Structural Factors for Flexible Pavements—Initial Evaluation of the SPS-1 Experiment Final Report

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Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

LTPP

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FOREWORD

This report documents a study undertaken to conduct a detailed review of the Long-Term Pavement Performance (LTPP) Special Pavements Study–1 (SPS-1) experiment to determine to what extent it will provide the necessary data to ensure that the objectives and expectations from this experiment are attained. The SPS-1 experiment entitled *Strategic Study of Structural Factors for Flexible Pavements* is one of the key experiments of the LTPP program. Its goal is to develop improved methodologies and strategies for the construction of flexible pavements. The review concentrated on the core experimental test sections with secondary emphasis on the supplemental test sections that were built by the individual agencies for each SPS-1 project.

As a result of this work, the data availability and completeness for the SPS-1 experiment are fairly complete with two exceptions. The two critical elements or parameters found to have significant deficiencies are the traffic and materials test data. These data deficiencies need to be addressed before a comprehensive analysis of the SPS-1 experiment is conducted. The majority of the SPS-1 data that have been collected are at level E.

This report will be of interest to highway agency engineers involved in the collection, processing, and analysis of SPS-1 data to improve the design procedures and standards for constructing hot-mix asphalt-surfaced pavements.

T. Paul Teng, P.E.
Director, Office of Infrastructure
Research and Development

NOTICE

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16. Abstract
The SPS-1 experiment entitled *Strategic Study of Structural Factors for Flexible 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 hot mix asphalt (HMA) design features (including surface and base thickness, base type, and drainage condition) and site conditions (traffic, subgrade type, and climatic factors) on performance. This report documents the first comprehensive review and evaluation of the SPS-1 experiment. Eighteen SPS-1 projects have been constructed and each site includes 12 core test sections and some sites also include supplemental sections. A total of 248 test sections are included in the SPS-1 experiment.

The data for the SPS-1 experiment are fairly complete with two exceptions: the traffic and materials test data. However, a significant amount of some types of data is still missing, especially the distress data. These data deficiencies need to be addressed before a comprehensive analysis of the SPS-1 experiment is conducted. The majority of the SPS-1 data that has been collected is at level E.

Required experimental design factors were compared with the actual constructed values. A large majority of SPS-1 sections follow the experiment design and can be characterized as good to excellent. Two projects are relatively new, and the data processing and materials testing are currently underway. The evaluation and detailed review have highlighted several significant problems that will clearly limit the results that can be obtained from the SPS-1 experiment. Specifically, these include the missing traffic and materials test data. These data must be collected in order for the SPS-1 experiment to meet the expectations for calibrating and validating mechanistic models. The performance trends and effects of several design features and site conditions were noted and documented.

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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)

TABLE OF CONTENTS

Section	Page
1. INTRODUCTION	1
BACKGROUND	1
STUDY OBJECTIVES	3
SCOPE OF REPORT	4
2. GENERAL OVERVIEW OF EXPERIMENT	7
ORIGINAL SPS-1 EXPERIMENT DESIGN	7
STATE SUPPLEMENTAL SECTIONS	10
CURRENT STATUS OF DESIGN FACTORIAL	10
3. PROJECT REQUIREMENTS	15
CONSTRUCTION MATERIAL REQUIREMENTS	15
MATERIALS SAMPLING AND TESTING	19
MONITORING REQUIREMENTS	20
4. EXPERIMENT ASSESSMENT—DATA AVAILABILITY AND COMPLETENESS	25
LTPP DATA QUALITY CONTROL CHECKS	25
DATA ELEMENT CATEGORIES	28
GENERAL SITE INFORMATION	31
DESIGN VERSUS ACTUAL CONSTRUCTION REVIEW	32
MATERIALS TESTING	37
TRAFFIC	46
MONITORING DATA	55
DYNAMIC LOAD RESPONSE DATA	58
SUMMARY	59
5. ANALYSIS OF EARLY PERFORMANCE OBSERVATIONS	63
GRAPHICAL COMPARISONS FROM TIME-SERIES DATA	63
ANALYSIS OF VARIANCE	72
EFFECT OF KEY EXPERIMENTAL FACTORS ON PERFORMANCE	73
SUMMARY	79
6. SUMMARY AND CONCLUSIONS	81
SPS-1 EXPERIMENT STATUS	81
DESIGN VERSUS ACTUAL CONSTRUCTION	82
DATA AVAILABILITY AND COMPLETENESS	83
EARLY PERFORMANCE TRENDS	85
EXPECTATIONS FROM THE STATES	91
CAN THE SPS-1 EXPERIMENT MEET EXPECTATIONS?	92
RECOMMENDATIONS FOR FUTURE ACTIVITIES	92

TABLE OF CONTENTS, continued

Section **Page**

APPENDIX A. SPS-1 PROJECT SUMMARIES 111
APPENDIX B. SUMMARY OF CONSTRUCTION DATA 167
REFERENCES 187

LIST OF FIGURES

Figure **Page**

1. Location of the SPS-1 projects 9
2. LTPP data collection and data movement flowchart 26
3. Thickness histograms for the thin HMA layer (102 mm) from tables SPS1_LAYER (construction data) and TST_L05B 38
4. Thickness histograms for the thick HMA layer (178 mm) from tables SPS1_LAYER (construction data) and TST_L05B 39
5. Thickness histograms for the thin ATB layer (102 mm) from tables SPS1_LAYER (construction data) and TST_L05B 40
6. Thickness histograms for the thick ATB layer (203 mm) from tables SPS1_LAYER (construction data) and TST_L05B 41
7. Thickness histograms for the PATB layer from tables SPS1_LAYER (construction data) and TST_L05B....42
8. Thickness histograms for the 102-mm DGAB layer from tables SPS1_LAYER (construction data) and TST_L05B 43
9. Thickness histograms for the 203-mm DGAB layer from tables SPS1_LAYER (construction data) and TST_L05B 44
10. Thickness histograms for the 305-mm DGAB layer from tables SPS1_LAYER (construction data) and TST_L05B 45

11 Histogram of air voids measured on the HMA surface layer 51

12. Histogram of air voids measured on the HMA binder layer....51
13. Histogram of air voids measured on the ATB layer 52
14. Histogram of the material passing the number 4 sieve, PATB layer....52
15. Histogram of material passing the number 200 sieve, PATB layer....53
16. Histogram of material passing the number 200 sieve, HMA surface layer 53
17. Histogram of material passing the number 200 sieve, ATB layer....54
18. Area of fatigue cracking measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined 64
19. Total length of transverse cracks measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined 64
20. IRI values measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined....65
21. Rut depths measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined....65
22. Longitudinal cracking in the wheel paths measured on different dates for the core test sections of the Alabama project....66
23. Longitudinal cracking outside the wheel paths measured on different dates for the core test sections of the Alabama project 67

LIST OF FIGURES, continued.

Figure **Page**

24. Transverse cracking measured on different dates for the core test sections of the Alabama project 68
25. Graphical illustration of the average amount of fatigue cracking observed on each of the projects, as of January 2000....70
26. Percentage of the core test sections that exceed an IRI value of 1.2 m/km 75
27. Percentage of the core test sections that exceed 8 mm of rutting 77
28. Percentage of test sections that exceed an IRI value of 1.2 m/km....78
29. Percentage of core test sections that have fatigue cracking 79

LIST OF TABLES

Table **Page**

1. Factorial for the SPS-1 experimental design and the sites/projects originally nominated for each cell within the experiment....8
2. Supplemental sections constructed on SPS-1 projects....11
3. Final factorial for the SPS-1 experiment design....13
4. Required testing for the SPS-1 experiment....21
5. Summary of SPS-1 data elements and their importance to experimental expectations...29
6. SPS-1 project site information and report availability....32
7. SPS-1 subgrade classification....34
8. Summary of key factor values for the SPS-1 projects....35
9. Summary of materials testing on the subgrade soils....47
10. Summary of materials testing on the unbound aggregate base materials....47
11. Summary of materials testing on the permeable asphalt treated base mixtures....48
12. Summary of materials testing on the asphalt treated base mixtures....48
13. Summary of materials testing on the HMA mixtures....49
14. Summary of materials testing completed by material type for the core test sections, percent complete....50
15. Summary of climatic and traffic data for the SPS-1 project sites....55
16. Summary of the minimum number of distress and other performance indicator measurements made at each project site.....56
17. Summary of the average time interval between the different performance indicator surveys....57
18. Summary of Level E dynamic load response data for the Ohio SPS-1 project....58
19. Summary of the overall construction difficulties and deviations, and the adequacy code for the projects included in the SPS-1 experiment....60
20. Percentage of the SPS-1 core test sections with distress magnitudes exceeding the value noted....69
21. Summary of the average area of fatigue cracking observed at each project....69
22. Summary of p-values from a one-way ANOVA to determine the effect of experimental factors on selected performance indicators....72
23. Average performance differences of the test sections between the different soil types included in the SPS-1 experiment....74
24. Average performance differences of the test sections between the different types of base layers included in the SPS-1 experiment....74
25. Average performance differences of the test sections between the different drainage conditions included in the SPS-1 experiment....74
26. Average performance differences of the test sections between the different HMA layer thickness included in the SPS-1 experiment....75
27. Summary of missing or limited data for the SPS-1 experiment....86
28. Deficiencies and action items for each SPS-1 project....90
29. Identification of future research studies from the SPS-1 experiment—initial analysis of the individual factorial cells and companion projects....96

LIST OF TABLES, continued.

Table **Page**

30. Identification of future research studies from the SPS-1 experiment—overall effect of the main experimental factors on performance 97
31. Identification of future research studies from the SPS-1 experiment—benefits of drainage 98
32. Identification of future research studies from the SPS-1 experiment—effect of thickness variations on performance....99
33. Identification of future research studies from the SPS-1 experiment—effect of base material type on pavement performance....100
34. Identification of future research studies from the SPS-1 experiment—effect of seasonal changes on pavement response and material responses related to performance 101
35. Identification of future research studies from the SPS-1 experiment—effect of soil type and stiffness on pavement performance 102
36. Identification of future research studies from the SPS-1 experiment—effect of base condition on pavement performance....103
37. Identification of future research studies from the SPS-1 experiment—effect of HMA properties on pavement performance 104
38. Identification of future research studies from the SPS-1 experiment—quantification of remaining life of cracked or damaged HMA layers 105
39. Identification of future research studies from the SPS-1 experiment—identify those properties and conditions most conducive to the development of surface initiated fatigue cracks 106
40. Identification of future research studies from the SPS-1 experiment—applicability of the subgrade protection criteria for use in design of flexible pavements 107
41. Identification of future research studies from the SPS-1 experiment—confirm the C-values or differences between laboratory measured resilient modulus and backcalculated elastic layer modulus....108
42. Identification of future research studies from the SPS-1 experiment—mechanistic analysis of the SPS-1 sites 109
43. Summary of key project monitoring data for the Alabama SPS-1 113
44. Summary of available materials testing data on the Alabama SPS-1....114
45. Summary of key project monitoring data for the Arizona SPS-1....116
46. Summary of available materials testing data on the Arizona SPS-1 117
47. Summary of key project monitoring data for the Arkansas SPS-1....119
48. Summary of available materials testing data on the Arkansas SPS-1 120
49. Summary of key project monitoring data for the Delaware SPS-1 122
50. Summary of available materials testing data on the Delaware SPS-1....123
51. Summary of key project monitoring data for the Florida SPS-1 125
52. Summary of available materials testing data on the Florida SPS-1....126
53. Summary of key project monitoring data for the Iowa SPS-1....128
54. Summary of available materials testing data on the Iowa SPS-1 129
55. Summary of key project monitoring data for the Kansas SPS-1 131

LIST OF TABLES, continued.

Table **Page**

56. Summary of available materials testing data on the Kansas SPS-1 132
57. Summary of key project monitoring data for the Louisiana SPS-1 134
58. Summary of available materials testing data on the Louisiana SPS-1 135
59. Summary of key project monitoring data for the Michigan SPS-1 137
60. Summary of available materials testing data on the Michigan SPS-1 138
61. Summary of key project monitoring data for the Montana SPS-1 140
62. Summary of available materials testing data on the Montana SPS-1 141
63. Summary of key project monitoring data for the Nebraska SPS-1 143
64. Summary of available materials testing data on the Nebraska SPS-1 144
65. Summary of key project monitoring data for the Nevada SPS-1 146
66. Summary of available materials testing data on the Nevada SPS-1 147
67. Summary of key project monitoring data for the New Mexico SPS-1 149
68. Summary of available materials testing data on the New Mexico SPS-1 150
69. Summary of key project monitoring data for the Ohio SPS-1 152
70. Summary of available materials testing data on the Ohio SPS-1 153
71. Summary of key project monitoring data for the Oklahoma SPS-1 155
72. Summary of available materials testing data on the Oklahoma SPS-1 156
73. Summary of key project monitoring data for the Texas SPS-1 158
74. Summary of available materials testing data on the Texas SPS-1 159
75. Summary of key project monitoring data for the Virginia SPS-1 161
76. Summary of available materials testing data on the Virginia SPS-1 162
77. Summary of key project monitoring data for the Wisconsin SPS-1 164
78. Summary of available materials testing data on the Wisconsin SPS-1 165

ABBREVIATIONS

AASHTO—American Association of State Highway and Transportation Officials
AC—Asphalt Concrete
ANOVA—Analysis of Variance
AGG—Aggregate bases, identical to dense graded aggregate base
ATB—Asphalt Treated Base
AVC—Automated Vehicle Classification
AWS—Automated Weather Stations
DGAB—Dense Graded Aggregate Base, identical to aggregate base
ESAL—Equivalent Single Axle Load
FHWA—Federal Highway Administration
FWD—Falling Weight Deflectometer
GPS—Global Positioning System
HMA—Hot-Mix Asphalt
HMAC—Hot-Mix Asphalt Concrete
IMS—Information Management System
IRI—International Roughness Index
LTPP—Long-Term Pavement Performance
NAA—National Aggregate Association
NCHRP—National Cooperative Highway Research Program
NIMS—National Information Management System
NOAA—National Oceanic and Atmospheric Association
PATB—Permeable Asphalt Treated Base mixtures
QC/QA—Quality Control/Quality Assurance
RCO—Regional Coordination Office
RIMS—Regional Information Management System
SHA—State Highway Agency
SHRP—Strategic Highway Research Program
SPS—Special Pavement Studies
WIM—Weigh-in-Motion

SPS-1 Project Name Abbreviations

AL—Alabama
AR—Arkansas
AZ—Arizona
DE—Delaware
FL—Florida
IA—Iowa
KS—Kansas
LA—Louisiana
MI—Michigan
MT—Montana
NM—New Mexico
NE—Nebraska
OH—Ohio
OK—Oklahoma
TX—Texas
VA—Virginia
WI—Wisconsin

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1. INTRODUCTION

One of the objectives of the Long-Term Pavement Performance (LTPP) studies is to develop improved design methodologies and strategies for the construction of flexible pavements. Those factors that can affect the performance of flexible pavements include, as a minimum, drainage, structural features (such as base type, base thickness, and asphalt thickness), environment, and subgrade type. The LTPP program incorporated all of these factors into a single experiment to study the structural factors for hot-mix asphalt (HMA) flexible pavements—Specific Pavement Studies (SPS) 1—entitled *Strategic Study of Structural Factors for Flexible Pavements*.

It is expected that the successful completion of the SPS-1 experiment will lead to improvements in design procedures and standards for construction of HMA-surfaced pavements. These improvements should contribute to achieving the overall goal of the LTPP program—increased pavement life and better utilization of resources. Investigating the effects of the specific experimental design features and site conditions (material types, layer thickness, subgrade soil, traffic, and climate), as well as their interactions on pavement performance, makes possible the evaluation of existing design methods and the performance equations. It also makes possible the development of new and improved design equations and calibration of mechanistic-empirical models.

BACKGROUND

The SPS-1 experimental plans were originally designed to incorporate project sites in all four LTPP climatic regions and on both fine- and coarse-grained subgrades. This requirement makes it possible to cover a large inference space of the continental United States. The Strategic Highway Research Program (SHRP), State highway agencies (SHAs), and the Federal Highway Administration (FHWA) made a major effort to identify appropriate SPS-1 sites and to construct all the test sections according to their original experimental design. A wide range of specific data was collected during construction and extensive field monitoring data (traffic, profile, cracking) have been collected from these test sections over time.

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

- Evaluation of existing design methods.
- Development of improved strategies and design procedures for the rehabilitation of existing pavements.
- Development of improved design equations for new and reconstructed pavements.
- Determination of the effects on pavement distress and performance of loading, environment, materials properties and variability, construction quality, and maintenance levels.
- Determination of specific design procedures to improve pavement performance.
- Establishment of a database to support these objectives and future needs.

The experimental designs for LTPP were developed with a clear relationship to these objectives. The following are the products 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**: The effects of the specific experimental design features, subgrade soil, traffic and climate, and their interactions (permeable drainage layers, widened slabs, asphalt concrete (AC) overlay thickness, pre-overlay repair and many others).
- **Other Products**: Test methods developed specifically for SPS test sections, correlations between material properties determined by different methods, study of other features and materials, and technology transfer.

The following objectives of the SPS-1 (new flexible pavement) and SPS-2 (new rigid pavement) experiments are stated in the same report:

- "The SPS will develop a comprehensive data base with information on construction, materials, traffic, environment, performance and other features pertaining to the test sections."
- "The primary objective of the experiments on structural factors for flexible and rigid pavements is to more precisely determine the relative influence and long-term effectiveness of the strategic factors that influence the performance of pavements."

The SPS-1 experiment was also expected to identify trends associated with the various design parameters on pavement performance and life expectancy and to provide data to help improve or validate current structural design procedures. With these improved methodologies and procedures, highway agencies should be able to determine and select more appropriate and optimum strategies for the design of flexible pavements and significantly reduce the occurrence of premature failures. However, there have been many concerns expressed regarding the ability of the SPS-1 experiment to meet these expectations satisfactorily.[2,3] Some of these concerns include the following:

- Lack of detailed expectations and objectives.
- The quality and completeness of the available data, both now and in the future.
- Deviations in the design and construction features of the in-place project (e.g., layers built to a different thickness or lack of compaction of the pavement layers).
- Deficiencies in construction, materials, climate, traffic, and performance data in relation to current and future analysis needs.

The full extent of the deviations and deficiencies and the potential impact of those deficiencies have not yet been quantified for the SPS-1 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 in the SPS-1 experiment.

The SPS-1 projects were constructed between 1993 and 1998, which means that they are young and may not yet directly support analysis activities to improve our knowledge in many of the above-listed areas. However, some of the SPS-1 sections have begun to exhibit distress; thus, it may now be possible to make some preliminary evaluations. To date, no in-depth assessment has been undertaken to determine to what extent this experiment will provide the necessary data to ensure the broader expectations of these experiments are attained. Therefore, this study was initiated to conduct a comprehensive review of all SPS-1 experimental sites to determine the current adequacy and potential of data from this experiment to adequately satisfy future pavement engineering needs.

This review compares the experiment sites as they exist today with both the original expectations and any new expectations for the 21st century. For example, there is a greater emphasis on mechanistic-based design now than existed a decade ago. This review will provide a sound basis for the following:

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

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

STUDY OBJECTIVES

As stated above, a detailed review was completed to determine to what extent this experiment will provide the necessary data to ensure that the objectives and expectations of the SPS-1 experiment are attained. Stated simply, the primary objective of the SPS-1 experiment on structural factors for flexible pavements was to determine the relative influence and long-term effectiveness of the strategic factors that influence the performance of flexible pavements. This review concentrated on the core experimental test sections and on the supplemental test sections that were built by the individual SHAs for each project. There were five specific objectives for this review, as listed below:

1. Evaluate the set of core and supplemental test sections constructed within the SPS-1 experiment in relation to their ability to support the objectives and characterize the overall “health” and analytical potential of the SPS-1 experiment. This includes identifying areas of strength and weakness and developing a plan of recommended corrective measures as appropriate to strengthen the SPS-1 experiment to accomplish its objectives, as well as developing analysis plans for both short-term and long-term goals. This objective was further subdivided into two areas, as noted below:

    - Evaluate the quality and completeness (in relation to current data collection requirements) of the SPS-1 construction data and provide recommendations for the resolution and correction of data that are anomalous or of inadequate quality.

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

2. Identify any confounding factors introduced into the SPS-1 experiment evaluated by construction deviations or other factors not accounted for in the original experimental design.
3. Consider both short-term and long-term horizons in the evaluation and the preparation of data analysis recommendations.
4. Evaluate the opportunities for local, regional, or national analysis of the core and supplemental test sections.
5. Identify specific objectives and expectations that should be pursued for the SPS-1 experiment, considering the original expectations and the needs of the future. Consider expectations at the local, regional, and national levels, as appropriate.

Specifically, this report focuses on the following four areas of the SPS-1 experimental data:

1. Review of data quality.
2. Detailed discussions on the quantity and percentage of data that are at Level E (the highest quality data) in the Information Management System (IMS) database as of January 2000.
3. Comparison of the designed versus as-constructed section parameters, especially those that were used for designing the experiment (e.g., 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 in nature, i.e., 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, i.e., January 2000.

SCOPE OF REPORT

The report is divided into six chapters, including this introduction. Chapter 2 provides an overview of the current status of the SPS-1 experiment in comparison to the original experiment designs. Chapter 3 summarizes the project requirements for each SPS-1 project. Chapter 4 summarizes each of the SPS-1 projects that have been built, the data that are available for each project, construction difficulties, and any data deficiencies. Chapter 5 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 6 summarizes the effects that the data deficiencies, if any, 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 are available for each project, and appendix B presents a summary of the available construction data for each project.

2. GENERAL OVERVIEW OF EXPERIMENT

The first step in the evaluation of the SPS-1 experiment is to assess how much of the original experiment was actually constructed and what effect any missing sites will have on the usefulness of the SPS-1 data. The original SPS-1 experiment design, the SPS-1 experimental sites actually constructed, the effects of missing experimental design cells, and information available from the SPS-1 supplemental sites are discussed in this chapter. The January 2000 release of the IMS that contains only Level E data was used for the detailed review.

ORIGINAL SPS-1 EXPERIMENT DESIGN

The SPS-1 experiment examines the effects of climatic factors (wet versus dry and freeze versus no-freeze) and type of subgrade (fine-grained and coarse-grained) on pavement sections incorporating different structural factors. These factors include:

- The presence or absence of a drainage layer or feature and its location within the pavement structure.
- The use of varying base types (dense-graded aggregate base, asphalt treated base, permeable asphalt treated base, and combinations of these).
- Varying base thickness (203 mm, 305 mm, or 406 mm).
- Varying HMA surface thickness (102 mm or 178 mm).

The original SPS-1 experiment factorial is shown in table 1. A total of 24 combinations of structural factors are presented by the factorial. Because 24 sections at one site would produce an undue burden on the SHAs, the projects were developed so that only 12 sections were built at any one site. Therefore, a complete factorial of all factors is made up of two columns of the factorial. The sections in the first half of a complete factorial are numbered 1–12, while the second half are numbered 13–24.

Each section varies from the others in terms of the structural factors mentioned above. The shaded cells in the factorial are those that were not expected to be filled by a section. As shown, the experimental factorial was completely filled with candidate projects that were nominated originally for the SPS-1 experiment. In total, the SPS-1 experiment has 216 core test sections.

Table 1 also illustrates which State projects were nominated initially to fill which design cells. The table shows that some of the cells contain replicate sections. In particular, the projects built in Iowa and Ohio are both in the wet-freeze environmental zone on fine-grained subgrades. The same set of sections was built on both of these projects. In addition, the projects built in Virginia and Michigan are both in the wet-freeze environmental zone on fine-grained subgrades. These two projects contain the offsetting sections from those built on the Iowa and Ohio projects. As of August 1999, the SPS-1 experiment has 18 projects located throughout the United States and Canada. A map of the selected sections is shown in figure 1.

Table 1. Factorial for the SPS-1 experimental design and the sites/projects originally nominated for each cell within the experiment.

