMENT (mm)						28	36	36	48		
Rod & Level Max											
AC OVERLAY (mm)		69	132	137	76	61	66	155	51		
MILL REPLACEMENT (mm)						69	89	86	99		
MILLING (mm)						74	53	58	64		
Lift Thicknesses											
Maximum Lift Thickness <= 75 mm		61	89	102	64	76	97	102	76		
AC Material Requirements											
Hveem Stability (minimum 37)											
Air Voids 3-5 %											
Virgin Mix											
Aggregate Pass #4 <40%			53	55			61	52			
RAP											
TOTAL AC											
NEW AC											
%AC OF SALVAGED MIX											
% NEW AGG. MATERIAL											
% RAP											
New Aggregate											
Aggregate Pass #4 <40%											

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 108. Summary of construction data for New Mexico.

New Mexico (35)	501	502	503	504	505	506	507	508	509
Required Thickness									
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50
L05B Thickness									
AC OVERLAY (mm)									
MILLING (mm)									
SPS Construction Thickness									
AC OVERLAY (mm)		56	107	117	64	109	188	188	107
Rod & Level									
AC OVERLAY (mm)	48	56	107	117	63	55	133	132	53
MILL REPLACEMENT (mm)						54	56	56	53
Rod & Level Std Dev									
AC OVERLAY (mm)	6	12	11	11	9	4	5	6	6
MILL REPLACEMENT (mm)						4	5	5	6
Rod & Level Min									
AC OVERLAY (mm)	33	33	86	91	48	48	122	122	33
MILL REPLACEMENT (mm)						46	46	46	33
Rod & Level Max									
AC OVERLAY (mm)	61	79	127	137	79	66	145	147	64
MILL REPLACEMENT (mm)						66	66	69	64
MILLING (mm)	51					51	51	64	51
Lift Thicknesses									
Maximum Lift Thickness <= 75 mm	76	76	102	76	64	76	76	76	76
AC Material Requirements									
Hveem Stability (minimum 37)									
Air Voids 3-5 %									
Virgin Mix									
Aggregate Pass #4 <40%			49		59		59	59	
RAP									
TOTAL AC									
NEW AC		5	5					5	5
%AC OF SALVAGED MIX									
% NEW AGG. MATERIAL		45	45					45	45
% RAP									
New Aggregate									
Aggregate Pass #4 <40%		43	43					43	43

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 109. Summary of construction data for Oklahoma.

Oklahoma (40)	501	502	503	504	505	506	507	508	509	560
Required Thickness										
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51	
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50	
L05B Thickness										
AC OVERLAY (mm)										
MILLING (mm)										
SPS Construction Thickness										
AC OVERLAY (mm)		46	112	119	43	99	163	147	79	
Rod & Level										
AC OVERLAY (mm)		46	112	119	43	99	163	146	78	
MILL REPLACEMENT (mm)										
Rod & Level Std Dev										
AC OVERLAY (mm)		8	13	13	7	13	11	13	9	
MILL REPLACEMENT (mm)										
Rod & Level Min										
AC OVERLAY (mm)		25	79	79	20	74	145	124	56	
MILL REPLACEMENT (mm)										
Rod & Level Max										
AC OVERLAY (mm)		64	140	142	56	124	188	170	97	
MILL REPLACEMENT (mm)										
MILLING (mm)						41	30	36	43	
Lift Thicknesses										
Maximum Lift Thickness <= 75 mm		64	89	89	64	102	102	102	102	
AC Material Requirements										
Hveem Stability (minimum 37)										
Air Voids 3-5 %										
Virgin Mix										
Aggregate Pass #4 <40%			42	47			42	34		
RAP										
TOTAL AC										
NEW AC		1	1					1	1	
%AC OF SALVAGED MIX										
% NEW AGG. MATERIAL		70	70					70	70	
% RAP										
New Aggregate										
Aggregate Pass #4 <40%		59	59					59	59	

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 110. Summary of construction data for Texas.