PAVEMENT STRUCTURE COMBINATIONS				FACTORS FOR MOISTURE, TEMPERATURE, SUBGRADE TYPE, AND LOCATION															
				Wet								Dry							
				Freeze				No-Freeze				Freeze				No-Freeze			
Drainage	Base Type	Total Base Thick	Surface Thick	Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
				J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
No	AGG	8"	4"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
			7"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
		12"	4"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
			7"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
	ATB	8"	4"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
			7"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
		12"	4"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
			7"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
	ATB / 4" AGG	8"	4"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
			7"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
		12"	4"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
			7"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
Yes	PATB / AGG	8"	4"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
			7"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
		12"	4"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
			7"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
		16"	4"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
			7"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
	ATB / PATB	8"	4"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
			7"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
		12"	4"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
			7"		VA, MI		WI		LA		AR		NE		MT		OK		AZ
		16"	4"	IA, OH		DE		AL		FL		KS		NV		NM		TX	
			7"		VA, MI		WI		LA		AR		NE		MT		OK		AZ

Shaded cells are not required by the experiment.
1 inch = 25.4 mm

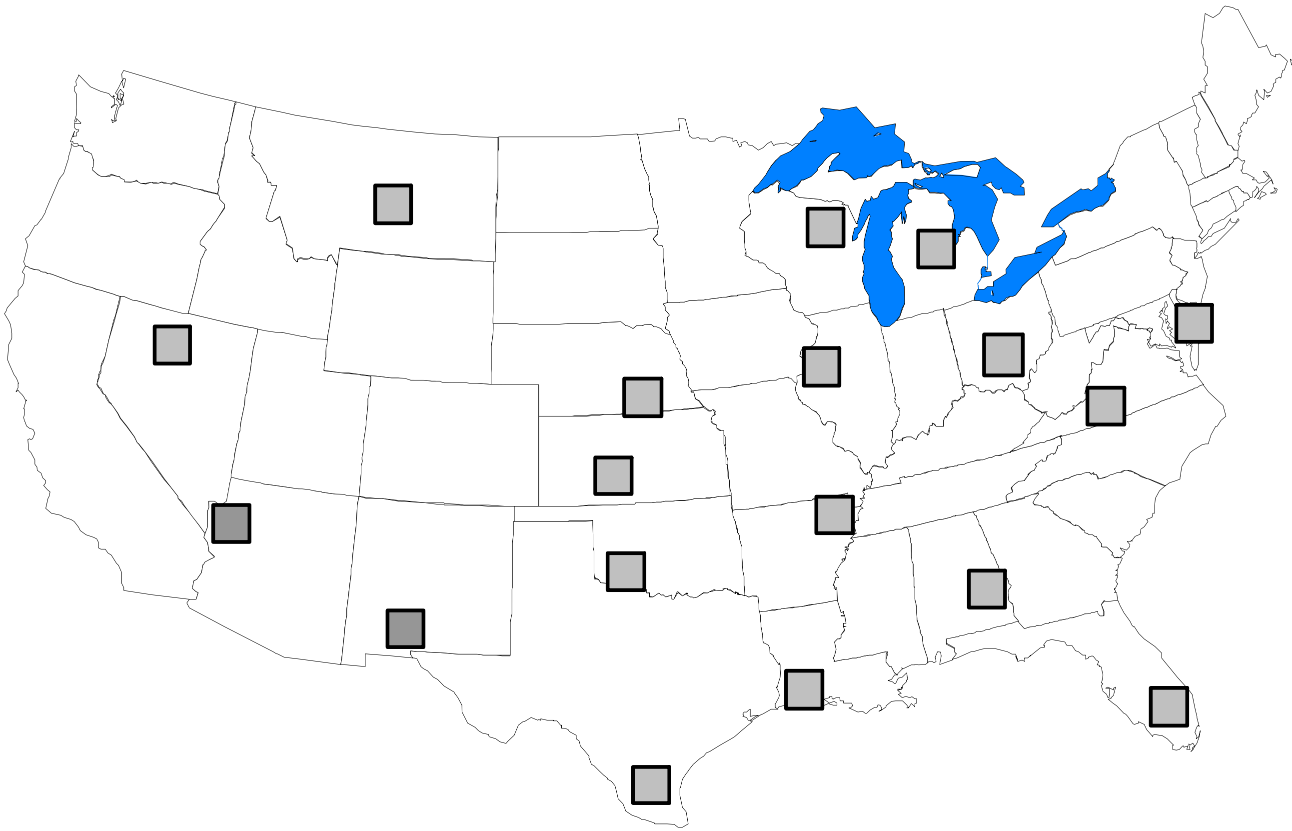


Figure 1. Location of the SPS-1 projects.

Each of the 12 sections was required to be 152.4 m in length. In addition, each project was required to have a minimum traffic loading of 100,000 equivalent single axle loads (ESALs) per year.

STATE SUPPLEMENTAL SECTIONS

In addition to the core sections located at each project, the States were allowed to add supplemental sections that are monitored by LTPP. These supplemental sections are usually a variation of the experiment and represent typical construction practices by the State. Thus, the main value of the supplemental sections will be as a direct comparison to the core sections. Table 2 provides a list of the SPS-1 projects and a general description of the supplemental sections that were built at each one.

A total of 32 supplemental sections have been built as part of the SPS-1 experiment, but only 25 sections are listed in table 2. The other seven supplemental sections have been built, but descriptions of the structures of these sections are not in the LTPP database at this time. The supplemental sections not included in the database are from Arizona (two sections are included and two are excluded), Arkansas (one section), Iowa (one section), Ohio (two sections), and Oklahoma (one section). These additional sections should add significant value to the experiment and can be used to estimate the expected variability in distress with time under the same conditions.

CURRENT STATUS OF DESIGN FACTORIAL

The current status of the SPS-1 site design factorial is provided in table 3. All projects have been located in the appropriate cells based on the actual test data and construction details, which will be discussed in greater detail in chapter 4. As shown, all cells have two projects, with the exception of the coarse-grained subgrades in a dry-no-freeze climate. However, it is important to note the following observations regarding the final experiment design:

1. The cell for the coarse-grained subgrades in a dry-no-freeze climate has only one project, while the cell for the fine-grained soils in a wet-freeze climate has four projects. This replication will be useful; however, if not analyzed properly, it could cause a bias in computing mean national trends.

2. Eleven SPS-1 projects have been built over fine-grained soils, while only seven have been built over coarse-grained soils. This imbalance is not critical, but it should be considered when evaluating and analyzing the data for determining the effects of the subgrade on performance.

3. The Alabama and Louisiana projects are located in the same cell (fine-grained soils in a wet-no-freeze climate) but are not paired as a complete factorial. Both of these projects contain pavement structure cells 1 to 12 (refer to table 1). Thus, this cell also contains only one of the companion projects, similar to the coarse-grained soils in a dry-no-freeze climate (the Arizona project).

Table 2. Supplemental sections constructed on SPS-1 projects.

SPS-1 Supplemental Sections			
STATE_CODE	SHRP_ID	LAYER_NO	Layer Description (from material codes)
1	0161	1	Silty Clay
		2	152 mm Crushed Stone
		3	152 mm Bituminous Bound Base
		4	102 mm HMAC
1	0162	1	Silty Clay
		2	249 mm Bituminous Bound Base
		3	114 mm HMAC
1	0163	1	Silty Clay
		2	152 mm Crushed Stone
		3	Woven Geotextile
		4	102 mm PATB
		5	150 mm Bituminous Bound Base
		6	119 mm HMAC
4	0161	1	Gravel
		2	94 mm Crushed Stone
		3	145 mm HMAC
4	0162	1	Gravel
		2	229 mm HMAC
10	0159	1	Silty Sand
		2	1219 mm Silty Sand
		3	193 mm Crushed Stone
		4	168 mm Bituminous Bound Base
		5	142 mm HMAC
		7	25 mm Porous Friction Course
10	0160	1	Silty Sand
		2	991 mm Silty Sand
		3	140 mm Cement-Aggregate Mixture
		4	142 mm Bituminous Bound Base
		5	175 mm HMAC
		7	25 mm Porous Friction Course
12	0161	1	Poorly Graded Sand
		2	259 mm Limerock, Caliche
		3	102 mm HMAC
20	0159	1	Sandy Silt
		2	152 mm Treated Subbase
		3	297 mm HMAC
20	0160	1	Sandy Silt
		2	152 mm Treated Subbase
		3	178 mm Crushed Stone
		4	165 mm HMAC
20	0161	1	Sandy Silt
		2	152 mm Treated Subbase
		3	279 mm Gravel
		4	140 mm HMAC
20	0162	1	Sandy Silt
		2	152 mm Treated Subbase
		3	251 mm ATB
		4	38 mm HMAC
20	0163	1	Sandy Silt
		2	152 mm Treated Subbase
		3	203 mm Gravel
		4	64 mm ATB
		5	38.1 mm Plant Mix (Cutback Asphalt) Material, Cold Laid
20	0164	1	Sandy Silt
		2	152 mm Treated Subbase
		3	305 mm HMAC
39	0160	1	Silty Clay
		2	102 mm Crushed Stone
		3	277 mm ATB
		4	104 mm HMAC
40	0160	1	Sandy Clay
		2	Lime Treated Subgrade Soil
		3	137 mm Crushed Stone
		4	PATB
		5	HMAC

Table 2. Supplemental sections constructed on SPS-1 projects, continued.

SPS-1 Supplemental Sections			
STATE_CODE	SHRP_ID	LAYER_NO	Layer Description (from material codes)
48	0160	1	Silty Sand
		2	305 mm Lime Treated Subgrade Soil
		3	269 mm Limerock Asphalt
		4	145 mm HMAC
48	0161	1	Silty Sand
		2	305 mm Lime Treated Subgrade Soil
		3	211 mm Limerock Asphalt
		4	109 mm HMAC
48	0162	1	Silty Sand
		2	305 mm Lime Treated Subgrade Soil
		3	203 mm Crushed Limestone
		4	121.9 mm HMAC
48	0163	1	Silty Sand
		2	305 mm Lime Treated Subgrade Soil
		3	251 mm Crushed Limestone
		4	117 mm HMAC
48	0164	1	Silty Sand
		2	305 mm Lime Treated Subgrade Soil
		3	208 mm Crushed Concrete
		4	127 mm HMAC
48	0165	1	Silty Sand
		2	305 mm Lime Treated Subgrade Soil
		3	185 mm Crushed Concrete
		4	112 mm HMAC
48	0166	1	Silty Sand
		2	305 mm Lime Treated Subgrade Soil
		3	343 mm Limerock, Caliche
		4	142 mm HMAC
48	0167	1	Silty Sand
		2	305 mm Lime Treated Subgrade Soil
		3	8 mm Reinforcing Geogrid
		4	244 mm Limerock, Caliche
		5	122 mm HMAC
51	0159	1	Silty Clay
		2	152 mm Soil Cement
		3	188 mm Crushed Stone
		4	102 mm PATB
		5	140 mm Bituminous Bound Base
		6	86 mm HMAC

Table 3. Final factorial for the SPS-1 experiment design.

Subgrade Soil Type	Pavement Structure (Refer to Table 1)	Climate, Moisture—Temperature			
		Wet-Freeze	**Wet-No-Freeze**	**Dry-Freeze**	**Dry-No-Freeze**
Fine-Grained	Cells 1–12	Site Cell 1.A IA(1)—7.0 OH(2)—4.6	Site Cell 2.A	Site Cell 3.A KS(6)—5.8	Site Cell 4.A NM(0)—3.7
	Cells 13–24	Site Cell 1.B MI(1)—4.0 VA(1)—3.7	Site Cell 2.B	Site Cell 3.B NB(1)—4.1	Site Cell 4.B OK(2)—2.1 TX(8)—2.3
Coarse-Grained	Cells 1–12	Site Cell 5.A DE(2)—3.2	Site Cell 6.A FL(1)—3.7	Site Cell 7.A NV(0)—4.0	Site Cell 8.A
	Cells 13–24	Site Cell 5.B WI(0)—1.8	Site Cell 6.B AR(1)—5.7	Site Cell 7.B MT(0)—0.8	Site Cell 8.B AZ(5)—6.0

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.

In summary, a total of 248 SPS-1 sections have been built across the United States and Canada. At least one project is located within each site factorial cell. It is expected that those cells with missing companion projects can be compensated for through the use of mechanistic-empirical studies and proper analyses of the data. Thus, the completeness of the SPS-1 experiment is considered to be in overall good condition to meet the experimental objectives and expectations that were noted in chapter 1.

3. PROJECT REQUIREMENTS

Each SPS-1 project had to meet certain criteria. There were limitations on the methods and materials used in construction of the sections, as well as requirements for testing and continued monitoring. Each of these criteria is outlined in this chapter.

CONSTRUCTION MATERIAL REQUIREMENTS

Construction requirements were provided in the "Construction Guidelines" section of the *Specific Pavement Studies of Structural Factors for Flexible Pavements (SPS-1) Guide*.(4) The overall length of each section was required to be 183 m with 152.4 m for monitoring and 15.25 m on each end for materials sampling. The distance between each of these sections had to be long enough to allow sufficient space for changes in materials and thicknesses during construction. The suggested length for these transitions was 30.5 m.

Subgrade Requirements

The finished subgrade elevations were not to vary from the design by more than 12 mm. This was to be determined using rod and level readings taken on the lane edge, outer wheel path, midlane, inner wheel path, and the inside lane edge at 15-m intervals throughout the project. Surface irregularities were not to exceed 6 mm between two points in any direction in a 3.05-m interval. If a working platform at the top of the subgrade was required, adding lime, portland cement, or other suitable material to the subgrade to alter the index properties of the soil could create it. The strength of the subgrade was not to be unduly increased.

Base Layers

Two types of bases are included in each project—drained and undrained. The drained bases include a permeable asphalt treated base with edge drains. The undrained bases consist of dense graded materials. The undrained bases were used on sections 1–6 and 13–18, and were defined as dense graded aggregate base (DGAB), asphalt treated base (ATB), or a combination of these two materials. The requirements for the DGAB were as follows:

- Minimum 50 percent retained on the No. 4 sieve.
- 38-mm top-size aggregate, unless the State agency normally specified and used less than 38 mm.
- Less than 60 percent passing the No. 30 sieve and less than 10 percent of the total same passing the No. 200 sieve.
- Liquid limit less than 25 and plasticity index less than 4 for the fraction passing the No. 40 sieve.
- If the L.A. Abrasion test was used by the agency, the loss shall not exceed 50 percent at 500 revolutions.
- The compacted lift thickness must not be greater than 152 mm.
- The DGAB was to be compacted to at least 95 percent of maximum density.

- In-place density of the DGAB was to be determined prior to the application of an asphalt prime coat, if used.
- A prime coat of low viscosity asphalt cement was specified for use prior to placement of the permeable asphalt treated base (PATB) layer (on sections that include a PATB layer).
- Final DGAB elevations were not to vary from design by more than 12 mm, as measured using the rod and level measurements taken on the lane edge, outer wheel path, mid lane, inner wheel path, and inside lane edge at a 15-m interval.

The requirements for the ATB layer were as follows:

- The aggregate used in the ATB layer had to meet the same requirements as the aggregate for the DGAB layer.
- Asphalt emulsions were not allowed.
- Experimental modifiers were not to be used in the core test sections, but could be used in supplemental sections.
- No recycled AC was allowed in the ATB.
- If the Hveem mix design procedure was used by the SHA, the ATB mixture had to meet the following requirements:

Swell	0.7 mm
Stabilometer Value	35 min.
Moisture Vapor Susceptibility	25
Design Air Voids	3 to 5 percent

- If the Marshall mix design procedure was used, the ATB had to meet the following requirements:

Compaction blows	50
Flow	2 mm to 5 mm
Stability	4.4 kN
Air Void	3 to 5 percent

- A low-viscosity asphalt was to be used as a tack coat on top of the ATB prior to placement of the HMA surface material.
- A track paver was specified for placing the ATB on the PATB layer.
- The maximum compacted lift thickness of the first lift was not to exceed 152 mm, and subsequent lifts were not to exceed 102 mm.
- The minimum compaction requirement was 90 percent of the maximum theoretical specific gravity for the first lift and 92 percent for subsequent lifts. There was no maximum compaction requirement for any of the HMA lifts.
- Final ATB elevations were not to vary from design more than 12 mm, as measured using the rod and level.
- The base layer thickness was not to vary from design by more than 6 mm.

Sections 7–12 and 19–24 incorporate the drained bases. Each of these sections includes a PATB layer with edge drains to permit water to drain out of the pavement structure. The requirements for the PATB layer were as follows:

- An asphalt emulsion was not allowed as a binder for the PATB layer.

- The gradation for the PATB was to have no more than 2 percent passing the No. 200 sieve. The following gradation was recommended:

38 mm	100 percent
25 mm	95 to 100 percent
13 mm	25 to 60 percent
No. 4	0 to 10 percent
No. 8	0 to 5 percent
No. 200	0 to 2 percent

- More than 90 percent of the aggregate was to have at least one crushed face.
- No recycled AC was permitted in the PATB.
- A static steel wheel roller was specified for compacting the PATB layer.
- No portion of the PATB was to be day-lighted.
- Other than the paver and the roller, no other equipment was allowed to travel or park on the PATB.
- Transverse interceptor drains were to be placed in the transition zone between the drained and undrained base structure sections on the down slope end of the PATB layers. They were to be placed at least 30 m past the end of the test section.

Drainage Materials

Filter fabrics were to be used on sections that include PATB layers. These were specified to prevent clogging of the PATB layer. The filter fabrics used were to meet the American Association of State Highway and Transportation Officials-American Building Contractors-American Road and Transportation Builders Association Task Force 25 recommendations, which include the following requirements:

- Nonwoven or woven geotextile materials had to conform to Class B drainage applications. However, fabric used where the PATB was constructed as the first layer and for the transverse interceptor drains had to meet Class A requirements.
- For sections where the PATB layer was placed on the subgrade, the filter fabrics were to be placed directly on the subgrade and extend around the outside edge drain trench, across the travel lanes, and around the inside edge drain.
- For sections where the PATB layer was placed on the DGAB, the filter fabrics were to extend around each edge drain and wrap around the outer edge of the PATB layer, but did not need to extend the full-width of the lane.
- Filter fabrics were to be installed in accordance with the manufacturer's specifications.
- Exposure of the geotextiles to the elements between laydown and cover could not exceed 14 days.
- Any fabric that was damaged had to be repaired with a patch that extended 914 mm beyond the perimeter of the damage, unless the fabric was replaced.
- The fabric had to be overlapped a minimum of 610 mm at all longitudinal and transverse geotextile joints.

Edge drains were to be installed on sections containing a PATB layer to collect water draining from the permeable base. The requirements on these drains were as follows:

- Inside and outside edge drains had to be constructed for crowned pavements.
- Edge drains could be no closer than 914 mm to the edge of the travel lanes.
- The edge drains had to run continuously throughout the sections incorporating the PATB layers.
- The PATB was recommended for backfill around the edge drains; however, other open graded material could be used, if approved.
- Collector pipes had to be at least 76-mm-diameter slotted plastic pipes.
- Outlet pipes had to be a minimum 76-mm-diameter unslotted rigid plastic pipe.
- Drainage pipes were to be sized for the expected flows determined as part of design. Discharge outlet pipes were to be located at maximum intervals of 76.2 m. Outlets were to be at least 152 mm above the expected 10-year flow elevation of the collector ditches to prevent backflow.

It should be noted that the construction requirements did not include video inspection of the edge drains after construction of the project or site was completed.

HMA Layers

The HMA surface had to meet the following requirements, as a minimum:

- If a Marshall mix design method was used, then the mix had to meet the following requirements:

Compaction blows	75
Stability (Minimum)	8 kN
Flow	2 mm to 4 mm

- However, if a Hveem mix design method was used, then the mix had to meet the following requirements:

Stability (Minimum)	37
Swell (Maximum)	0.7 mm
Air Voids	3 to 5 percent

- No recycled materials were permitted in the HMA mixtures placed on the sections.
- The aggregate were to have a minimum 60 percent retained on the No. 4 sieve with two fractured faces, and a minimum sand equivalency of 45.
- The asphalt grade and characteristics were to be selected based on normal agency practice.
- The use of modifiers or experimental additives was discouraged in the main sections; however, these materials could be used in supplemental sections.
- Lift thicknesses could not exceed 102 mm.
- Longitudinal joints were to be staggered between successive lifts to avoid vertical joints.
- If a distinct surface course mix was used, then the same thickness was to be used on all sections on the project.
- The compacted thickness of any single layer had to be at least 51 mm.
- All transverse construction joints were to be placed outside the sections.
- The thickness of the AC layers (surface and binder) had to be within 6 mm of the thickness specified by the experiment design.

- The riding surface of the pavement had to be smooth. As a target, the as-constructed surface was to have a prorated profile index of less than 158 mm per 1,000 m, as measured by a California type profilograph.

The shoulders placed on these projects had to be a minimum of 1.2-m wide. If possible, the shoulders were to be paved full-width with the surface course to eliminate longitudinal joints. If this was not possible, then the shoulders were to be paved such that the longitudinal joint was to be at least 305 mm outside the travel lane.

Surface friction courses were allowed on the sections if these layers were required by the participating agency. The friction courses were required to be no thicker than 19 mm and were not to be considered as part of the AC thickness required for any specific test section in the experiment.

MATERIALS SAMPLING AND TESTING

Sampling and testing were required on each of the materials being placed. The materials characterization is necessary to evaluate differences between the sections and between projects within the experiment. The parameters measured are those used in most design procedures and those used to assess important performance characteristics of these materials.

A general sampling and testing plan was created for use as a guideline.(4) This guideline was then used to develop the sampling and testing plan specific to each project. Because each State was allowed to add supplemental test sections, the number of tests may vary from project to project (test numbers increasing with increase in test sections). These plans were created prior to the construction of each individual project and provided the location of each sample to be taken, where the sample should be sent, and the tests that were 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 the DGAB.
- Jar samples of the DGAB.
- Bulk samples of the PATB.
- Bulk samples of the ATB.
- Bulk samples of the asphalt mixes used in the surface and binder courses.
- Bulk samples of the asphalt cement used in all mixes.
- Cores of the ATB, asphalt binder (if present), and asphalt surface.

In addition to each of these samples, bulk samples were to be taken of the asphalt cement, aggregates, and uncompacted AC mixes to be stored long term. A series of auger probes were to be performed in the shoulder of each test section to a depth of 6 m. This allows for the 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 divided between FHWA and the SHAs. FHWA conducted the resilient modulus tests, creep compliance tests, and other associated tests. The associated tests are those for which the results are required prior to running the resilient modulus tests. For instance, the protocol for determining the resilient modulus on unbound materials is dependent upon the material classification. Table 4 lists the tests that were to be performed and the minimum number required.

MONITORING REQUIREMENTS

The monitoring of these projects includes several different types of data—distress surveys, deflection measurements, transverse profile measurements, friction measurements, and longitudinal profile measurements. Each of these measurements has different frequency requirements, as noted in the following paragraphs, but these frequencies have been revised over time. The detailed review on the data completeness and availability was based on the cited reference. There can be numerous reasons why a regional coordination office (RCO) was unable to satisfy the monitoring frequency requirements that were in place when a project was built. Some of these reasons are as follows:

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

Distress Surveys

A distress survey was to be performed on the sections within 6 months of construction. A manual distress survey is to be performed on the sections biennially, with the exception of the “weak” sections. These weak sections are numbers 1, 9, 13, and 21, and they are surveyed annually. [5] If necessary, the surveys may be postponed up to 1 year. In addition to the manual surveys, video distress surveys are performed.

Deflection Surveys

Deflection measurements are to be collected using a falling weight deflectometer (FWD) from 1 to 3 months after the project has been constructed.[6] Long-term monitoring of these projects is to be completed biennially, except for the “weak” sections. This testing can also be postponed up to 1 year if necessary. Sections 1, 9, 13, and 21 were to be tested every 6 months, but this testing can be postponed up to 6 months.

Table 4. Required testing for the SPS-1 experiment.

Material Type and Properties	LTPP Protocol	Minimum No. of Tests per Layer
Subgrade (when embankment ≥ 1.2 m)		
No Testing		
Subgrade		
Sieve Analysis	P51	6
Hydrometer to 0.001 mm	P42	6
Atterberg Limits	P43	6
Classification	P52	6
(visual-manual on thin-wall tubes)		18
Moisture-Density Relations	P55	6
Resilient Modulus	P46	6
Unit Weight (only if thin-wall tubes available)	P56	6
Natural Moisture Content	P49	6
Unconfined Compressive Strength	P54	6
(only if thin-wall tubes available)		
Permeability	P57	3
Permeability	P48	6
Embankment < 1.2 m		
Sieve Analysis	P51	6
Hydrometer to 0.001 mm	P42	6
Atterberg Limits	P43	6
Classification	P52	6
Moisture-Density Relations	P55	6
Resilient Modulus	P46	6
Natural Moisture Content	P49	6
Permeability	P48	6
Embankment ≥ 1.2 m		
Sieve Analysis	P51	6
Hydrometer to 0.001 mm	P42	6
Atterberg Limits	P43	6
Classification (visual-manual on thin-wall tubes)	P52	6
Moisture-Density Relations		18
Resilient Modulus	P55	6
Unit Weight (only if thin-wall tubes available)	P46	6
Natural Moisture Content	P56	6
Unconfined Compressive Strength	P49	6
(only if thin-wall tubes available)	P54	6
Permeability		
Permeability	P57	3
	P48	6
Unbound Granular Base		
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
Permeable Treated Asphalt Base		
Asphalt Content (Extraction)	P04	3

Table 4. Required testing for the SPS-1 experiment, continued.

Material Type and Properties	LTPP Protocol	Minimum No. of Tests per Layer
Extracted Aggregate:		
Gradation of Aggregate	P14	3
Asphalt Treated Base		
Core Examination/Thickness	P01	34
Bulk Specific Gravity	P02	34
Maximum Specific Gravity	P03	3
Asphalt Content (Extraction)	P04	3
Moisture Susceptibility	P05	3
Resilient Modulus	P07	9
Tensile Strength	P07	12
Extracted Aggregate:		
Specific Gravity:		
Coarse Aggregate	P11	3
Fine Aggregate	P12	3
Gradation of Aggregate	P14	3
National Aggregate Association (NAA) Test for Fine Aggregate Particle Shape	P14A	3
Asphalt Cement:	P21	3
Abson Recovery	P22	3
Penetration at 25 °C and 46 °C	P23	3
Specific Gravity at 16 °C	P25	3
Viscosity at 60 °C and 135 °C		
Asphalt Cement (from Tanker or Plant):	P22	3
Penetration at 25 °C and 46 °C	P23	3
Specific Gravity at 16 °C	P25	3
Viscosity at 60 °C and 135 °C		
Asphalt Concrete Surface and Binder		
Core Examination/Thickness	P01	60
Bulk Specific Gravity	P02	60
Maximum Specific Gravity	P03	3
Asphalt Content (Extraction)	P04	3
Moisture Susceptibility	P05	3
Creep Compliance	P06	3
Resilient Modulus	P07	18
Tensile Strength	P07	24
Extracted Aggregate		
Specific Gravity:	P11	3
Coarse Aggregate	P12	3
Fine Aggregate	P14	3
Gradation of Aggregate	P14A	3
NAA test for Fine Aggregate Particle Shape		
Asphalt Cement:		
Abson Recovery	P21	3
Penetration at 25 °C, 46 °C	P22	3
Specific Gravity at 16 °C	P23	3
Viscosity at 60 °C, 135 °C	P25	3
Asphalt Cement (from Tanker):		
Penetration at 25 °C, 46 °C	P22	3
Specific Gravity at 16 °C	P23	3
Viscosity at 60 °C, 135 °C	P25	3

Transverse Profiles

Transverse profile measurements are to be taken at the same frequency, and at the same time, as the distress surveys.[5] As part of a manual distress survey, the surveyor takes transverse profile measurements using a FACE Dipstick®. The PASCO units take automated transverse profile surveys in addition to the automated distress surveys.

Longitudinal Profiles

Longitudinal profile measurements are to be taken on the sections within 3 months after construction.[7] These measurements can be postponed up to 3 additional months. The “weak” sections (sections 1, 9, 13, and 21) are monitored every 6 months but monitoring can be postponed up to 6 additional months. The other sections are to be monitored biennially. These tests can be postponed up to 1 year, if necessary.

Friction Surveys

Friction measurements were to be taken from 3 to 12 months after the sections were constructed. Long-term monitoring is to be conducted biennially. However, as of January 1, 1999, friction measurements are no longer required on any test section.[8] These measurements are considered optional and the data are being stored in the national IMS database, if collected.

Traffic Data

Traffic data are to be collected on each of the projects as well. The current requirement states that weigh-in-motion (WIM) data are to be collected continuously on SPS-1 sections. Continuous data collection is defined as the “use of a device that is intended to operate throughout the year and to which the SHA 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.”[9] WIM devices are to be calibrated biannually. This level of data collection is considered necessary to provide accurate traffic loading measurements.

Climatic Data

Each SPS-1 project was to include the installation of an automated weather station (AWS).[10] The site is to be located close enough to the project to provide weather data that is representative of the weather on the project. The equipment installed at these locations includes a rain gauge. A desiccant, humidity indicator, and conduit putty are used to measure humidity. A wind monitor is included in the installation to measure wind speeds. Equipment also is included to determine the cloud cover and temperature at the site. All of this data is collected and stored by a datalogger. The data is downloaded from the datalogger at least every 6 months.

In addition to the AWS used to collect weather data, data are obtained from four to five National Oceanic and Atmospheric Association (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 includes information about the temperature, rainfall, wind, and solar radiation.

Each of the SPS-1 projects was supposed to meet these minimum requirements. Any deviation from these requirements could affect the results obtained from the analysis of the data. The next chapter examines how each of the SPS-1 projects have deviated from the requirements and how these deviations can be expected to affect the results that can be achieved from this experiment.

4. EXPERIMENT ASSESSMENT—
DATA AVAILABILITY AND COMPLETENESS

This chapter presents a summary of the SPS-1 experimental data and summarizes the level E data in the IMS based on the LTPP data collection guidelines at the time of the SPS-1 experimental review. Appendix A provides a brief discussion and summary of each SPS-1 project, including a review of the construction difficulties and project deviations from the experimental plan.

As stated in chapter 1, 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 flow chart showing the movement of data and the data quality checks through LTPP. This flow chart is useful for understanding why some of the key data that have been 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 type of 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 QC program that classifies each of the data elements into categories depending upon the location of the data in this QC process. Several components comprise the overall QC/QA plan used on the LTPP data as discussed below.

- **Collect Data**: Procedures for collecting data are documented for each module in the IMS. These procedures are intended to ensure that data are collected in similar format, amounts, conditions, etc.
- **Review Data**: Regional engineers review all data input into 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 the data are entered. The IMS contains mandatory, logic, range, data verification, and other miscellaneous checks that are invoked during input.

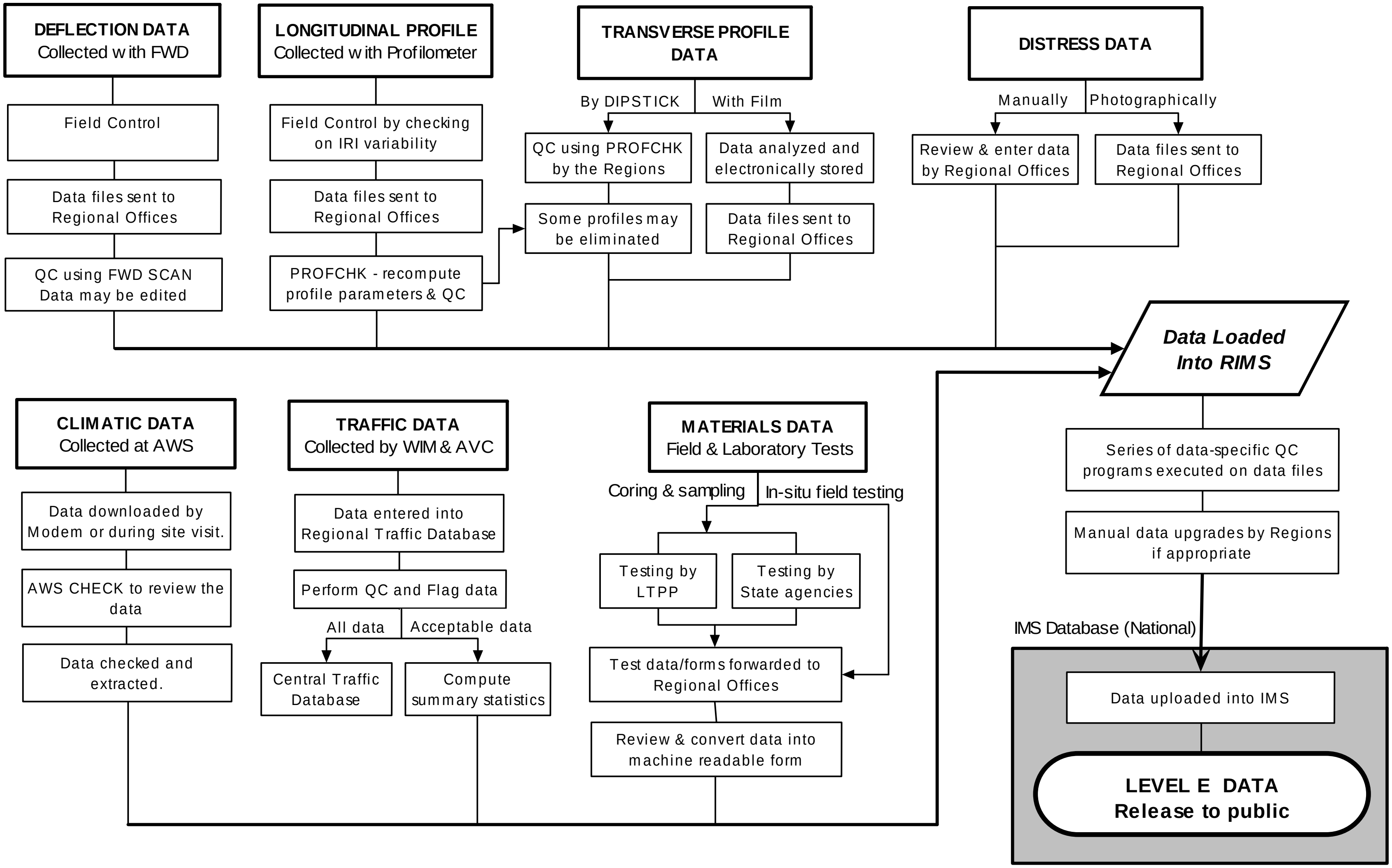


Figure 2. LTPP data collection and data movement flowchart.

- **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 National IMS (NIMS) data transfer.
    - Level B—A set of dependency checks are 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 in the process of incorporation 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 contains the coordinates of the section, that friction data contains the skid number, and that rehabilitation data has 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—Intramodular 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 regional engineers 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 regional engineer 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 prior to release 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 and 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. Since 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 numerous reasons why some data may be unavailable from the publicly released IMS database at the time the data were actually collected. Following are some examples:

- 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 States. 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 why that data did not pass all of the QC checks. Many of the reasons that prevent data from reaching Level E status are not the result of poor quality or unreliability of the data. The LTPP program is embarking on a systemwide effort to resolve all unavailable data so that future researchers can access them.

DATA ELEMENT CATEGORIES

All of the data elements included in the SPS-1 experiment were reviewed for their availability and completeness in the LTPP database as listed in table 5. The data elements were divided into three categories for the review process—essential, explanatory, and informational. Each category is defined briefly below.

- **Essential—**Data elements that are needed to accomplish the SPS-1 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 the experimental expectations, but are needed to explain any differences or anomalies in the performance observations.
- **Informational—**Data elements that are not needed or required to achieve the experimental objectives. These data elements would only provide information that may be needed for future and more generalized studies.

Although the review of the SPS-1 experiment included all data elements, the detailed review concentrated on those elements that were identified as essential and explanatory. 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, and are discussed in this chapter:

- General Site Information.
- Pavement Structure.
- Construction Data.
- Monitoring Data.
- Materials Data.
- Traffic Data.
- Climate.

Table 5. Summary of SPS-1 data elements and their importance to experimental expectations.

Module ID	Data Element	*Data Avail., %	Data Importance		
			Essential	Explanatory	Informational
Automated Weather Station (AWS)	Daily Max Temp	83			X
	Daily Min Tem				X
	Daily Mean Temp				X
	Maximum Avg Monthly Humidity				X
	Minimum Avg Monthly Humidity				X
	Monthly Precipitation		X		
	Number of Days with Precipitation				X
	Number of Days with Intense Precipitation				X
	Avg Daily Mean Solar Radiation by Month			X	
	Mean Monthly Temp				X
	Avg Min Monthly Temp			X	
	Avg Min Monthly Temp			X	
	Days >32 ºC			X	
	Days <0 ºC			X	
	Freeze Index		X		
	Number of Freeze-Thaw Cycles			X	
	Mean by Month of Avg Daily Wind Speed				X
Climatic (CLM)	Maximum Avg Annual Humidity	89			X
	Minimum Avg Annual Humidity				X
	Annual Precipitation		X		
	Number of Days with Intense Precipitation				X
	Number of Days with Precipitation				X
	Annual Snowfall				X
	Number of Days with Snowfall				X
	Mean Annual Temp				X
	Avg Max Annual Temp				X
	Avg Min Annual Temp				X
	Max Annual Temp			X	
	Min Annual Temp			X	
	Day >32 ºC			X	
	Days <0 ºC			X	
	Freeze Index		X		
	Annual Number of Freeze-Thaw Cycles			X	
	Mean Wind Speed				X
Maintenance (MNT)	Crack Sealing	0			X
	Patching	6			X
	Asphalt Seal	6			X
Monitoring (MON)	Deflections	100	X		
	Temp at Testing	94	X		
	Backcalculated Modulus	–	X		
	Manual Distress	100	X		
	PASCO Distress	50	X		
	Friction	38			X
	Longitudinal Profile	100	X		
	Transverse Profile	89	X		
Construction	Layer Thickness	94	X		
	Rod and Level Thickness	78		X	
	Asphalt Grade	72			X
	Aggregate Type	67			X
	Specific Gravity of Aggregate	56			X
	Compaction of the Asphalt	78			X
	Laydown Temp	72			X
	In Situ Density of Bound Layers	33		X	
	Mix Design Air Voids	67		X	

*Data Availability—percentage of SPS-1 required testing for which data generally are available in the database at Level E.

Table 5. Summary of SPS-1 data elements and their importance to experimental expectations, continued.

Module ID	Data Element	*Data Avail., %	Data Importance		
			Essential	Explanatory	Informational
Construction	Mix Design Asphalt Content	67		X	
	Design VMA	67		X	
	Design Effective Asphalt Content	89		X	
	Marshall Stability	39			X
	Marshall Flow	39			X
	Hveem Stability	11			X
	Hveem Cohesiometer	0			X
	Haul Distance	83			X
	Plant Type	89			X
	Paver Type	89			X
	Laydown Width	83			X
	Lift Thickness	89			X
	Subgrade Stabilization	39		X	
	Location	100			X
	Functional Class	100			X
	Elevation	100			X
	Cost	22			X
	Drainage Type	78	X		
	Shoulder Type	78			X
Traffic (TRF)	Estimated ESALs	22			X
	Estimated AADT	22			X
	W4 Tables	50	X		
	Monitored AVC	50	X		
	Monitored AADT	17		X	
	Monitored ESALs	39	X		
[Materials] Testing (TST)	Core Examination	85	X		
	Bulk Specific Gravity	67	X		
	Max Specific Gravity	65	X		
	Asphalt Content	67		X	
	Moisture Susceptibility	44		X	
	Asphalt Resilient Modulus	0		X	
	Ash Content of AC	44			X
	Penetration	67			X
	Asphalt Specific Gravity	67			X
	Viscosity	67		X	
	Aggregate Specific Gravity	67			X
	Aggregate Gradation	67		X	
	Fine Aggregate Particle Shape	39			X
	In Situ Density	83		X	
	Layer Thickness	67	X		
	Treated Base Type	17		X	
	Treated Base Compressive Strength	0			X
	Unbound Base Gradation	67	X		
	Unbound Base Classification	67	X		
	Unbound Compressive Strength of the Subgrade	33			X
	Unbound Base Permeability	39		X	
	Unbound Base Optimum Moisture	67		X	
	Unbound Base Max Density	67		X	
	Unbound Base Modulus	17		X	
	Unbound Base Moisture Content	50			X
	Subgrade Gradation	72	X		
	Subgrade Hydrometer Analysis	78	X		
	Subgrade Classification	78	X		

*Data Availability—percentage of SPS-1 required testing for which data generally are available in the database at Level E.

Table 5. Summary of SPS-1 data elements and their importance to experimental expectations, continued.

Module ID	Data Element	*Data Avail.%	Data Importance		
			Essential	Explanatory	Informational
TST	Subgrade Permeability	33		X	
	Atterberg Limits	78	X		
	Subgrade Max Density	83		X	
	Subgrade Modulus	83	X		
	Subgrade Moisture Content	72			X

*Data Availability—percentage of SPS-1 required testing for which data generally are available in the database at Level E.

GENERAL SITE INFORMATION

This assessment includes the site identification and location, key equipment installed at the site, the construction report's availability, and important dates associated with each of the SPS-1 projects. The information for this review was obtained from the site construction report, deviation report, or from the IMS tables entitled **EXPERIMENT_SECTION** and **SPS_ID**. All of the site level records for the 18 constructed SPS-1 projects are at Level E. These data records are complete, as noted in the project summary records presented in appendix A. Table 6 includes a summary of the site information and report availability for each of the projects.

Construction and deviation reports were available for review from all of the projects except Michigan, Wisconsin, and Montana. Montana and Wisconsin are new projects, while the Michigan project is 4 years old. The construction report for the Montana project has been drafted, but is awaiting additional construction information before submittal to LTPP and the Wisconsin construction report was submitted to LTPP after the review had been completed.

AWS equipment has been installed at all sites. However, WIM and Automated Vehicle Classification (AVC) equipment has not been installed at five of the project sites: Alabama, Delaware, Louisiana, Oklahoma, and New Mexico (see table 6). This is considered significant to the experiment, especially when trying to validate the more sophisticated mechanistic-empirical design-analysis procedures. Specifically, reliable and site-specific traffic data are considered vital to National Cooperative Highway Research Program (NCHRP) Project 1-37A, development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures.

Table 6. SPS-1 project site information and report availability.

Project	Region	Age, Years	Equipment Installed			Report Availability	
			AWS	WIM	AVC	Construction	Deviation
Delaware	NA	3.2	X			X	X
Virginia		3.7	X	X	X	X	X
Iowa	NC	7.0	X	X	X (5)	X	X
Kansas		5.8	X	X	X	X	X
Nebraska		4.1	X	X	X	X	X
Michigan		4.0	X	X	X		X
Ohio		4.6	X		X (4)	X	X
Wisconsin		1.8	X (3)	X (3)	X (3)	X (3)	X
Alabama	S	6.4	X			X	X
Arkansas		5.7	X	X	X	X	X
Florida		3.7	X	X	X	X	X
Louisiana		2.1	X			X	X
New Mexico		3.7	X			X	X
Oklahoma		2.1	X			X	X
Texas		2.3	X	X (6)	X (6)	X	X
Arizona	W	6.0	X	X	X	X	X
Montana		0.8	X	X (2)		X (2)	X
Nevada		4.0	X (1)	X	X	X	X

Notes: (1) The AWS for the Nevada project is linked to test sections 320100 and 320200 that are back-to-back.
(2) The Montana project has had a WIM system installed, but the data is on hold pending installation of the new traffic processing software. The construction report for the Montana project is in draft form and is awaiting additional construction information.
(3) The construction report for the Wisconsin project was submitted to LTPP after the review had been completed. In addition, AWS, WIM and AVC equipment have been installed recently, but no Level E data are available in the IMS.
(4) AVC data were submitted for the Ohio project in 1998, but were not at Level E in the January 2000 release of the database.
(5) AVC data were submitted for the Iowa project in 1993 and 1996, but are not at Level E.
(6) Traffic data have been collected for the Texas project, but those data are not included in the IMS.

DESIGN VERSUS ACTUAL CONSTRUCTION REVIEW

Chapter 3 presented a summary of the construction and specification requirements for each of the SPS-1 projects. Additionally, the Nomination Guidelines [(11)] and Construction Guidelines [(12)] for FHWA's *Guidelines for Nomination and Evaluation of Candidate Projects for Experiment SPS-1 Strategic Study of Structural Factors for Flexible Pavements* also established specific site selection criteria and key variable construction guidelines. The guidelines presented in both of these reports were developed to control quality and integrity of the SPS-1 experiment results and findings. Therefore, they should be considered in the construction adequacy evaluation and assessment.

One of the main objectives of this study was to identify any confounding factors introduced into the SPS-1 experiment regarding construction deviations 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-1 experiment and to determine if any deviation of the design parameters established for the design factorial will adversely affect the experimental expectations.

This section of the report evaluates the design versus the actual construction of key variables identified within the experimental factorial and the above-mentioned experiment guidelines.

Subgrade Soil

The type of subgrade soil is a key factor in the experimental design. Specifically, the SPS-1 experimental design called for half of the projects to be constructed on coarse-grained soils and the other half to be built over fine-grained soils. An additional requirement of the experiment was that all test sections at a site be constructed on the same type of soil (i.e., the same soil classification). Table 7 provides a summary of the subgrade soils and their classification in comparison to the original nomination (refer to table 1). As tabulated, only one of the sites (Texas) is now listed within a different experimental cell because the subgrade soils were found to be different than originally nominated.

Similarly, the subgrade soils on which these projects were built are relatively consistent for each of the core test sections at a site. In fact, there are only two projects where the subgrade classification varies between the different test sections at a project—Kansas and New Mexico. The test sections with the different soil classifications are noted in table 7 and show that 5 of the 18 test sections in Kansas are classified as coarse-grained subgrades, while only 1 of the 12 test sections in New Mexico is classified as coarse-grained. This subgrade variation is considered typical, and it is not believed that this deviation from the experiment requirement will have a detrimental impact in achieving the expectations of the SPS-1 experiment.

One major discrepancy was noted during the review process. All subgrades are classified by the RCO and this classification is entered into the **SPS1_LAYER** table, as shown in table 7. In some cases, this classification is different from the soil type identified on table **TST_L05B**. For example, Kansas, Nevada, and Texas have different classifications between tables **TST_L05B** and **SPS1_LAYER**. Thus, an additional check should be added to cross-reference the subgrade soil classification between the **TST_L05B** and **SPS1_LAYER** tables to ensure that the same data elements are consistent.

Climate

The SPS-1 experimental design called for each project to be located in one of four different climates: wet-freeze, wet-no-freeze, dry-freeze, or dry-no-freeze. The main purpose of this factor was to obtain SPS-1 projects in different climates, as well as a geographical distribution across the United States and Canada. Figure 1 provided a summary of the geographical distribution of these projects across the United States and Canada. Table 8 tabulates the average annual rainfall, mean annual air temperatures, and freezing index that have been measured, which define each site’s climatic zone.

Table 7. SPS-1 subgrade classification.

State	Nominated Soil Type	From TST L05B Soil Type	No. Sections	Class.OK?	From SPS1 LAYER table
AL	Fine	Silty Clay	15	X	Silty Clay
AZ	Coarse	Well-Graded Sand with Silt and Gravel	3	X	Silty Sand
		Silty Sand with Gravel	7		
		Clayey Sand with Gravel	1		
		Well-Graded Gravel with Silt and Sand	5		
AK	Coarse	Clayey Sand	12	X	Clayey Sand
DE	Coarse	Poorly Graded Sand	14	X	Silty Sand
FL	Coarse	Silty Sand with Gravel	9	X	Poorly Graded Sand
		Poorly Graded Sand with Silt and Gravel	4		
IA	Fine	Clay	1	X	Sandy Clay
		Clay with Gravel	8		
		Clay with Sand	2		
		Lean Clay with Sand	1		
		Silty Clay	1		
KS	Fine	Clay with Sand	7	X	Sandy Silt
		Sandy Clay	4		
		Silty Clay	2		
		Sand	1		
		Silty Sand	4		
LA	Fine	Clay	12	X	Silty Clay
MI	Fine	Sandy Clay	13	X	
MT	Coarse	Poorly Graded Sand with Silt	12	X	Silty Sand
NE	Fine	Silty Clay	12	X	Silty Clay
NV	Coarse	Silty Sand	6	X	Silt
		Clayey Sand	6		
NM	Fine	Lean Inorganic Clay	1	X	Clay, Liquid Limit > 50
		Fat Inorganic Clay	4		
		Lean Clay with Sand	2		
		Fat Clay with Sand	1		
		Sandy Lean Clay	1		
		Sandy Fat Clay	2		
		Clayey Sand	1		
OH	Fine	Silty Clay	13	X	Silty Clay
OK	Fine	Sandy Clay	13	X	Sandy Clay
TX	Coarse	Sandy Silt	20	NO	Silty Sand
VA	Fine	Fat Clay with Gravel	3	X	Silty Clay
		Silty Clay with Sand	1		
		Gravelly Silty Clay	1		
		Sandy Silty Clay with Gravel	5		
		Silt	1		
		Sandy Silt with Gravel	2		
WI	Coarse				Silty Sand

Table 8. Summary of key factor values for the SPS-1 projects.