Texas (48)	501	502	503	504	505	506	507	508	509
Required Thickness									
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50
L05B Thickness									
AC OVERLAY (mm)		56	135	135	51	99	178	185	109
MILLING (mm)		0	0	0	0				
SPS Construction Thickness									
AC OVERLAY (mm)		58	124	124	97	114	175	168	102
Rod & Level									
AC OVERLAY (mm)		58	123	122	59	59	120	116	54
MILL REPLACEMENT (mm)						56	55	53	47
Rod & Level Std Dev									
AC OVERLAY (mm)		8	19	9	10	7	7	7	11
MILL REPLACEMENT (mm)						7	6	6	5
Rod & Level Min									
AC OVERLAY (mm)		43	0	102	30	46	99	102	0
MILL REPLACEMENT (mm)						41	38	43	33
Rod & Level Max									
AC OVERLAY (mm)		74	145	145	79	76	135	127	71
MILL REPLACEMENT (mm)						71	76	64	66
MILLING (mm)						44	46	37	43
Lift Thicknesses									
Maximum Lift Thickness <= 75 mm		58	53	48	58	58	56	48	53
AC Material Requirements									
Hveem Stability (minimum 37)									
Air Voids 3-5 %									
Virgin Mix									
Aggregate Pass #4 <40%							55		55
RAP									
TOTAL AC									
NEW AC		3	3					3	3
%AC OF SALVAGED MIX									
% NEW AGG. MATERIAL		65	65					65	65
% RAP									
New Aggregate									
Aggregate Pass #4 <40%		71	71					71	71

Note: The number after the state name is the state’s numeric code in the LTPP data base.

Table 111. Summary of construction data for Alberta.

Alberta (81)	501	502	503	504	505	506	507	508	509
Required Thickness									
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50
L05B Thickness									
AC OVERLAY (mm)		53	127	122		94	163	178	84
MILLING (mm)		0		0	0	41	56	76	64
SPS Construction Thickness									
AC OVERLAY (mm)		53	127	122	53	94	160	178	84
Rod & Level									
AC OVERLAY (mm)									
MILL REPLACEMENT (mm)									
Rod & Level Std Dev									
AC OVERLAY (mm)									
MILL REPLACEMENT (mm)									
Rod & Level Min									
AC OVERLAY (mm)									
MILL REPLACEMENT (mm)									
Rod & Level Max									
AC OVERLAY (mm)									
MILL REPLACEMENT (mm)									
MILLING (mm)						56	53	48	50
Lift Thicknesses									
Maximum Lift Thickness <= 75 mm		58	74	76	58	61	71	74	61
AC Material Requirements									
Hveem Stability (minimum 37)									
Air Voids 3-5 %									
Virgin Mix									
Aggregate Pass #4 <40%				64				64	
RAP									
TOTAL AC									
NEW AC		4	4					4	4
%AC OF SALVAGED MIX									
% NEW AGG. MATERIAL		70	70					70	70
% RAP									
New Aggregate									
Aggregate Pass #4 <40%		64	64					64	64

Note: The number after the state name is the state's numeric code in the LTPP data base.

Table 112. Summary of construction data for Manitoba.

Manitoba (83)	501	502	503	504	505	506	507	508	509
Required Thickness									
AC OVERLAY (mm)	0	51	127	127	51	51	127	127	51
MILLING (mm)	0	<25.4	<25.4	<25.4	<25.4	38-50	38-50	38-50	38-50
L05B Thickness									
AC OVERLAY (mm)		69	124	142		81	165	165	94
MILLING (mm)					0				
SPS Construction Thickness									
AC OVERLAY (mm)		64	140	127	51	89	165	165	89
Rod & Level									
AC OVERLAY (mm)									
MILL REPLACEMENT (mm)									
Rod & Level Std Dev									
AC OVERLAY (mm)									
MILL REPLACEMENT (mm)									
Rod & Level Min									
AC OVERLAY (mm)									
MILL REPLACEMENT (mm)									
Rod & Level Max									
AC OVERLAY (mm)									
MILL REPLACEMENT (mm)									
MILLING (mm)						38	38	38	38
Lift Thicknesses									
Maximum Lift Thickness <= 75 mm		51	51	51	51	51	38	38	51
AC Material Requirements									
Hveem Stability (minimum 37)									
Air Voids 3-5 %		4.5	4.5	3.9	3.9	3.9	3.9	4.5	4.5
Virgin Mix									
Aggregate Pass #4 <40%									
RAP									
TOTAL AC		5	5					5	5
NEW AC									
%AC OF SALVAGED MIX									
% NEW AGG. MATERIAL		70	70					70	70
% RAP									
New Aggregate									
Aggregate Pass #4 <40%		62	62					62	62

Note: The number after the state name is the state's numeric code in the LTPP data base.

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