Climate	Subgrade Soil	Project ID	Type of Subgrade Soil	Average Annual Rainfall, mm	Mean Annual Air Temp. °C	Freeze Index °C-Day	Age, Years	AWS, Days	WIM, Days	Estimated KESALs, Year
Wet-Freeze	Fine-Grained	IA	Clay	982	10.8	235	7.0	815	108	130
		MI	Sandy Clay	870	8.6	283	4.0	670	250	?
		OH	Silty Clay	972	10.1	207	4.6	1,600	0(1)	?
		VA	Silty Clay	1,142	14.1	38	3.7	1,299	313	?
	Coarse-Grained	DE	Poorly Graded Sand	1,145	13.3	58	3.2	1,200	0	203
		WI	Silty Sand	?	?	?	1.8	0(2)	0	?
Wet-No-Freeze	Fine-Grained	AL	Silty Clay	1,340	17.3	9	6.4	1,394	0	237
		LA	Clay	1,538	12.9	2	2.1	300	0	524
	Coarse-Grained	AR	Clayey Sand	1,224	15.6	47	5.7	1,100	89	170
		FL	Silty Sand	1,325	23	0	3.7	800	342	1,463
Dry-Freeze	Fine-Grained	KS	Clay	627	12.9	136	5.8	1,000	232	?
		NE	Silty Clay	785	11	228	4.1	1,024	531	119
	Coarse-Grained	MT	Poorly Graded Sand	317	7.6	200	0.8	370	0(3)	?
		NV	Clayey Sand	223	9.7	156	4.0	0(4)	338	799
Dry-No-Freeze	Fine-Grained	NM	Clay	290	15.4	5	3.7	1,075	0	393
		OK	Sandy Clay	869	15.9	45	2.1	400	0	280
		TX	Sandy Silt	561	23.3	1	2.3	187	0	10
	Coarse-Grained	AZ	Silty Sand	241	18.3	1	6.0	1,480	1,588	185

Notes:
(1) 278 WIM days were submitted for the Ohio project in 1998, but data are not available for review.
(2) AWS equipment is installed at the site, but no data are available in the January 2000 IMS.
(3) See Montana note 2 at the bottom of table 6.
(4) AWS for the Nevada project is linked to test sections 320100 and 320200.

The general climatic data include actual measurements from at least one nearby weather station for each LTPP site. In addition, a site-specific statistical estimate, based on as many as five nearby weather stations, is available 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 weather stations and actual weather stations are kept off-line. General environmental data available in the IMS are derived from weather data originally collected from the NOAA.

AWS equipment is installed at every SPS-1 project site (refer to table 6). The AWS provides site-specific information for the same parameters as the general environmental tables, but these data are available with monthly, daily, or hourly statistics. The number of days from the AWS at each project site is summarized in table 8. An appreciable amount of climatic data has been collected from the AWS.

The SPS-1 project sites include a wide range of freezing index, temperatures, and annual rainfall, as originally planned. Those sites with an average annual rainfall greater than 1,000 mm are classified as wet and those sites with less than 1,000 mm are classified as dry. Similarly, the sites with a freezing index greater than 60 ºC-days would be classified as a freezing climate and those with less than 60 ºC-days would be designated as a no-freeze climate. It should be noted that the values used to determine the specific climatic cell assignment are arbitrary and 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, while an annual rainfall of 508 mm is used in the latest version of DATAPAVE® for designating the site as wet or dry. A freezing index value of 60 ^{o}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.

Using these definitions, some sites do not appear to be in the correct experimental cells. For example, Iowa, Michigan, and Ohio all have average annual rainfalls less than 1,000 mm, but are in the experimental cells designated as a wet climate. It is expected that the average rainfall at the project sites will increase with time. Similarly, Virginia was originally nominated for a freezing climate but has an average freezing index of 38 ^{o}C-days since construction. It is expected that the average freezing index at this site will increase over time.

All sites are in compliance with the appropriate cell requirements based on the NOAA and historical data. As a result, the climate designations have not been changed on the basis of a few years' worth of data. These relatively small differences in the average rainfall and freezing index are not considered detrimental to achieving the SPS-1 experimental objectives or expectations. The experimental sites still represent a diverse range of climates across the United States and Canada, as originally planned.

Layer Thickness/Structure

The pavement structure data are divided into two elements—layer data and design features. Important general design features such as drainage, lane width, and shoulder type are included in table **SPS_GENERAL**. All of the key design feature data are available for all of the SPS-1 test sections, and all are at Level E.

The pavement layer data for the SPS-1 test sections are available from two different sources. These two sources include the rod and level measurements (IMS Table **SPS1_LAYER**) and thicknesses from the cores recovered on-site (IMS Table **TST_L05B**). Both of these tables were examined to evaluate the thickness measurements and variation of the layer thickness data for each of the structural layers within the SPS-1 cross-sections. The average thickness of each layer is provided in appendix B for all of the projects for which data are available. The **TST_L05B** table contains records for all layers for 17 of the 18 projects. Layer information on Wisconsin has yet to become available because this project is new and the data have not undergone the QC process.

The **SPS1_LAYER** table contains all layer data for the 14 SPS-1 projects that are at Level E. The projects from which construction data do not exist are Wisconsin, Michigan, Montana, and Nebraska. The Montana and Wisconsin projects are relatively new; the data have been collected, but have not passed the entire QC process

In general, the average layer thicknesses for each layer were as originally planned within the construction guidelines for the SPS-1 experiment. The one construction element that was not satisfied included the layer thickness deviations from the planned thickness within the experiment. On every test section and project, the variation of the layer thicknesses was greater than the maximum value identified in the construction guidelines (refer to chapter 3). It is believed that the construction guidelines called for a tolerance that was impractical.

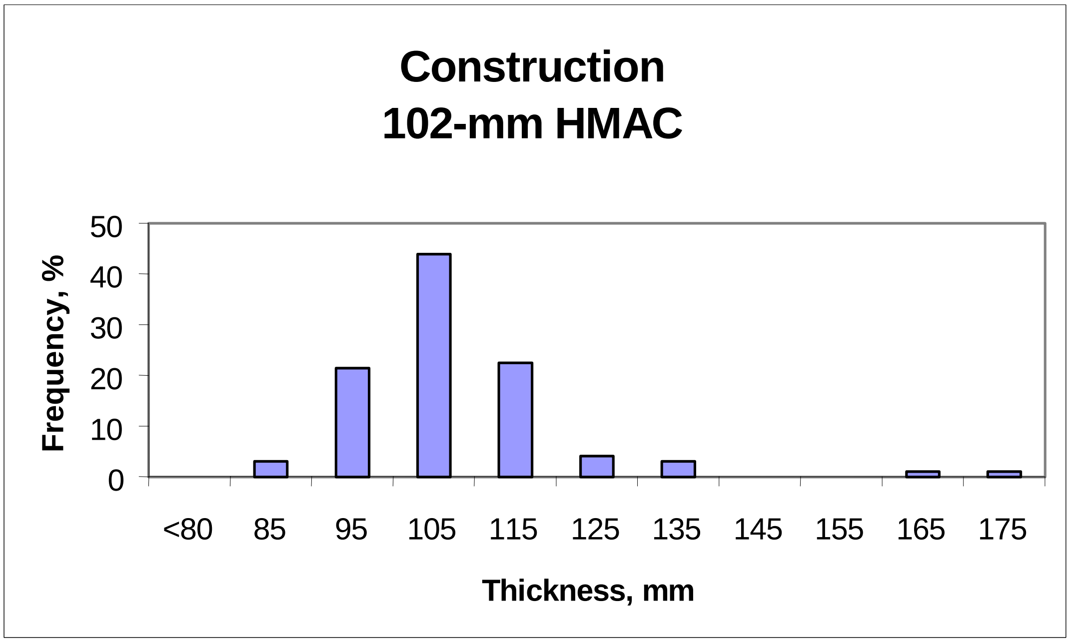
Histograms for each layer type and thickness level were prepared to review the distribution of layer thicknesses for all projects. Examples of these histograms are included in figures 3 through 10. Each figure includes the distribution of layer thicknesses as included in table **TST_ L05B** and from the construction data or table **SPS1_LAYER**. As shown, the distributions between the different thickness methods are very similar, and the average values from those thickness determination methods are approximately equal. These thickness variations (or histograms) represent typical construction practices, and all data sets are normally distributed (with the possible exception of the thin [102-mm] DGAB layer). This variation of layer thickness, which is greater than required by the construction guidelines, is not believed to be a detriment to the experiment or to prevent the experimental objectives from being met. None of the thickness data sets for the same material overlap (e.g., 102 mm versus 178 mm for the HMA layers).

The pavement cross-section and material types planned for each test section within the core experiment of each project were generally met and adhered to based on the construction guidelines. The only deviation to the planned cross-sections was for the Iowa project, where a DGAB layer was placed beneath the PATB layer on one of the test sections. This is not believed to have a significant effect on the experiment.

MATERIALS TESTING

Field and laboratory tests were conducted to establish the properties of each material included in the SPS-1 experiment. The material properties and the variation of those properties, both between and within the test sections, are required to evaluate and explain causes of performance differences between the test sections. Many of these properties or material characteristics are those that are currently used in existing pavement design and analysis methods.

The material sampling and testing requirements are documented in the SPS-1 materials sampling and testing guidelines report.[4] This report contains the development of the SPS-1 sampling and testing plans, field material sampling and testing requirements, and laboratory materials testing requirements for each SPS-1 project site. SPS-1 materials sampling and testing plans for the subgrade and base materials are provided in chapter 3. In addition, the testing requirements for each of the materials are designated in appendix A.



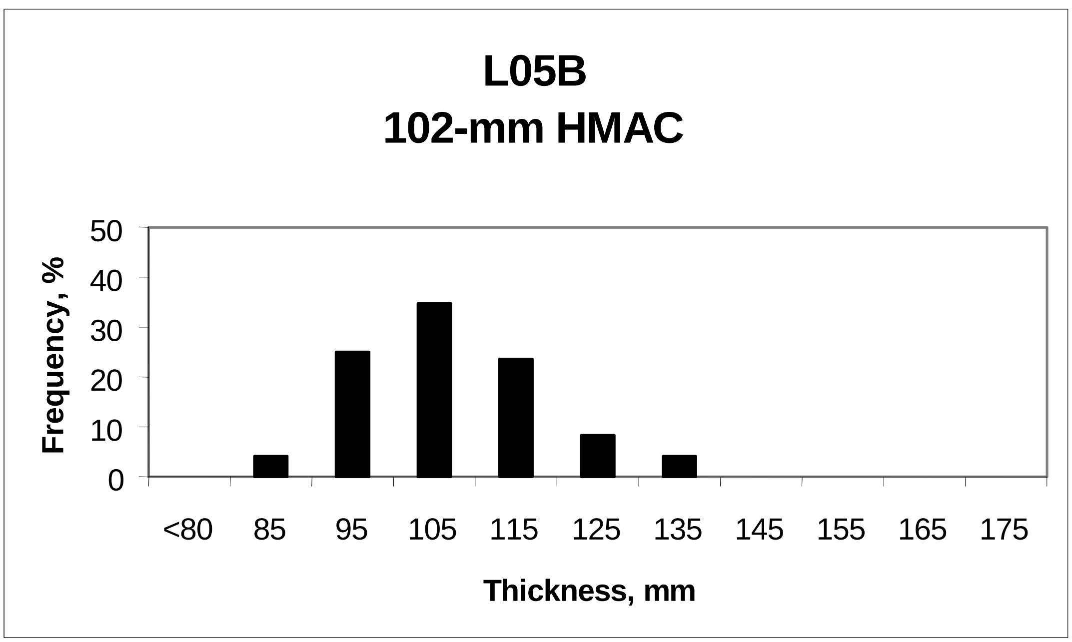
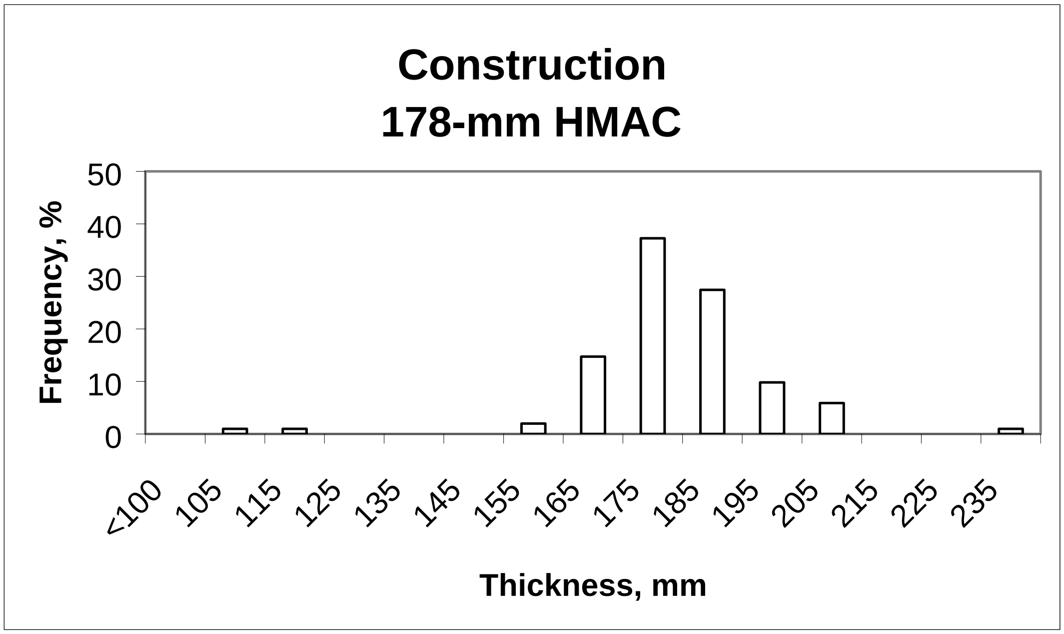


Figure 3. Thickness histograms for the thin HMA layer (102 mm) from tables SPS1_LAYER (construction data) and TST_L05B.



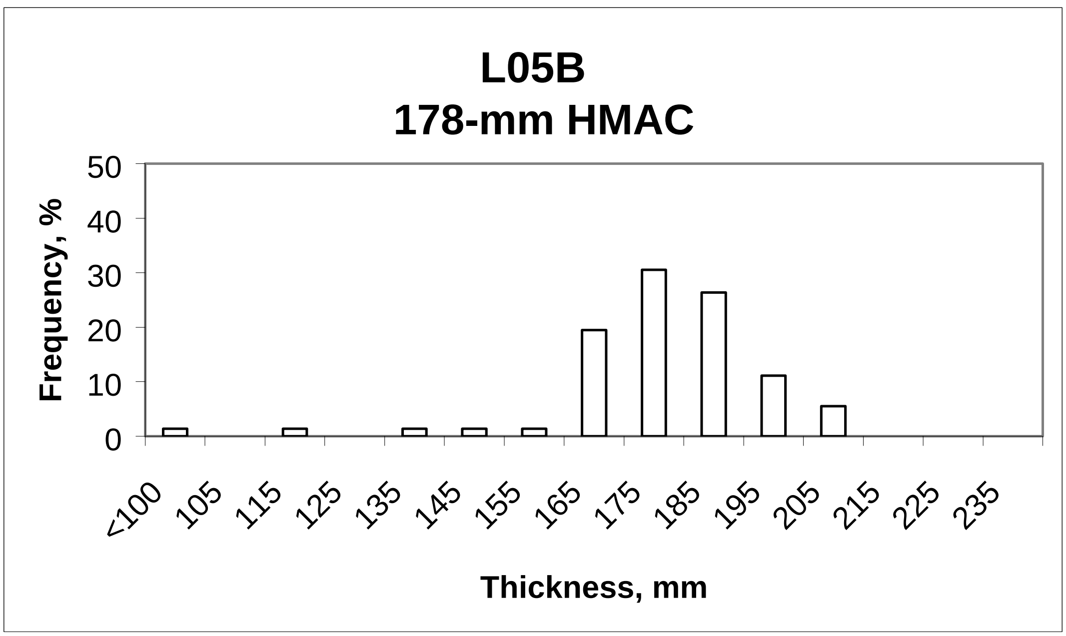
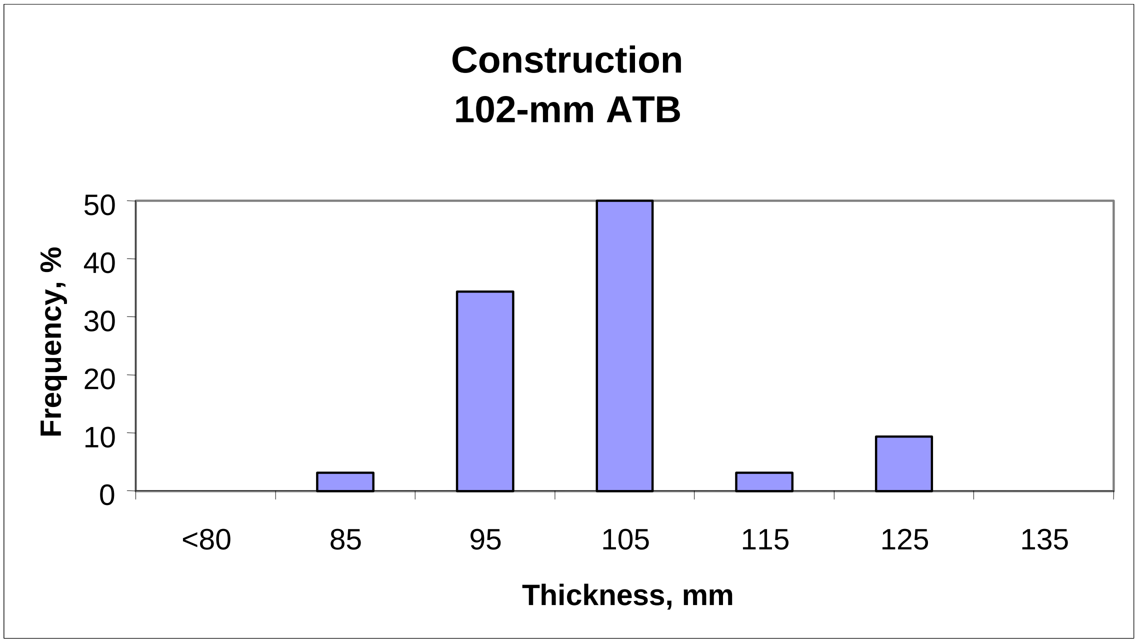


Figure 4. Thickness histograms for the thick HMA layer (178 mm) from tables SPS1_LAYER (construction data) and TST_L05B.



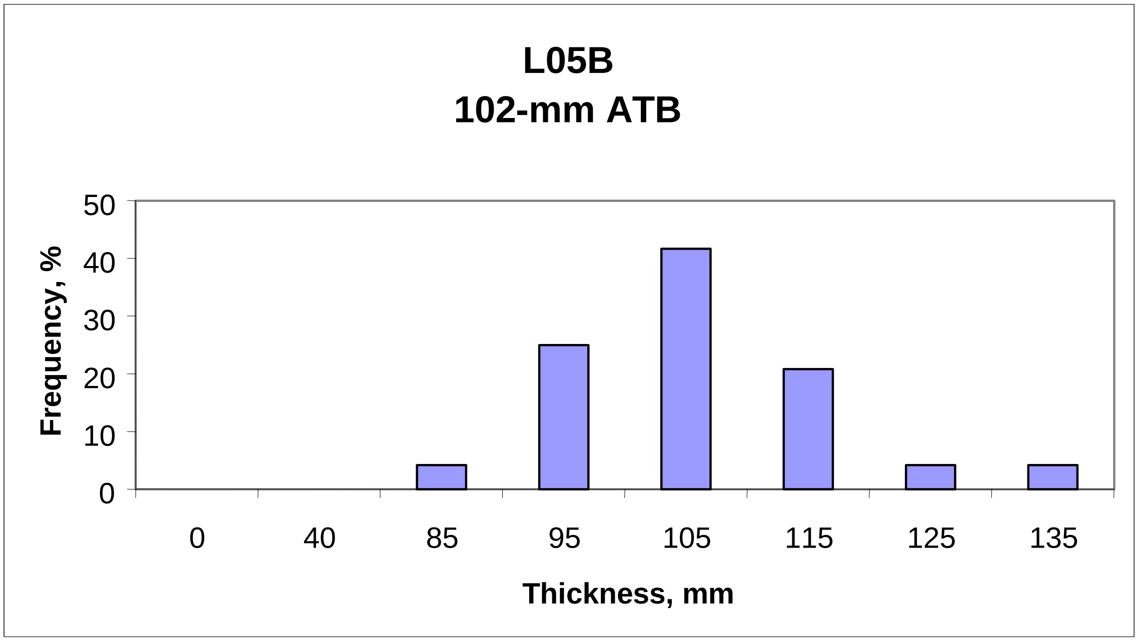


Figure 5. Thickness histograms for the thin ATB layer (102 mm) from tables SPS1_LAYER (construction data) and TST_L05B.

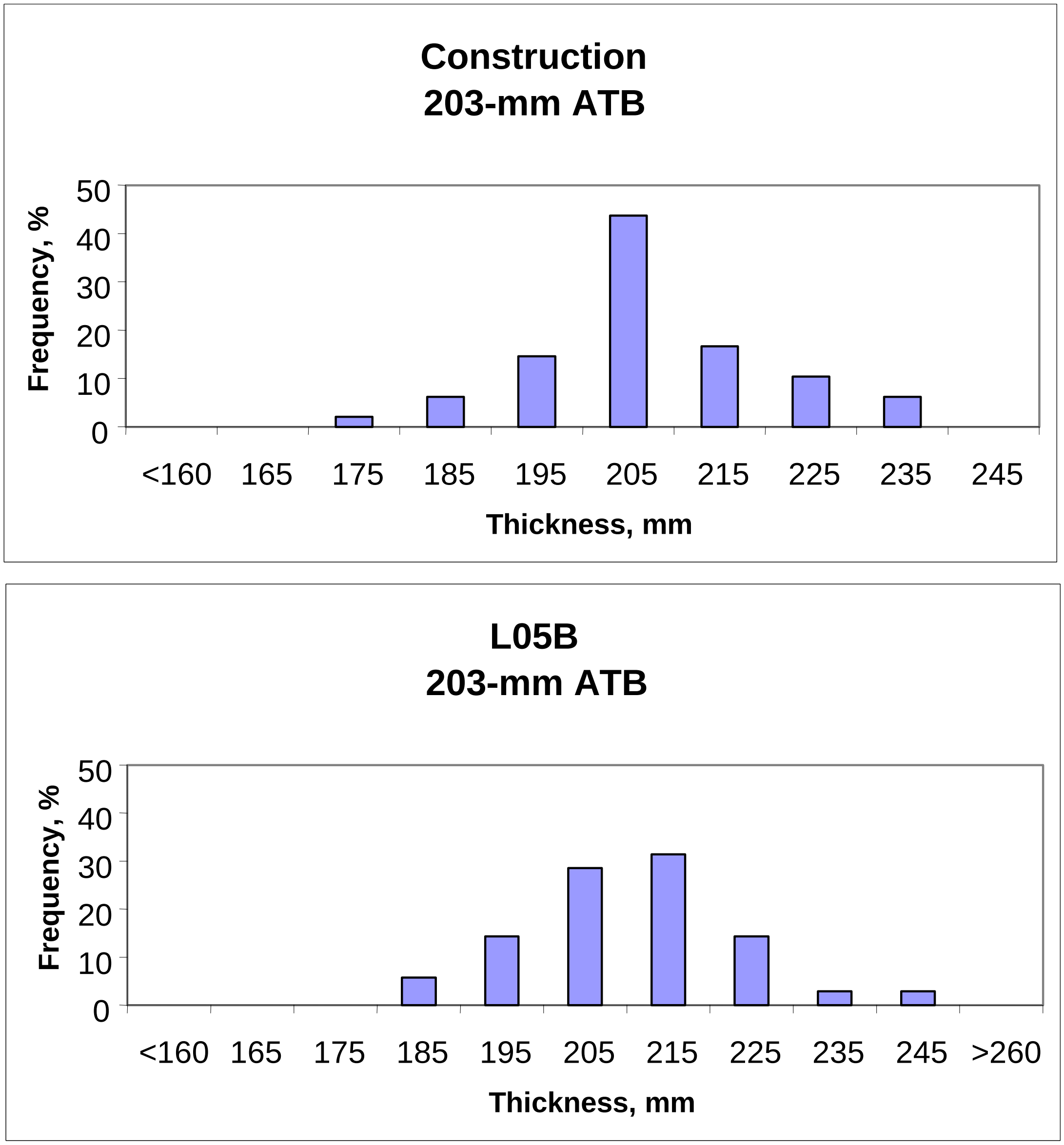
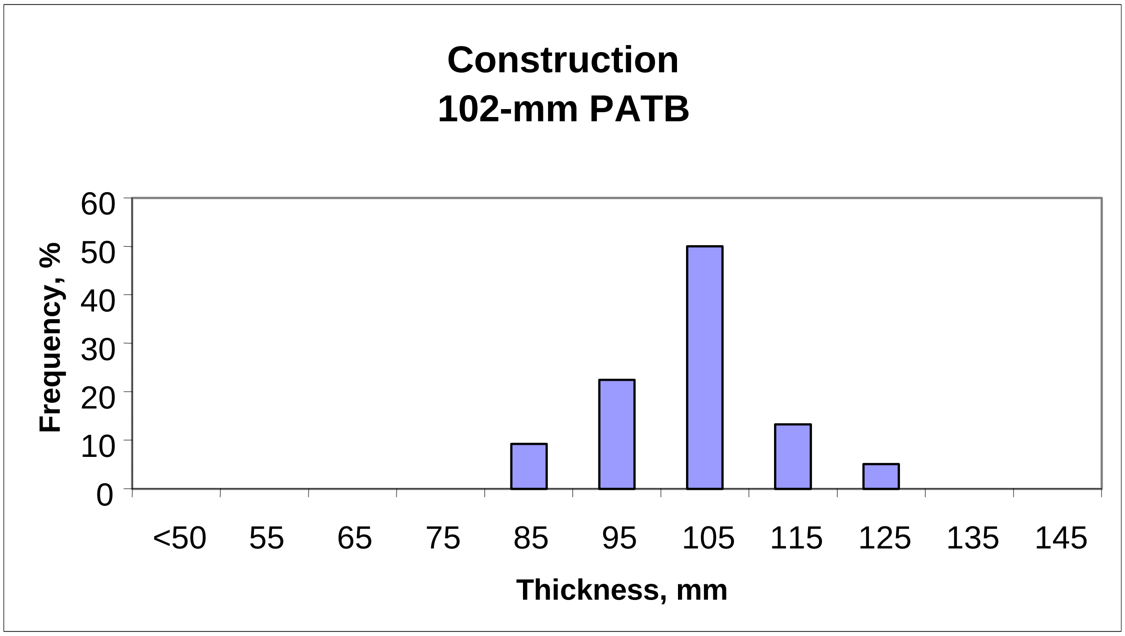


Figure 6. Thickness histograms for the thick ATB layer (203 mm) from tables SPS1_LAYER (construction data) and TST_L05B.



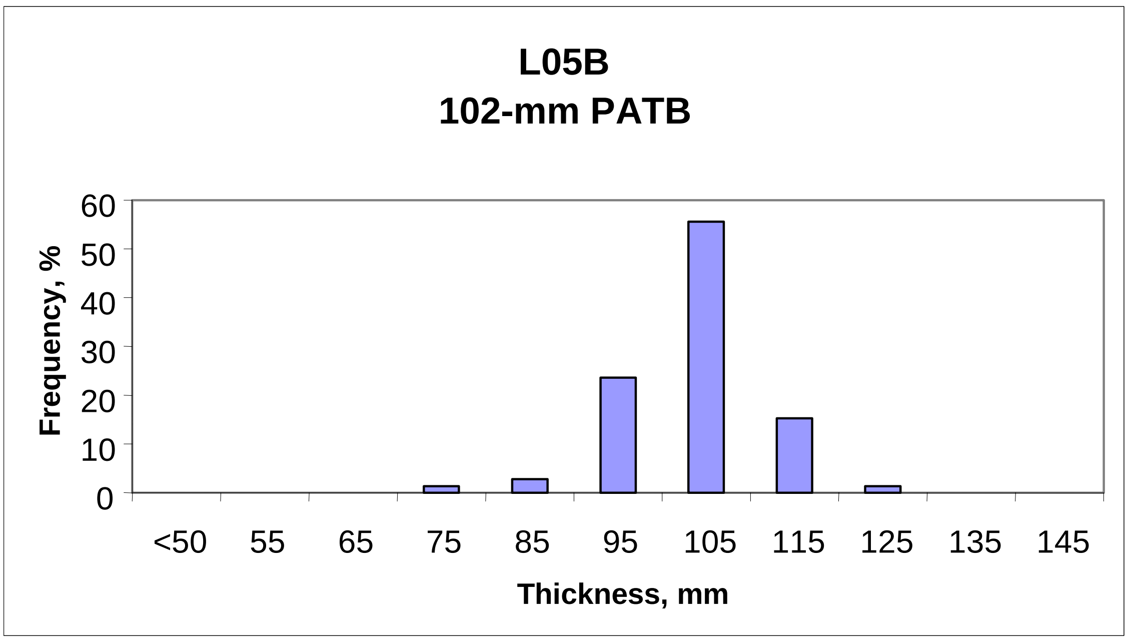
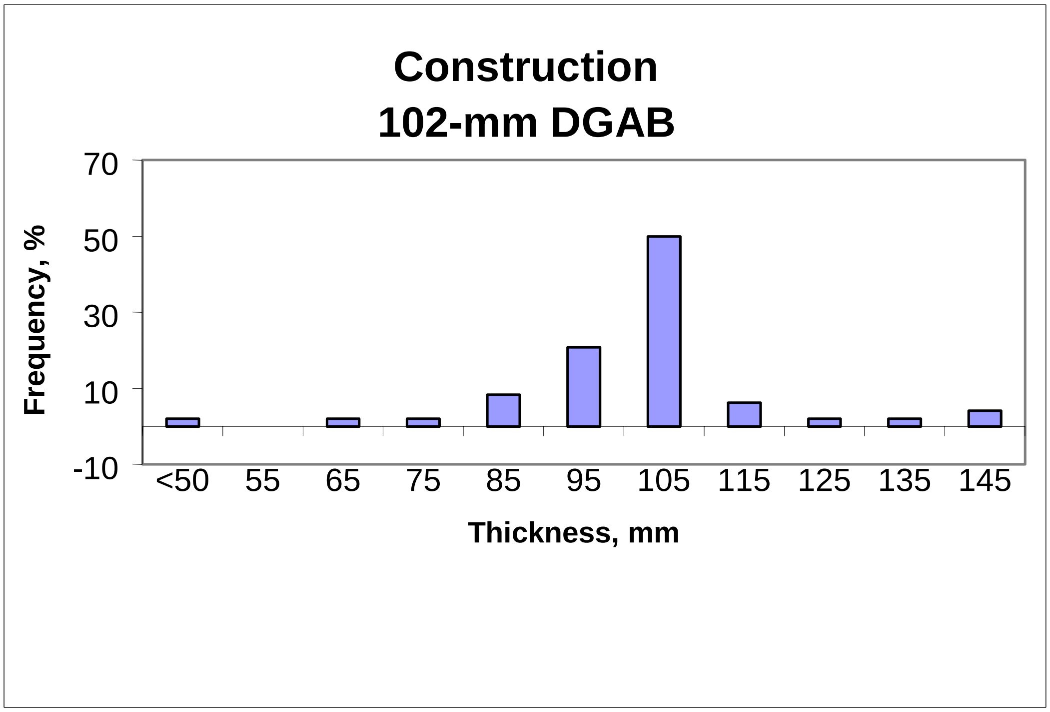


Figure 7. Thickness histograms for the PATB layer from tables SPS1_LAYER (construction data) and TST_L05B.



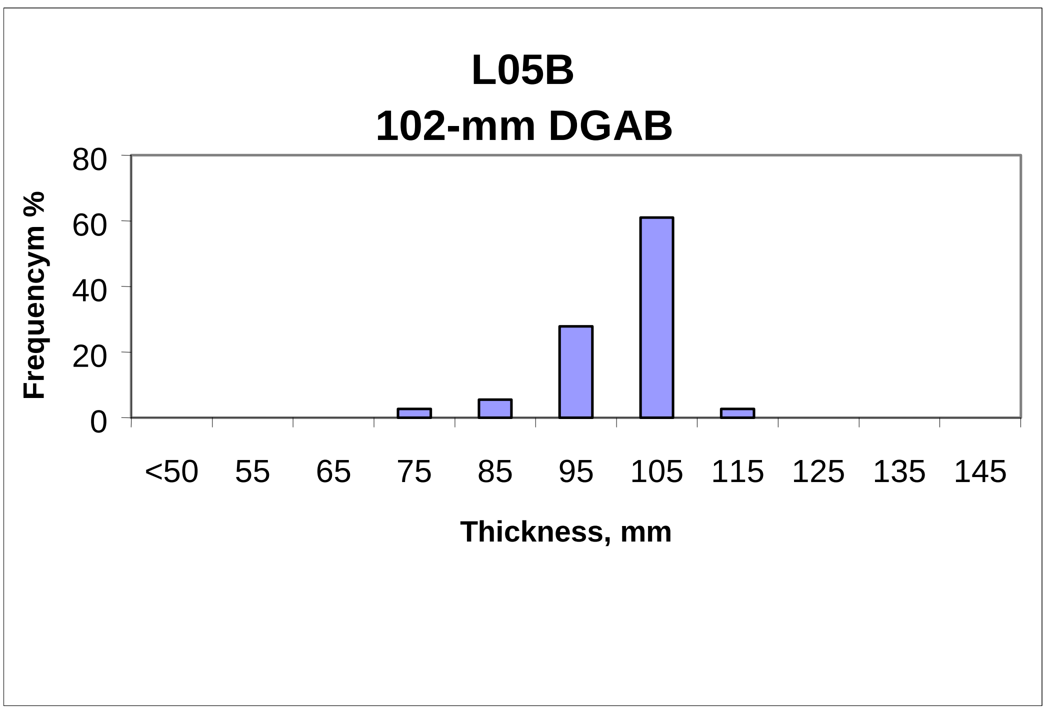
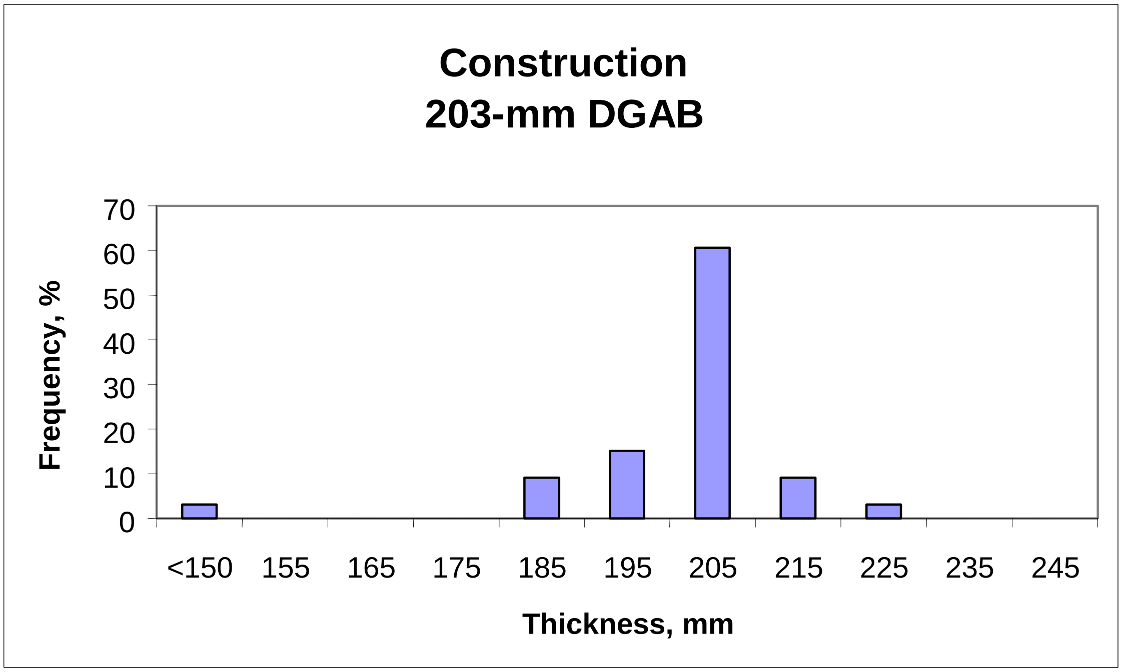


Figure 8. Thickness histograms for the 102-mm DGAB layer from tables SPS1_LAYER (construction data) and TST_L05B.



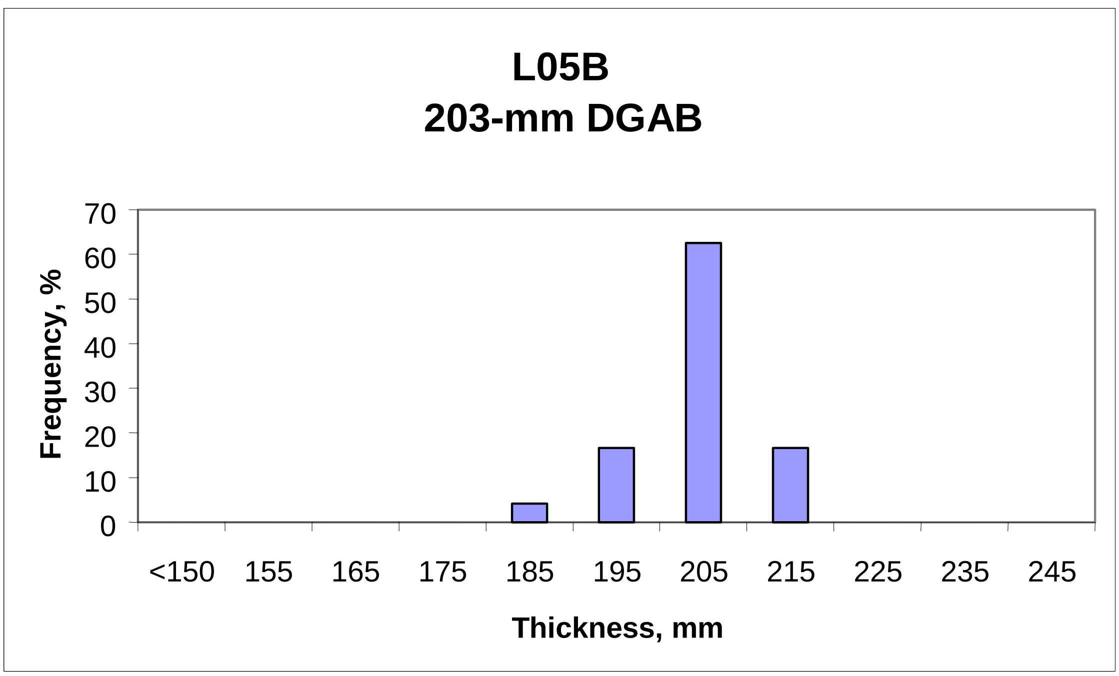
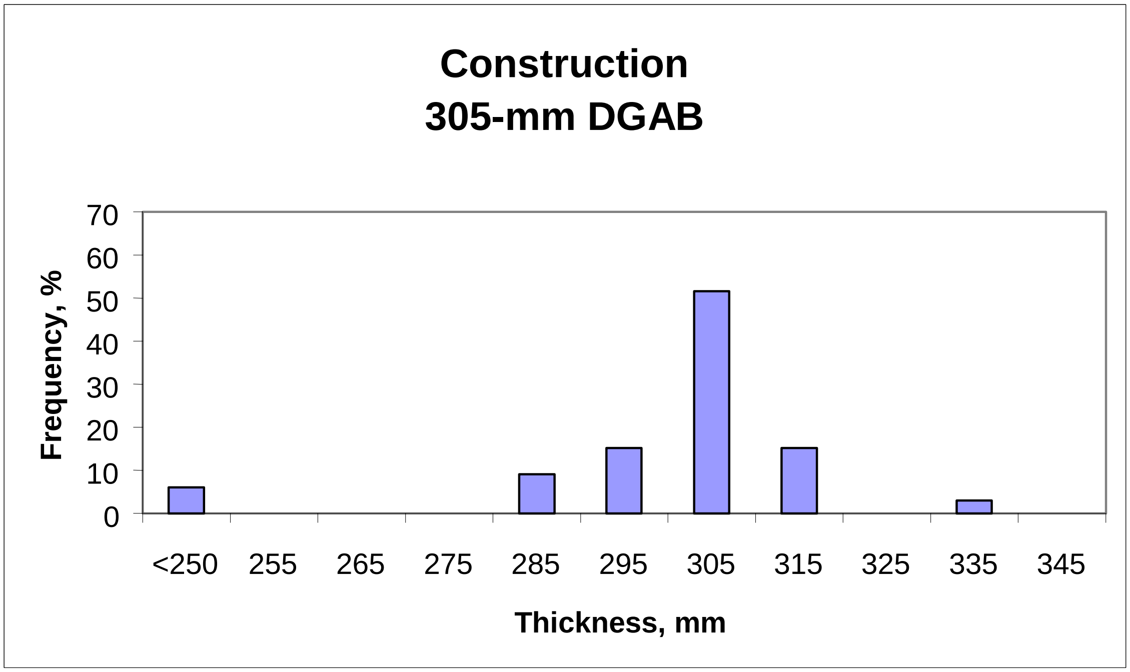


Figure 9. Thickness histograms for the 203-mm DGAB layer from tables SPS1_LAYER (construction data) and TST_L05B.



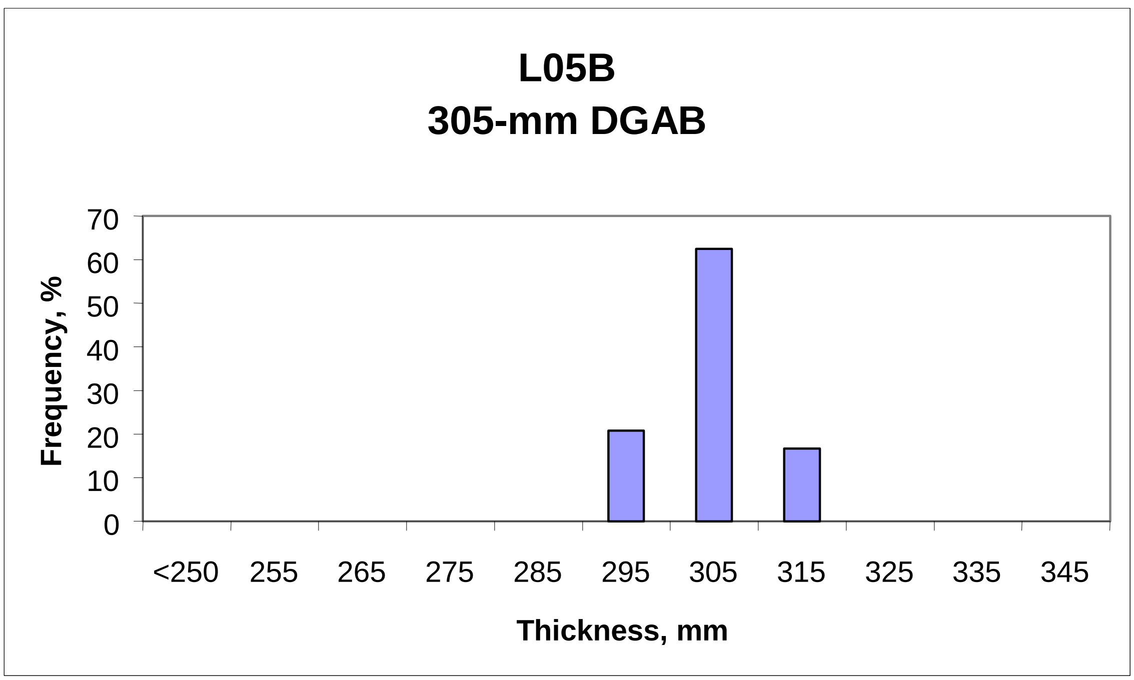


Figure 10. Thickness histograms for the 305-mm DGAB layer from tables SPS1_LAYER (construction data) and TST_L05B.

Tables 9 through 13 summarize the available test data from selected tests by material type for each of the projects while table 14 provides a summary of the overall materials testing completed for the core test sections. As shown, there is still a substantial amount of testing that needs to be completed to fill the experiment, even for those data elements or material properties identified as essential (refer to table 5). If this testing is not completed (at least for the essential data elements), the missing laboratory test results from most of the SPS-1 projects will have a detrimental impact on the experiment for achieving the experimental objectives and expectations.

To evaluate the relative difference in construction or the in-place properties, histograms of different material properties were prepared. Figures 11 through 13 show the variation of air voids in the different HMA and ATB layers. As shown, these variations are substantial enough to cause a significant difference in performance. In fact, some of the air voids are greater than 10 percent, which indicates inadequate compaction or other mixture problems. These differences in air voids need to be considered and accounted for in any evaluation or analysis of the performance data.

The material test data that are available were further reviewed to evaluate other material and construction variations between and within the different cells of the experiment. Figures 14 and 15 show the gradation test results for the percentage passing the number 4 and 200 sieves for the PATB material. As illustrated, there are only a small percentage of the tests where the measured gradation may significantly restrict the layer's capacity to remove any surface water infiltration quickly. Figures 16 and 17 show other typical examples of the variability in the percentage passing the number 200 sieve for the HMA surface and ATB layers that exists in this SPS-1 experiment.

This variability is typical for the other materials using standard construction practices for each specific material. These test results suggest that the materials used in construction have similar physical properties.

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 the traffic. For the SPS-1 experiment, traffic data are collected at the project site using a combination of permanent and portable equipment by the individual States and Provinces.

The SPS-1 experiment design calls for continuous WIM monitoring, as permitted by WIM scale operating divisions. Table **TRF_MONITOR_BASIC_INFO** was examined to identify the SPS-1 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."

Table 9. Summary of materials testing on the subgrade soils.

Project	Age, years	Subgrade Soil Testing—Percent Complete				
		Gradation	Atterberg Limits	Moist.-Den. Relations	Resilient Modulus	Permeability
Iowa	7.0	0	0	0	100	0
Alabama	6.4	100	100	100	100	0
Arizona	6.0	100	100	100	35	0
Kansas	5.8	0	100	100	50	0
Arkansas	5.7	100	100	100	0	0
Ohio	4.6	0	0	0	0	66
Nebraska	4.1	100	100	100	80	33
Michigan	4.0	35	35	35	85	0
Nevada	4.0	100	100	100	100	50
Florida	3.7	100	100	100	100	100
New Mexico	3.7	100	100	100	100	100
Virginia	3.7	100	100	100	0	100
Delaware	3.2	0	0	0	100	0
Texas	2.3	60	0	0	100	0
Oklahoma	2.1	100	35	0	100	0
Louisiana	2.1	100	60	100	100	0
Wisconsin	1.8	0	0	0	0	0
Montana	0.8	0	0	0	0	0

Table 10. Summary of materials testing on the unbound aggregate base materials.

Project	Age, years	Unbound Aggregate Base Testing—Percent Complete				
		Gradation	Atterberg Limits	Moist.-Den. Relations	Resilient Modulus	Permeability
Iowa	7.0	33	0	33	0	0
Alabama	6.4	100	0	67	0	0
Arizona	6.0	100	100	100	35	0
Kansas	5.8	0	0	0	0	0
Arkansas	5.7	0	0	0	0	0
Ohio	4.6	33	0	0	0	66
Nebraska	4.1	0	100	100	0	0
Michigan	4.0	66	66	66	0	0
Nevada	4.0	100	0	0	0	100
Florida	3.7	66	66	66	0	0
New Mexico	3.7	0	0	0	0	100
Virginia	3.7	100	100	0	0	0
Delaware	3.2	0	0	0	0	66
Texas	2.3	0	0	0	100	0
Oklahoma	2.1	0	0	0	0	0
Louisiana	2.1	0	0	0	33	0
Wisconsin	1.8	0	0	0	0	0
Montana	0.8	0	0	0	0	0

Table 11. Summary of materials testing on the permeable asphalt treated base mixtures.

Project	**Age, years**	**Permeable Asphalt Treated Base Testing—Percent Complete**	
		Asphalt Content	**Gradation**
Iowa	7.0	100	100
Alabama	6.4	0	0
Arizona	6.0	100	100
Kansas	5.8	0	0
Arkansas	5.7	0	0
Ohio	4.6	100	100
Nebraska	4.1	67	100
Michigan	4.0	0	0
Nevada	4.0	0	0
Florida	3.7	33	33
New Mexico	3.7	33	33
Virginia	3.7	100	100
Delaware	3.2	66	66
Texas	2.3	0	0
Oklahoma	2.1	100	100
Louisiana	2.1	0	0
Wisconsin	1.8	0	0
Montana	0.8	0	0

Table 12. Summary of materials testing on the asphalt treated base mixtures.

Project	**Age, years**	**HMA Testing—Percent Complete**					
		Core Exam.	**Spec. Grav. Bulk/Rice**	**Asphalt Content**	**Moisture Suscep.**	**Gradation**	**AC Viscosity**
Iowa	7.0	67	0/0	100	0	100	50
Alabama	6.4	64	56/0	0	0	0	0
Arizona	6.0	100	100/100	100	100	100	100
Kansas	5.8	0	0/0	0	0	0	0
Arkansas	5.7	100	0/0	0	0	0	0
Ohio	4.6	0	0/33	33	0	33	17
Nebraska	4.1	100	33/100	100	0	33	35
Michigan	4.0	0	0/0	0	0	0	0
Nevada	4.0	75	5/0	0	0	0	0
Florida	3.7	100	100/100	100	100	100	100
New Mexico	3.7	100	100/100	100	100	100	100
Virginia	3.7	100	66/100	100	100	100	50
Delaware	3.2	56	33/66	66	0	66	0
Texas	2.3	0	0/0	0	0	0	0
Oklahoma	2.1	100	100/100	100	100	100	100
Louisiana	2.1	0	0/0	0	0	0	0
Wisconsin	1.8	0	0/0	0	0	0	0
Montana	0.8	0	0/0	0	0	0	0

Note: LATB indirect tensile resilient modulus and strength tests are missing for all of the projects.

Table 13. Summary of materials testing on the HMA mixtures.

Project	Age, years	HMA Testing—Percent Complete					
		Core Exam.	Spec. Grav. Bulk/Rice	Asphalt Content	Moisture Suscep.	Gradation	AC Viscosity
Iowa	7.0	0	0/67	0	0	0	0
Alabama	6.4	76	82/0	0	0	0	0
Arizona	6.0	100	100/100	100	0	100	75
Kansas	5.8	0	0/0	0	0	0	0
Arkansas	5.7	100	0/0	0	0	0	0
Ohio	4.6	86	35/100	100	0	100	75
Nebraska	4.1	50	30/100	33	0	33	18
Michigan	4.0	0	0/0	0	0	0	0
Nevada	4.0	100	50/0	0	0	0	0
Florida	3.7	94	100/100	100	100	100	100
New Mexico	3.7	100	100/100	100	100	100	100
Virginia	3.7	100	75	33	33	33	18
Delaware	3.2	81	86/0	100	0	100	100
Texas	2.3	0	0/0	0	0	0	0
Oklahoma	2.1	100	100/100	100	100	100	100
Louisiana	2.1	0	0/0	0	0	0	0
Wisconsin	1.8	0	0/0	0	0	0	0
Montana	0.8	0	0/0	0	0	0	0

Note: HMA indirect tensile resilient modulus, strength, and creep compliance tests are missing for all of the projects.

Table 14. Summary of materials testing completed by material type for the core test sections, percent complete.

Climate	Subgrade Soil Classification	Project ID	Shoulder	Material				
				HMA Surface	**Dense Graded Aggregate Base**	**Asphalt Treated Base**	**Permeable Asphalt Treated Base**	**Subgrade**
Wet-Freeze	Fine-Grained	Iowa	HMA	6	11	56	100	14
		Michigan	HMA	0	45	0	0	35
		Ohio	HMA	82	17	19	100	9
	Coarse-Grained	Delaware	HMA	75	12	25	67	14
		Virginia	HMA	43	50	76	100	71
		Wisconsin	HMA	0	0	0	0	0
Wet-No-Freeze	Fine-Grained	Alabama	HMA	10	40	8	0	86
		Louisiana	HMA	0	6	0	0	71
	Coarse-Grained	Arkansas	HMA	9	0	9	0	62
		Florida	HMA	86	45	72	33	86
Dry-Freeze	Fine-Grained	Kansas	?	0	0	0	0	48
		Nebraska	HMA	36	33	57	84	76
	Coarse-Grained	Montana	HMA	0	0	0	0	0
		Nevada	HMA	14	50	6	0	91
Dry-No-Freeze	Fine-Grained	New Mexico	HMA	86	33	90	33	100
		Oklahoma	HMA	78	0	90	100	48
		Texas	HMA	0	0	0	0	57
	Coarse-Grained	Arizona	None	73	50	73	100	76

Note: The materials testing for the Wisconsin project is underway, but was not at Level E in the January 2000 release.

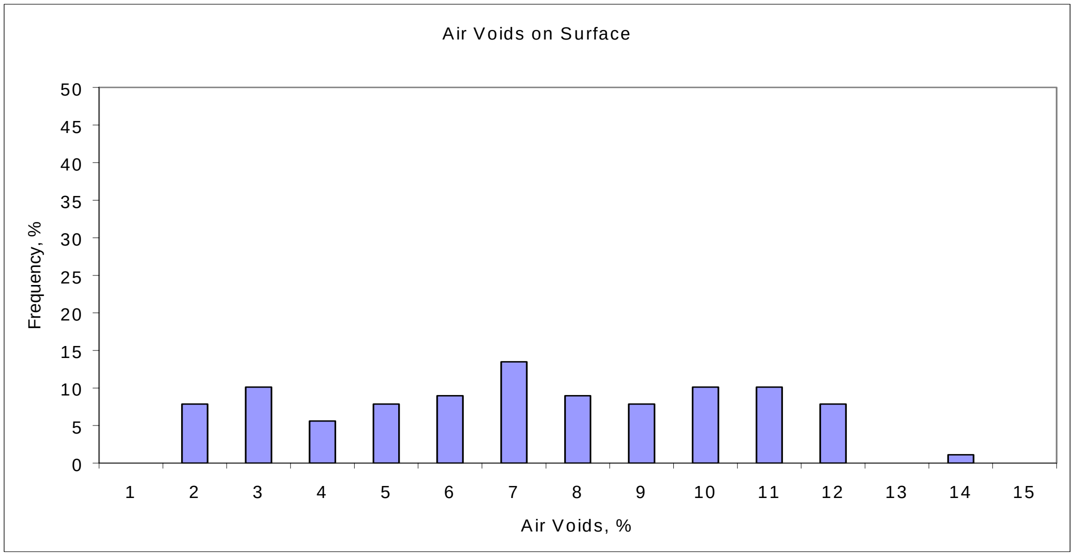


Figure 11. Histogram of air voids measured on the HMA surface layer.

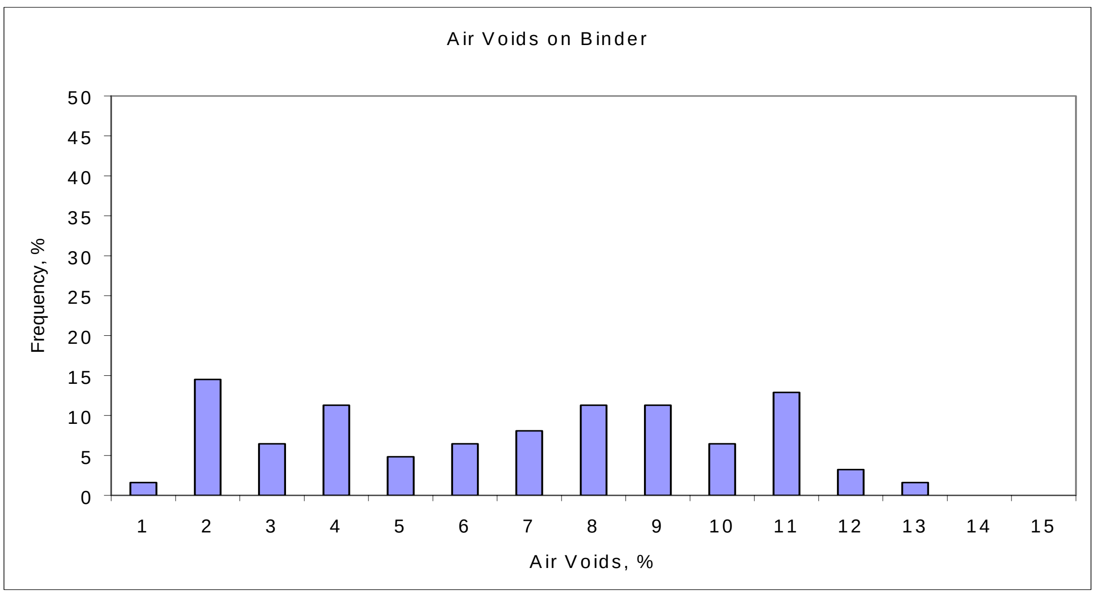


Figure 12. Histogram of air voids measured on the HMA binder layer.

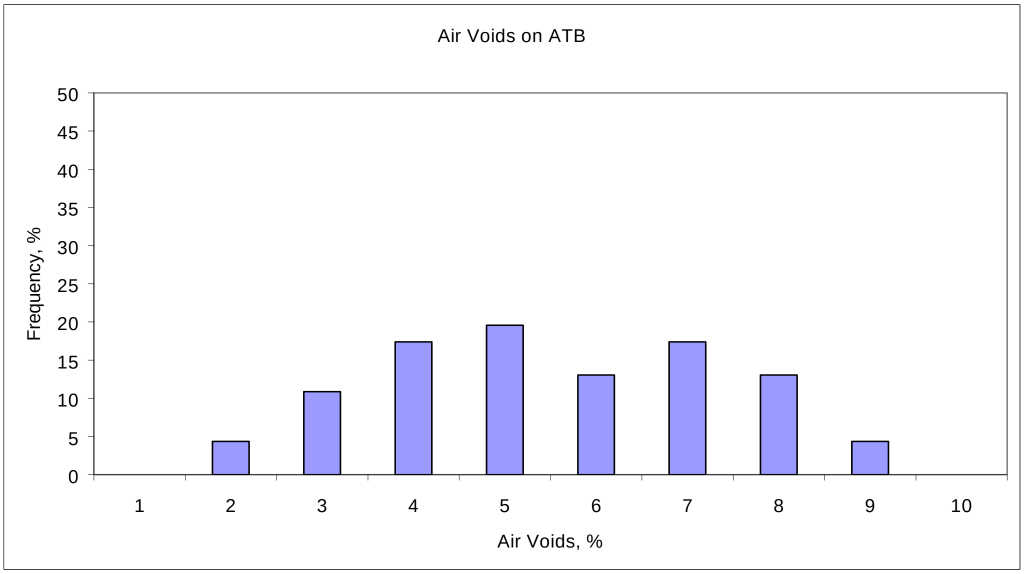


Figure 13. Histogram of air voids measured on the ATB layer.

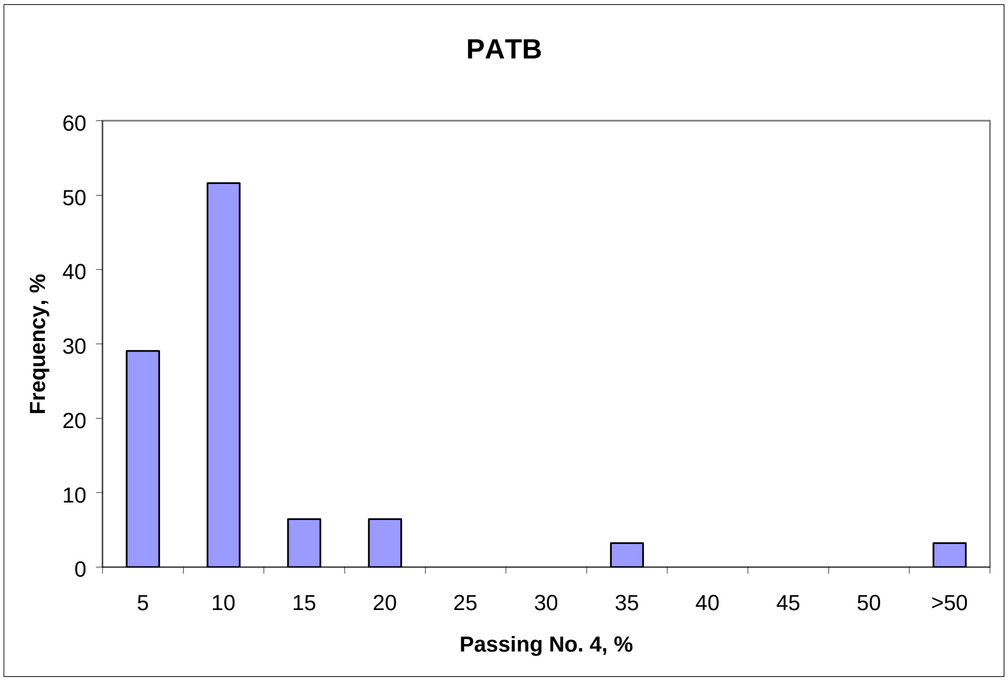


Figure 14. Histogram of the material passing the number 4 sieve, PATB layer.

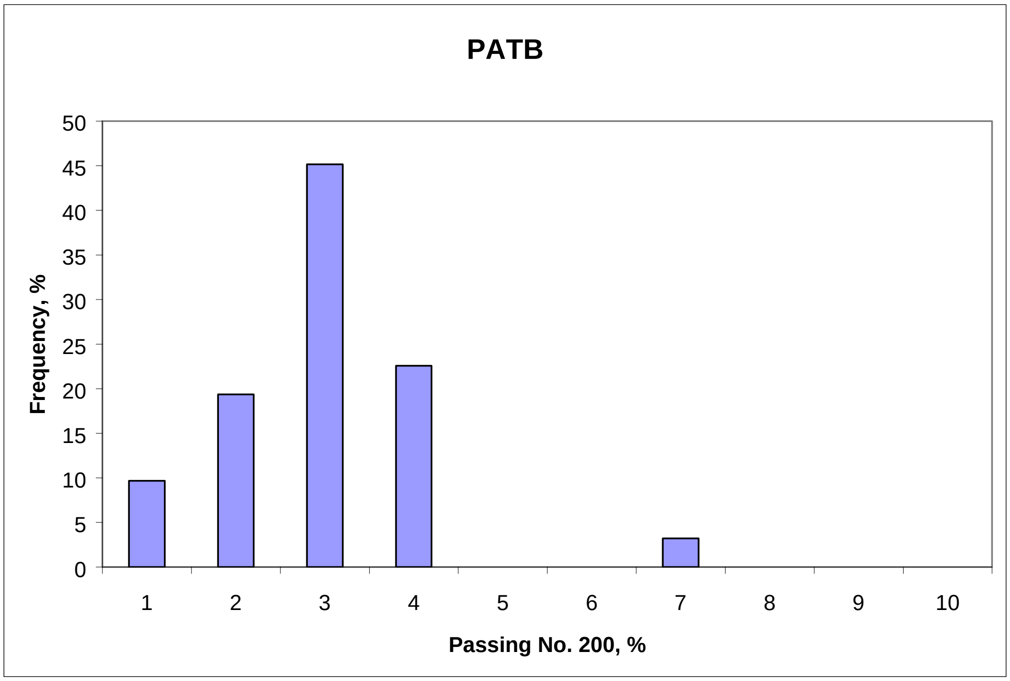


Figure 15. Histogram of material passing the number 200 sieve, PATB layer.

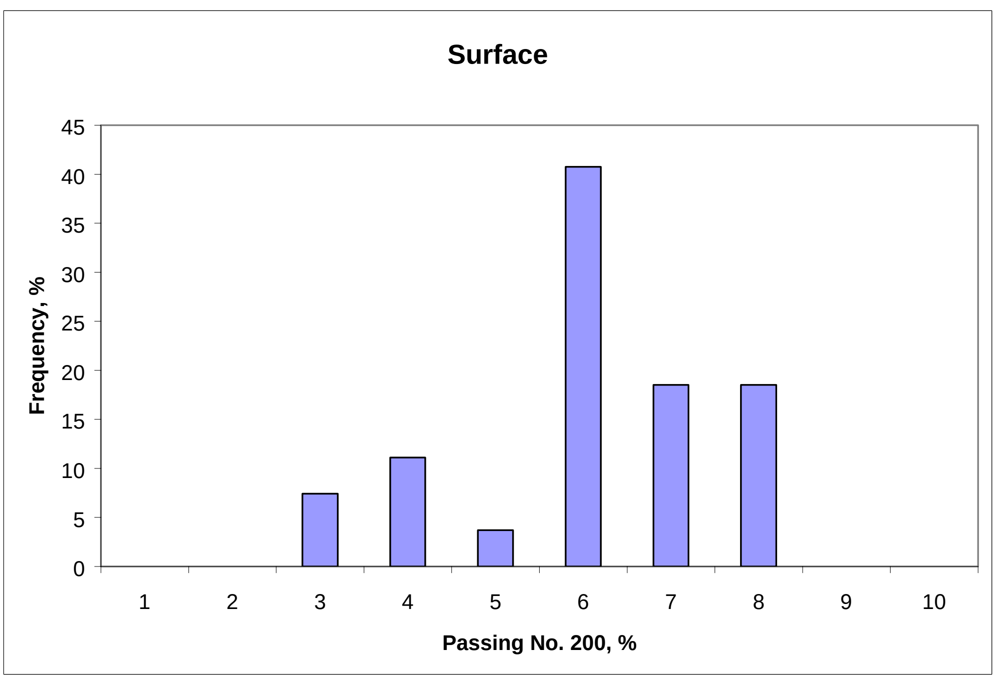


Figure 16. Histogram of material passing the number 200 sieve, HMA surface layer.

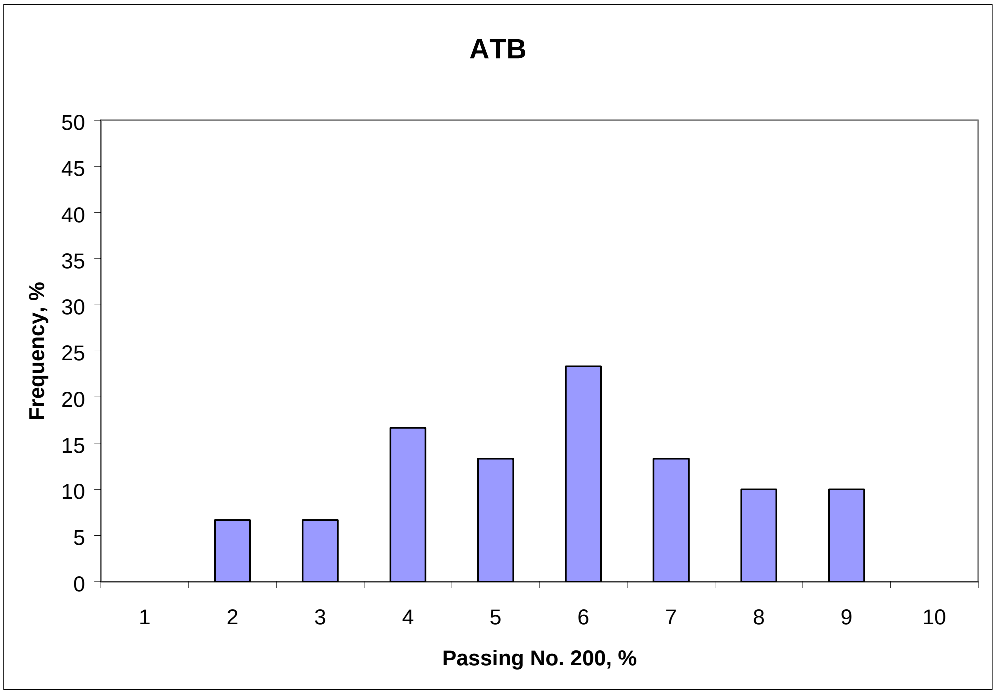


Figure 17. Histogram of material passing the number 200 sieve, ATB layer.

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

Table 8 provided a summary of the number of continuous WIM days available at each of the project sites. Table 6 also identified those sites where WIM and AVC equipment had been installed. As tabulated, over 50 percent of the SPS-1 projects do not have any WIM or AVC data at Level E in the IMS. As previously stated, this is considered a significant detriment to achieving the experimental objectives and expectations. On the positive side, WIM and AVC equipment have been installed at the Iowa, Ohio, Montana, Texas, and Wisconsin sites, but the data collected are not at Level E. Table 15 shows that the greatest amount of Level E traffic data, in general, are available for the oldest projects, as expected.

In the original SPS-1 experimental design, traffic was incorporated as a covariant in the experimental design. A traffic level of at least 100,000 ESALs per year was required for each of the projects. The actual ESALs per year at each site are shown in table 8 (note that initial estimated ESALs are unavailable for six sites). The traffic level requirement was met for all of the sites except the Texas project, which is located along a rural route with little truck traffic. The project with the highest annual ESALs is the Florida project (1,463,000 per year).

Table 15. Summary of climatic and traffic data for the SPS-1 project sites.

Project	Age, years	Climate Data		Traffic Data		
		Equipment installed	Number of AWS days	Equipment installed	Number of WIM days	Number of AVC days
Iowa	7.0	√	815	√	108	–
Alabama	6.4	√	1,394	–	–	–
Arizona	6.0	√	1,480	√	1,588	1,544
Kansas	5.8	√	1,000	√	232	18
Arkansas	5.7	√	1,100	√	89	89
Ohio	4.6	√	1,600	√	–	–
Nebraska	4.1	√	1,024	√	531	581
Michigan	4.0	√	670	√	250	–
Nevada	4.0	√	–	√	338	299
Florida	3.7	√	800	√	342	220
New Mexico	3.7	√	1,075	–	–	–
Virginia	3.7	√	1,299	√	313	312
Delaware	3.2	√	1,200	–	–	–
Texas	2.3	√	187	√	–	–
Oklahoma	2.1	√	400	–	–	–
Louisiana	2.1	√	300	–	–	–
Wisconsin	1.8	√	–	√	–	–
Montana	0.8	√	370	√	–	–

The range of traffic loadings between the sites will need to be fully considered in any comparative analysis of these data. More importantly, the missing traffic data will severely restrict the use of the SPS-1 experiment data for validating mechanistic-empirical design and analysis methods.

MONITORING DATA

Several types of monitoring data are included in the LTPP IMS. These monitoring data include distresses (from both manual and automated or PASCO surveys), longitudinal profiles, transverse profiles, deflection, and friction. Chapter 3 of this report reviewed the required monitoring frequency for each of the data elements for the SPS-1 experiment. In general, these minimum requirements are being met for the long-term monitoring frequency, but have not been met for the initial data collection requirements. The number of measurements for each of the test sections within each project was tabulated and discussed in appendix A.

Table 16 provides a summary of the minimum number of distress and other performance indicator measurements made at each of the SPS-1 project sites. As tabulated, very few friction measurements have been performed on these projects, while there have been numerous deflection and manual distress surveys. At least one survey for each of the monitoring data elements has been made at each site, with the exception of the friction surveys and transverse profile measurements at selected sites.

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	Pasco			
Delaware	North Atlantic	3.2	1	3	0	2	7	0
Virginia		3.7	2	3	0	2	7	1
Iowa	North Central	7.0	3	1	2	4	6	5
Kansas		5.8	6	4	2	7	6	6
Nebraska		4.1	2	2	1	3	4	$0^{(1)}$
Michigan		4.0	2	4	1	2	3	1
Ohio		4.6	5	3	1	3	4	0
Wisconsin		1.8	1	1	0	$0^{(2)}$	3	0
Alabama	South	6.4	5	3	2	2	4	2
Arkansas		5.7	5	1	1	1	2	0
Florida		3.7	1	1	0	0	4	0
Louisiana		2.1	3	2	0	1	1	0
New Mexico		3.7	1	2	0	2	1	0
Oklahoma		2.1	2	3	0	0	1	0
Texas		2.3	1	3	0	2	2	0
Arizona	West	6.0	7	3	1	4	5	0
Montana		0.8	3	2	0	$0^{(3)}$	2	0
Nevada		4.0	6	3	1	3	3	0

Note: (1) Friction measurement are available for the Ohio project, but are not at Level E.
(2) Transverse profiles were measured on the Wisconsin project, but are not at Level E.
(3) Transverse profiles were performed in Montana at the same time that manual distress surveys were performed. The two sets of transverse profile measurements are not included as Level E data in the IMS.

Transverse profiles are not yet measured at the Oklahoma and Florida sites. Transverse profiles were measured for the Montana and Wisconsin projects, but those data are not yet at Level E and are unavailable in the IMS. The Wisconsin and Montana sites are relatively new, whereas the Oklahoma and Florida sites are over 2 years of age.

Longitudinal profiles have been completed at least once for all SPS-1 projects. However, the first longitudinal profile measured on 9 of the 18 projects was more than 1 year after construction. The discrepancy for the initial measurements may be related to the definition of the construction date or other scheduling difficulties as identified in chapter 3. In some cases, the construction date was defined as *completion of pavement placement* rather than *acceptance by the State agency*. Those projects that were more than 1 year in age before the first longitudinal profile measurement was taken include Alabama, Arkansas, Florida, Iowa, Michigan, Nevada, New Mexico, Ohio, and Virginia.

Table 17 summarizes the age, in years, between each set of measurements for each performance indicator. Most of the monitored data have been measured more frequently than required by the guidelines referenced in chapter 3.

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

Project	**Age, years**	**Long. Profiles**	**Transverse Profiles**	**Distress**		**Deflection Surveys**
				Manual	**Pasco**	
Iowa	7.0	1.2	1.8	7.0	3.5	2.3
Alabama	6.4	1.6	3.2	2.1	3.2	1.3
Arizona	6.0	1.2	1.5	2.0	6.0	0.9
Kansas	5.8	1.0	0.8	1.5	2.9	1.0
Arkansas	5.7	2.9	5.7	5.7	5.7	1.3
Ohio	4.6	1.2	1.5	1.5	4.6	0.9
Nebraska	4.1	1.0	1.4	2.1	4.1	2.1
Michigan	4.0	1.3	2.0	1.0	4.0	2.0
Nevada	4.0	1.3	1.3	1.3	4.0	0.7
Florida	3.7	0.9	–	3.7	–	3.7
New Mexico	3.7	3.7	1.9	1.9	–	3.7
Virginia	3.7	0.5	1.9	1.2	–	1.9
Delaware	3.2	0.5	1.6	1.1	–	3.2
Texas	2.3	1.2	1.2	0.8	–	2.3
Oklahoma	2.1	2.1	–	0.7	–	1.1
Louisiana	2.1	2.1	2.1	1.1	–	0.7
Wisconsin	1.8	0.6	–	1.8	–	1.8
Montana	0.8	0.4	–	0.4	–	0.3

DYNAMIC LOAD RESPONSE DATA

Various flexible pavement test sections of the Ohio SPS-1 site were selected for measuring pavement response under controlled loading conditions. The instrumented sections are: 329-0102, 39-0104, 39-0108, and 39-0110. During the early life of the pavement, dynamic load response data were collected on a quarterly basis. However, data collection was terminated after 2 years.

The dynamic load response data for the flexible pavement test sections are stored in the DLR_* module in the following nine IMS tables:

- DLR_LVDT_CONFIG_AC: LVDT gauge, settings, and location information.
- DLR_LVDT_TGRACE_SUM_AC: LVDT trace summary information.
- DLR_MASTER_AC: Dynamic load response site and instrumentation summary information.
- DLR_PRESSURE_CONFIG_AC: Pressure gauge, settings, and location information.
- DLR_PRESSURE_TRACE_SUM_AC: Data load response pressure trace summary information.
- DLR_STRAIN_CONFIG_AC: Sensor gauge, settings, and location information.
- DLR_STRAIN_TRACE_SUM_AC: Data load response strain trace summary information.
- DLR_TEST_MATRIX: Data load response test matrix summary information.
- DLR_TRUCK_GEOMETRY: Data load response truck geometry summary information.

The data availability assessment of these tables is provided in table 18. All records in these tables are at Level E.

Table 18. Summary of Level E dynamic load response data for the Ohio SPS-1 project.

Data Table Name	Total Records (All at E)	Records for Each Section			
		0102	0104	0108	0110
DLR_LVDT_CONFIG_AC	131	16	34	40	41
DLR_LVDT_TRACE_SUM_AC	348	74	96	98	80
DLR_MASTER_AC	23	4	7	6	6
DLR_PRESSURE_CONFIG_AC	52	8	16	14	14
DLR_PRESSURE_TRACE_SUM_AC	335	71	121	79	64
DLR_STRAIN_CONFIG_AC	571	72	192	147	160
DLR_STRAIN_TRACE_SUM_AC	304	18	86	88	112
DLR_TEST_MATRIX	350	48	111	92	99
DLR_TRUCK_GEOMETRY	1	1 Truck ID/Type			

SUMMARY

Table 19 presents an overall summary of the SPS-1 projects, 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 and provides an overall rating of the project and test sections for fulfilling the original experimental objectives and expectations. A definition of this numerical scale is given below.

- 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.

Relatively few project deviations and 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, some data elements at specific project sites will have a negative effect on accomplishing the experimental objectives if they are not collected in the future. Primarily, these include traffic data and some of the materials/layer properties. The omission of these data elements is reflected in the overall adequacy code for each project.

As listed in table 19, two projects have an adequacy code of *0*. The Montana and Wisconsin projects are newly constructed and have little data in the database at this time. It is expected that the adequacy of these two projects will increase as more data become available and are entered into the IMS.

Three projects have an adequacy code of *2*: Alabama, Louisiana, and Oklahoma. None of these projects have WIM equipment installed at the site; all have substantial materials test data that are missing; and most have missing or infrequent monitoring data.

Six of the projects were assigned an adequacy code of *3* for a variety of reasons. These projects include Arkansas, Delaware, Florida, Michigan, New Mexico, and Texas. The traffic data and a substantial amount of materials test data are unavailable for most of these projects. The adequacy code of these projects will increase as the data reach Level E.

Table 19. Summary of the overall construction difficulties and deviations, and the adequacy code for the projects included in the SPS-1 experiment.

Project	Construction Difficulties and Deviations	Adequacy Code
Alabama	• Mechanical problem with paver; construction joint placed in Section 010111. • Deformations occurred on top of the PATB. • DGAB contained excess minus 200 material.	2
Arizona	• Rain delays during subgrade preparation. • Fill material pumped, but was replaced prior to paving. • Section 0122 included a layer of DGAB below the PATB. • DGAB for sections 0119 and 0122 did not meet the gradation requirements.	5
Arkansas	• Rain caused construction delays, but surfaces were allowed to dry prior to resuming construction. • DGAB thickness on section 0114 was less than half of the required value. Many other sections were also less than the design value. • The stability of the HMA mixture was less than the specified value.	3
Delaware	• High water table along the project. • Ditches were shallow, so outlets of edge drains were not placed at the 76-m spacing. • The number 4 sieve from the gradation tests for the HMA surface did not meet the project specifications.	3
Florida	• Rain delays caused the DGAB to be reworked multiple times. • The number 4 sieve from the gradation tests for the HMA surface and binder layers did not meet the project specification.	3
Iowa	• Multiple rain delays, but surfaces were allowed to dry and were reworked. • PATB "rolled out" on the sides, which resulted in the placement of an extra lift to meet the thickness requirement. • The number 4 sieve from the gradation tests for the HMA binder layer exceeded the project requirements.	4
Kansas	• Excessive moisture in the subbase, which caused difficulty in compacting the material. • Fly ash was added to the subbase layer for stabilization purposes.	4
Louisiana	• Test sections for thickness cells 1 to 12 rather than 13 to 24 were built. • Rain delays. • Subgrade was stabilized with cement. • Fabric did not meet overlay requirements. • Aggregate in drainage trenches contained fines. • DGAB was compacted in one lift. • Select material was used at site to achieve the final elevation.	2
Michigan	• No construction report was available for review.	3
Montana	• Recently constructed.	0
Nebraska	• Three test sections were constructed over culverts. • Rain delays. • The minus 200 material for the PATB exceeded the project requirements.	4
Nevada	• Plant breakdown occurred while placing the PATB for test section 320110. • The DGAB contained excess minus 200 materials.	4
New Mexico	• HMA facility breakdown. • High air voids reported in the ATB prior to plant breakdown. • Localized tenderness problem noted.	3
Ohio	• Fill material placed on all sections. • DGAB thickness was much larger than the planned thickness. • The number 4 sieve for the HMA surface did not meet the project requirements.	4
Oklahoma	• The number 4 sieve for the HMA surface did not meet the project requirements. • One of the two ATB lifts exceeded the project thickness requirements.	2
Texas	• Transverse interceptor drains not installed along the project.	3
Virginia	• Subgrade treated with cement. • The number 4 sieve for the HMA surface did not meet the project requirements.	4
Wisconsin	• Recently constructed.	0

The Michigan project has an adequacy code of *3* rather than *4* because four of the test sections were taken out of service without measurements for distress, longitudinal profile, international roughness index (IRI), or transverse profile (rut depth). These deficiencies should have minimal impact on the SPS-1 experiment because the project is in the wet-freeze climate and fine-grained subgrade soil site factorial cell of the experiment (refer to table 3), and there are three other projects within this cell that will provide sufficient data for analysis purposes. In addition, the value of this project will increase after the test results reach a Level E status. All other projects were assigned an adequacy code of *4* or *5*.

5. ANALYSIS OF EARLY PERFORMANCE OBSERVATIONS

The purpose of this chapter is to provide an evaluation of the early observations based on initial performance data and to identify performance differences both within and between the SPS-1 projects. This is not intended to be a comprehensive analysis of the performance data of the SPS-1 experiment. Appendix A includes a summary of the amount of distress and performance data that have been collected at each of the 18 SPS-1 sites over time.

GRAPHICAL COMPARISONS 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 the wheel path 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 18 through 21 compare the performance of the test sections with and without drainage layers for all of the SPS-1 projects (between-project differences). As shown, many of these test sections have little to no distress at this time, making it difficult to identify any effect of the key experimental factors on performance. There also is extensive variability (i.e., traffic levels) between the test site companion full factorial projects, making any kind of graphical comparison very difficult to interpret.

Time-series data were also plotted for the individual projects to observe and evaluate trends between the test sections of the same project and to identify possible anomalies in the performance data. Examples of the time-series distress data plots are shown in figures 22 through 24. As shown, there is extensive variability in the data and, more importantly, many of the distresses (and deflections) abruptly decrease with time. 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. These inconsistent trends severely complicate graphical comparisons and other analyses based on early distress observations. Thus, only those distresses with reasonably consistent time-series data were used to evaluate early performance trends from the experiment. These distresses include rut depths, IRI, fatigue cracking, and transverse cracking.

Table 20 lists the percentage of the core test sections with distress magnitudes that can be used in comparative studies and in future calibration and validation studies of distress prediction models. As tabulated, relatively few of the core test sections have exhibited distress magnitudes that exceed the “minimum value” for each of the four distresses, with the exception of rutting; 18 percent of the test sections exceed the minimum rut depth of 7 mm.

The following provides a brief overview relative to the four major distress types or performance indicators.

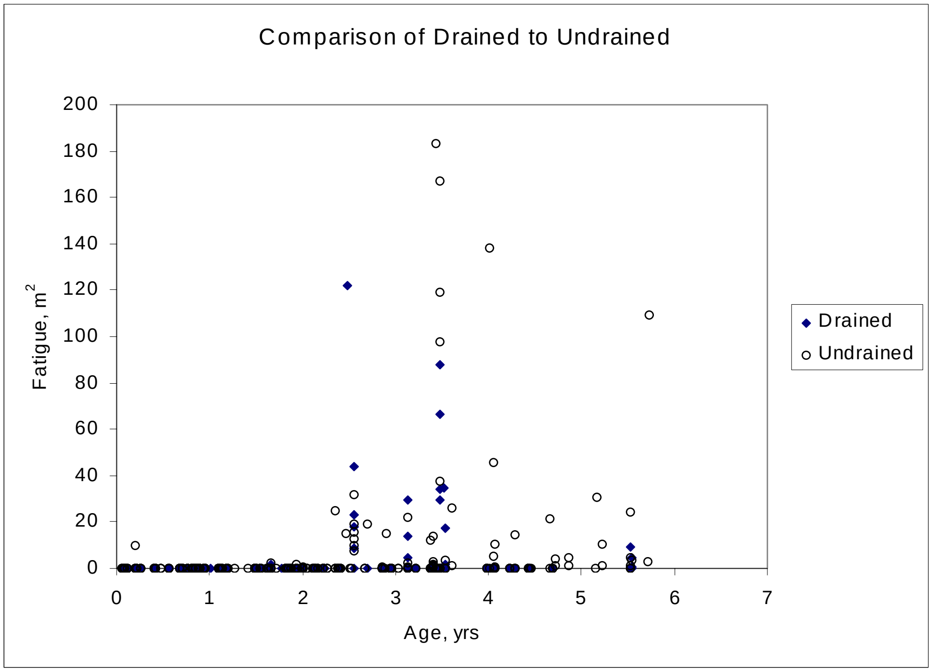


Figure 18. Area of fatigue cracking measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined.

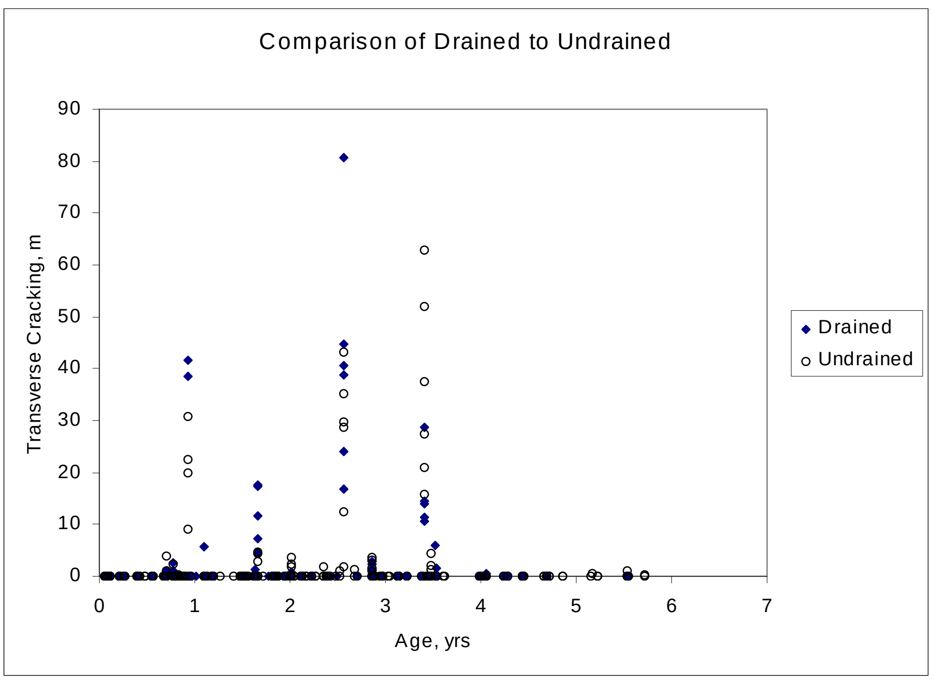


Figure 19. Total length of transverse cracks measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined.

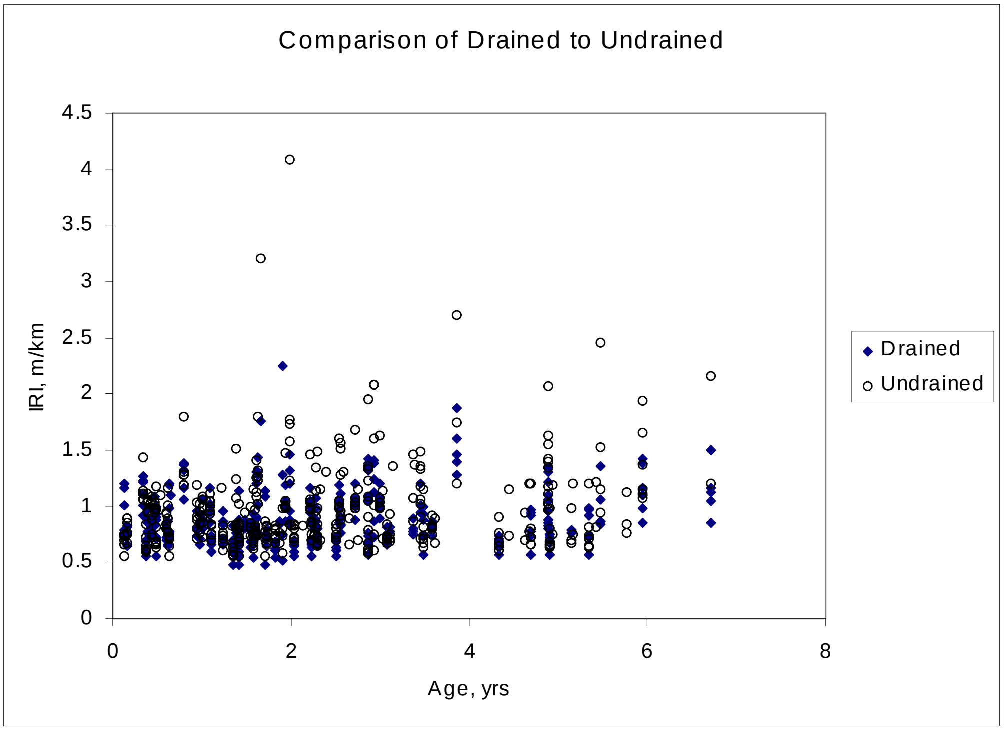


Figure 20. IRI values measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined.

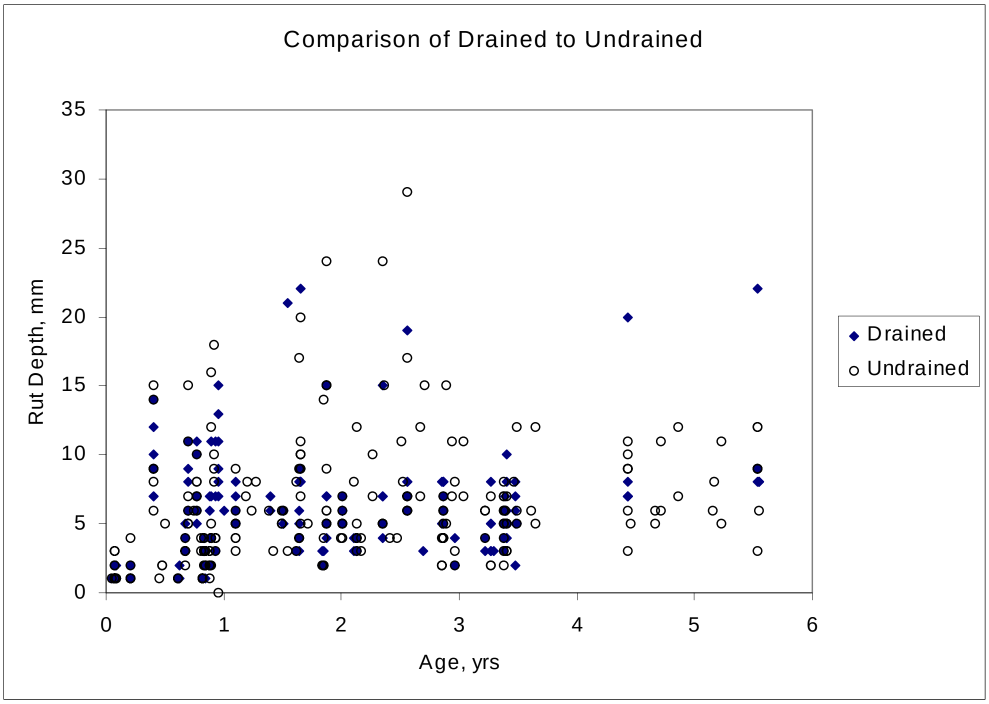
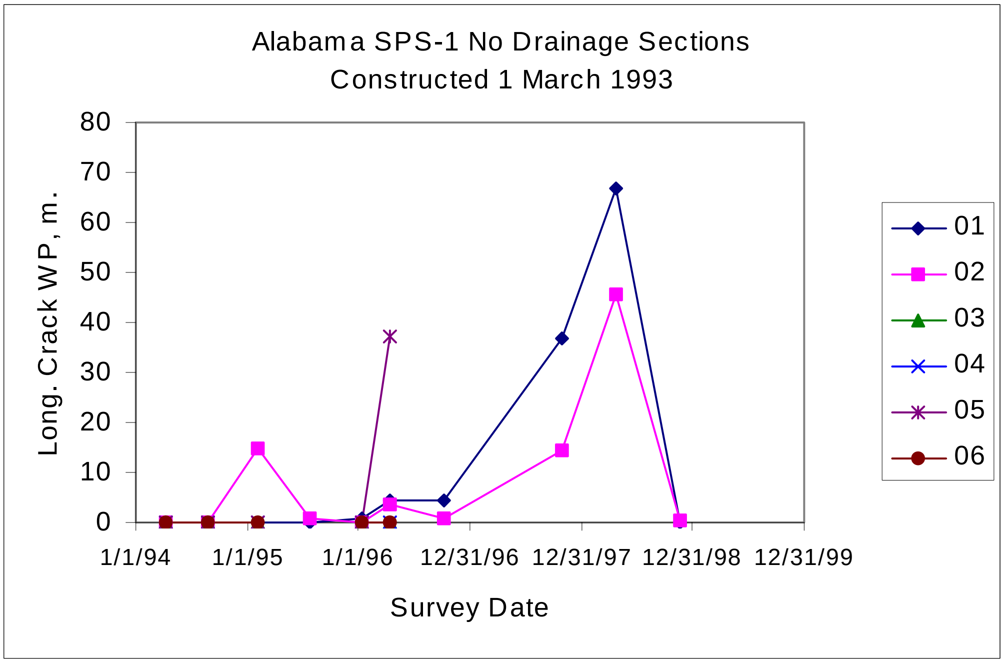


Figure 21. Rut depths measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined.



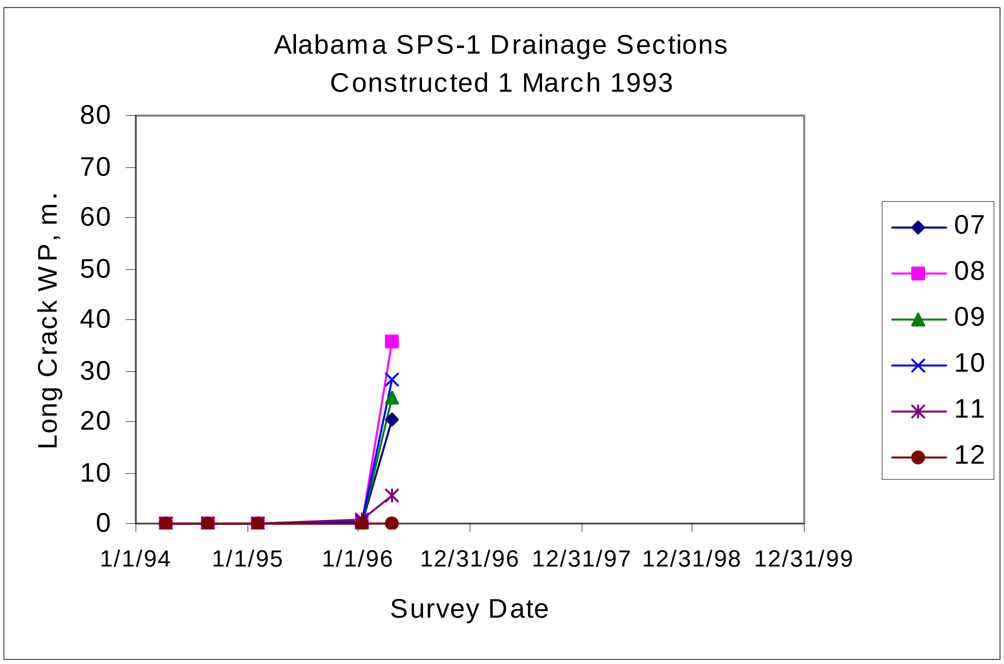
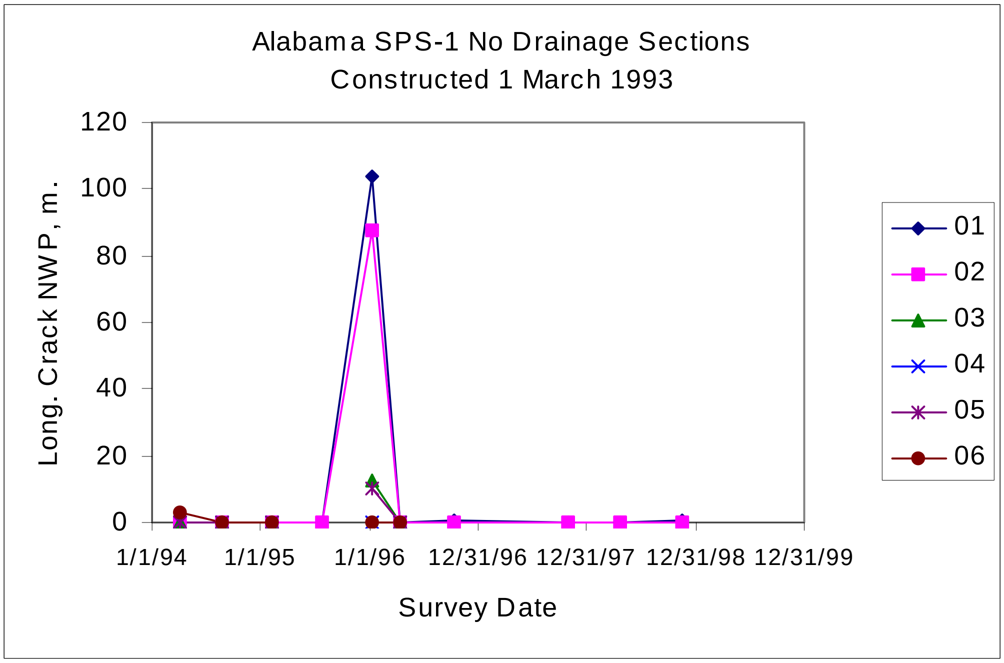


Figure 22. Longitudinal cracking in the wheel paths measured on different dates for the core test sections of the Alabama project.



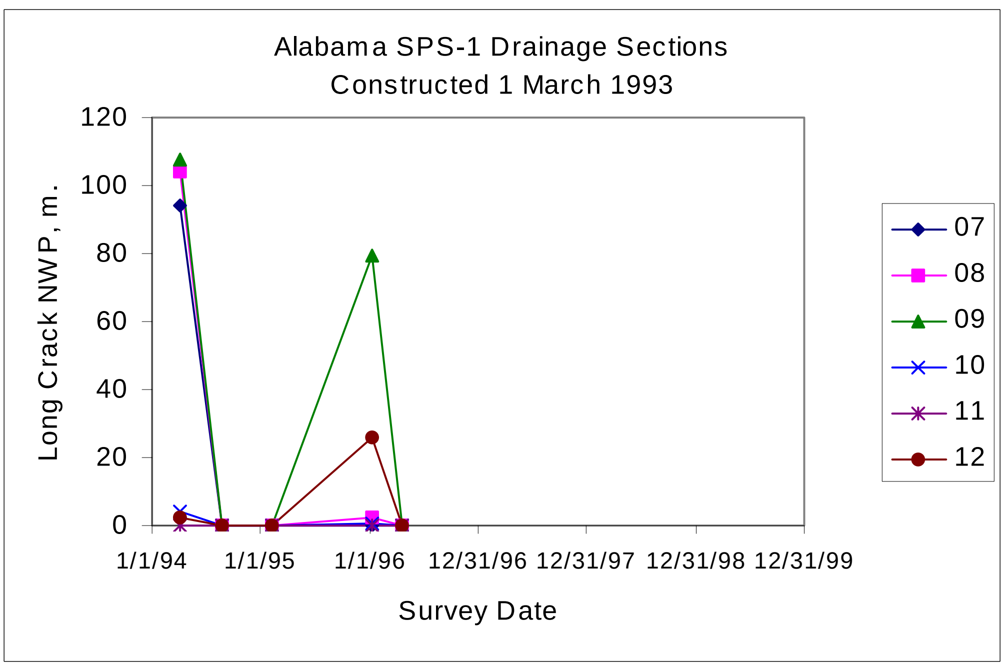
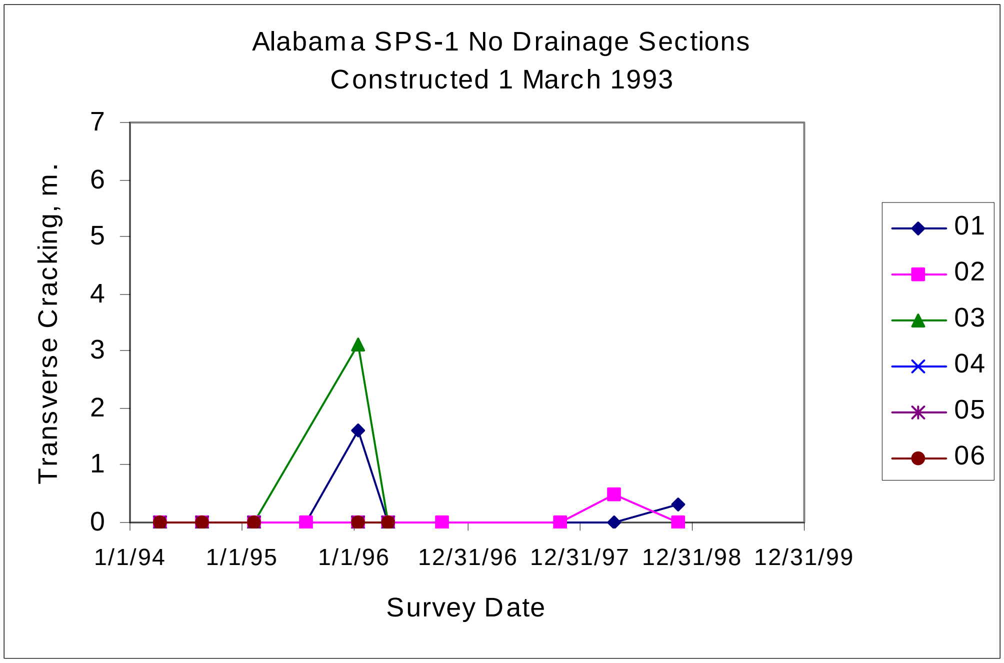


Figure 23. Longitudinal cracking outside the wheel paths measured on different dates for the core test sections of the Alabama project.



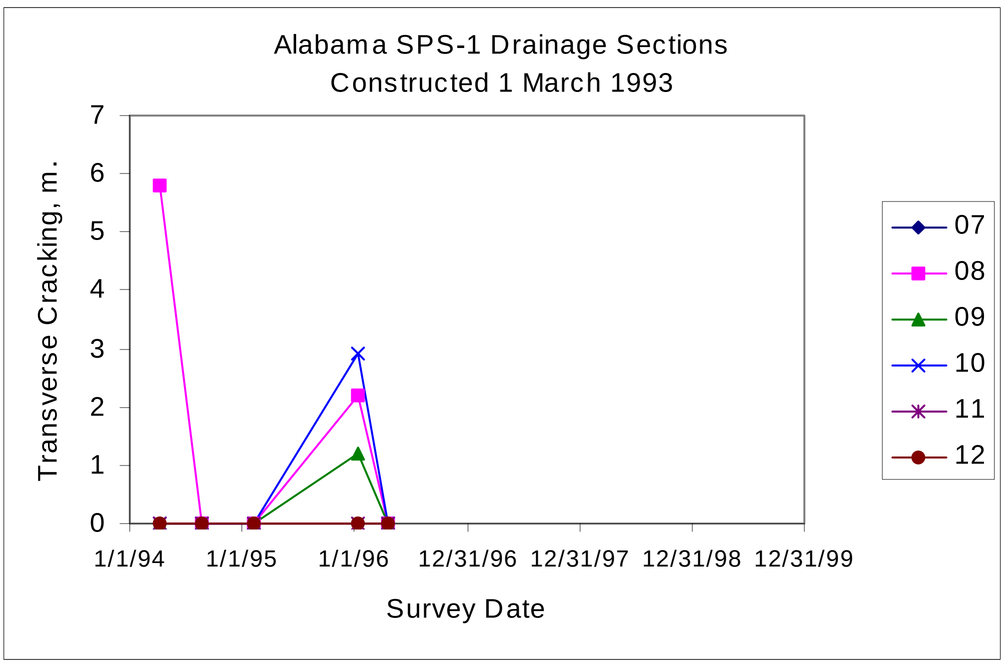


Figure 24. Transverse cracking measured on different dates for the core test sections of the Alabama project.

Table 20. Percentage of the SPS-1 core test sections with distress magnitudes exceeding the value noted.

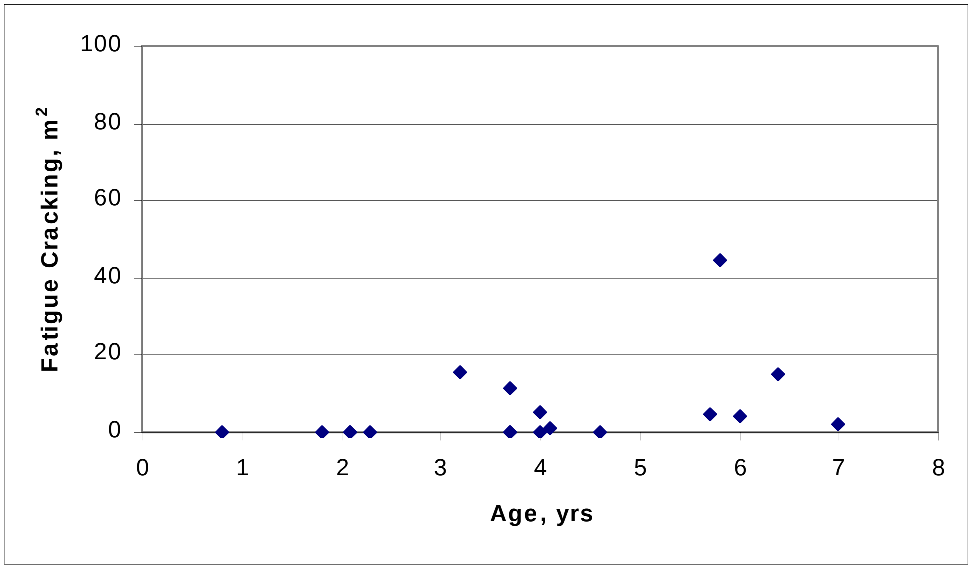
Performance Indicator	Distress Magnitude Minimal Value	Core Test Sections Exceeding Minimal Value	
		Percentage of Sections	No. of Sections
Rut Depth	> 7 mm	18.1	39
IRI	> 1.4 m/km	5.6	12
Fatigue Cracking	> 25 m^2	6.0	13
Transverse Cracking	> 9 m	5.6	12

Fatigue Cracking

Fatigue cracking has occurred on some of the test sections of the older projects. Table 21 shows the average amount of fatigue cracking observed at each project and the age of that project. Figure 25 shows the average area of fatigue cracking at a project compared to the age of that project and the total number of test sections with fatigue cracking. As shown in table 21 and figure 25, the number of sections with fatigue cracking is consistently less for the younger projects, while the average fatigue cracking for a project appears to be less age dependent. This observation suggests a substantial difference in the fatigue resistance of the flexible pavements and HMA mixtures between the projects. This trend may change as more data become available with time.

Table 21. Summary of the average area of fatigue cracking observed at each project.

Project	Age, Years	Core Test Sections with Fatigue Cracking, No.	Area of Fatigue Cracking, m^2		Initial IRI	
			Average	Standard Deviation	Age, Yrs.	IRI, m/km
Iowa	7.0	10	2.0	3.78	2.3	0.970
Alabama	6.4	6	15.1	31.2	2.9	0.686
Arizona	6.0	7	4.0	7.03	0.5	0.778
Kansas	5.8	8	44.8	51.5	0.6	0.811
Arkansas	5.7	5	4.8	10.6	3.6	0.808
Ohio	4.6	0	0.0	0.0	2.0	1.490
Nebraska	4.1	1	1.2	4.2	0.3	1.140
Nevada	4.0	5	5.1	13.1	1.7	0.713
Michigan	4.0	0	0.0	0.0	1.4	0.783
Virginia	3.7	1	11.5	39.9	1.1	1.002
Florida	3.7	0	0.0	0.0	1.2	0.754
New Mexico	3.7	0	0.0	0.0	1.4	0.623
Delaware	3.2	1	15.3	52.8	0.6	0.819
Texas	2.3	0	0.0	0.0	0.4	0.847
Oklahoma	2.1	0	0.0	0.0	0.4	0.943
Louisiana	2.1	0	0.0	0.0	0.4	0.649
Wisconsin	1.8	0	0.0	0.0	0.2	0.775
Montana	0.8	0	0.0	0.0	0.1	0.818



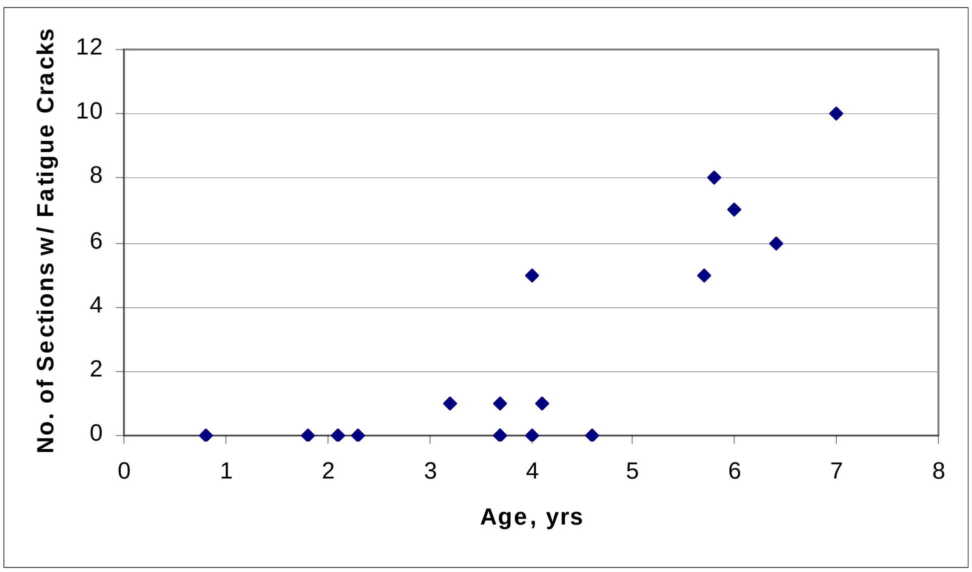


Figure 25. Graphical illustration of the average amount of fatigue cracking observed on each of the projects, as of January 2000.

The Kansas test sections consistently have the greatest area of fatigue cracking, but are not from the oldest project. In fact, all eight of the test sections that have cracked show over 25 m^2 of fatigue cracking. The Kansas SPS-1 project had a wet subbase that was difficult to compact (refer to table 19). In all probability, the wet subbase and low densities are the reasons for this large amount of fatigue cracking. These data will still be invaluable for comparative studies and for calibrating mechanistic prediction models once the materials test results become available.

All except two of the Iowa test sections have fatigue cracking, but the areas measured within each test section are small—the average fatigue cracking is 2.0 m^2. Conversely, a large area of fatigue cracking has been recorded on one test section of the Delaware and Virginia projects. The reason for this large area of fatigue cracking in one test section when the other 11 have none is unknown, and both of these test sections are considered anomalies relative to each project.

Transverse Cracking

Transverse cracking has occurred on all except one of the Iowa test sections. The length of the transverse cracks measured along the test sections that have cracked exceed 9 m. The only other projects exhibiting some transverse cracking are the Kansas and Arkansas projects. However, the total length of transverse cracking at these two sites is less than 9 m for all except one of the Kansas test sections. This transverse cracking is probably more related to the HMA mixture characteristics or properties than to any of the key experimental factors, including the climate.

The Arkansas, Iowa, and Kansas sites are the oldest projects in a freezing climate. The age of the Iowa project is 7 years, the Kansas project is 5.8 years, and the Arkansas project is 5.7 years. Thus, age also may be an important factor. In fact, mechanistic-based models consider the binder and mixture properties, climate, and age to be the most important factors in the occurrence of transverse cracking.

Smoothness—IRI Values

The Iowa, Kansas, and Nebraska projects have the most test sections with IRI values greater than 1.4 m/km. These are the same projects that have extensive transverse and fatigue cracking. The occurrence of transverse and fatigue cracking are probably causing the increased roughness (increased IRI values) at these sites. The authors have found from previous studies that the IRI is related to the standard deviation of the rut depth, transverse cracking, fatigue cracking, and other distresses.[13] Thus, there are interactions between the performance measures, which will need to be considered in future studies using data from this experiment.

Rut Depths

Rut depths exceeding 7 mm have been measured along 10 of the 18 SPS-1 projects—Alabama, Arizona, Iowa, Kansas, Michigan, Nebraska, Nevada, Virginia, Ohio, and Texas. These projects are located in very different climates. However, rut depths in only one of the test sections in the Michigan, Nevada, and Virginia projects exceeds 7 mm; the rut depths in the other 11 test sections within these 3 projects are less than 7 mm. Thus, those projects with the greatest rut depths have been in-place longer, with the exception of the Texas project (refer to table 21 for the age of the projects). The Texas project is located along a rural highway and has less traffic than any of the other 18 SPS-1 projects with only 10,000 ESALs per year (refer to table 8). In all probability, the rut depths measured along the Texas project are more related to the HMA mixture characteristics than to any key factor included in the experiment.

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 a significant effect on those distresses from these early observations. The major factors included in the ANOVA are listed below.

- Subgrade type: Fine-grained versus coarse-grained soils.
- HMA thickness: Thin versus thick surface layers.
- Base type: Granular or unbound aggregate versus ATB layers.
- Drainage condition: Permeable versus dense layers.

Results from this one-way ANOVA are summarized in table 22 and indicate that subgrade soil, drainage condition, type of base material, and HMA thickness have a significant effect on all distresses with the exception of rut depth. Although there are possible interactions between these factors, the one-way ANOVA demonstrates that the key factors of the SPS-1 experiment design are having an effect on the early performance observations.

Table 22. Summary of p-values from a one-way ANOVA to determine the effect of experimental factors on selected performance indicators.

Experimental Factor	Performance Indicator/Surface Distress			
	Rut Depths	IRI	Fatigue Cracking	Transverse Cracking
Subgrade Soil Type	0.132	<0.0001	0.034	0.006
Base Type	<0.0001	<0.0001	0.092	0.604
Drainage Condition	0.897	0.003	0.246	0.465
Nominal Base Thickness	0.254	0.003	0.898	0.589
Nominal HMA Thickness	0.556	<0.0001	0.013	0.815
Age of Project	<0.0001	0.001	<0.0001	0.068

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

- **Rut Depth**: Base type and the age of the project are important and have an effect on the measured rut depths. On the average, those test sections with unbound aggregate base layers were found to have the highest rut depths while those with ATB layers have the lowest.
- **IRI**: Subgrade soil type, base type, drainage condition, base thickness, HMA surface thickness, and age all are important in calculating the IRI from the longitudinal profiles. Those test sections with the following site and structural factors were found to be

smoother: coarse-grained soils, ATB layers, permeable base layers, thicker base, and thicker HMA layers.

- **Fatigue Cracking**: HMA surface thickness and the age of the project appear to affect the fatigue cracking. The test sections that are younger and that have the thicker HMA layers have the least amount of fatigue cracks. Subgrade soil type also appears to be important relative to fatigue cracking. On average, the projects built over fine-grained soils have more fatigue cracking than those projects built over coarse-grained soils. However, the Kansas project with the wet subbase and variable densities was built on a fine-grained soil and has a large amount of fatigue cracking. The difficulties encountered during the construction of this section (rather than the fine-grained soil) could be biasing the statistical comparison related to subgrade soil type.
- **Transverse Cracking**: Subgrade soil type and, to a lesser degree, age are important relative to the amount of transverse cracking measured at each site. However, nearly all of the test sections with the greatest lengths of transverse cracking are from the Iowa project. The greatest lengths of cracking on this one project could be distorting the results.

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 23 through 26 summarize the differences in the average performance measures between the key factors of the experiment.

Subgrade Soil Type

HMA pavements built over fine-grained subgrade soils exhibit higher IRI values than those pavements built over coarse-grained soils (table 23). More importantly, a much greater percentage of the HMA core test sections built over fine-grained soils in a freeze climate have exceeded 1.2 m/km (see figure 26). This observation is consistent with previous findings from evaluating the General Pavement Studies (GPS) test sections.[14]

The Iowa, Kansas, and Nebraska projects consistently have higher IRI values. The initial IRI values were reviewed to determine if these projects had higher IRI values immediately after construction. The initial IRI values and the age of the project when those values were measured are summarized in table 21. As shown, these projects did not exhibit the higher values after construction. As stated in chapter 4 and listed in table 21, the first longitudinal profiles were measured over 1 year after construction on 50 percent of the SPS-1 projects. Chapter 3 explained some of the reasons why data were not measured sooner following construction.

Table 23. Average performance differences of the test sections between the different soil types included in the SPS-1 experiment.

Distress or Performance Indicator		**Soil Type**	
		Fine-grained	**Coarse-grained**
Rut Depth	Mean, mm	6	6
	Std. Deviation, mm	4	4
	COV, %*	74	71
IRI	Mean, m/km	1.03	0.78
	Std. Deviation, m/km	0.364	0.137
	COV, %	35	18
Fatigue Cracking	Mean, m^2	1.5	3.5
	Std. Deviation, m^2	11.8	16.7
	COV, %	802	481
Transverse Cracking	Mean, m	2.1	0.3
	Std. Deviation, m	8.7	1.8
	COV, %	410	547

Table 24. Average performance differences of the test sections between the different types of base layers included in the SPS-1 experiment.

Distress or Performance Indicator		**Base Type**	
		ATB	**Unbound Aggregate**
Rut Depth	Mean, mm	4	7
	Std. Deviation, mm	3	5
	COV, %*	77	71
IRI	Mean, m/km	0.89	1.014
	Std. Deviation, m/km	0.280	0.433
	COV, %	31	43
Fatigue Cracking	Mean, m^2	1.6	6.2
	Std. Deviation, m^2	10.1	23.7
	COV, %	637	380
Transverse Cracking	Mean, m	1.5	0.9
	Std. Deviation, m	7.3	5.7
	COV, %	474	638

Table 25. Average performance differences of the test sections between the different drainage conditions included in the SPS-1 experiment.

Distress or Performance Indicator		**Drainage Condition**	
		Permeable Base	**Dense Base**
Rut Depth	Mean, mm	6	6
	Std. Deviation, mm	4	4
	COV, %*	70	75
IRI	Mean, m/km	0.884	0.965
	Std. Deviation, m/km	0.243	0.367
	COV, %	28	38
Fatigue Cracking	Mean, m^2	1.8	3.5
	Std. Deviation, m^2	10.3	18.1
	COV, %	584	518
Transverse Cracking	Mean, m	1.5	1.3
	Std. Deviation, m	7.4	6.5
	COV, %	482	490

Table 26. Average performance differences of the test sections between the different HMA layer thickness included in the SPS-1 experiment.

Distress or Performance Indicator		HMA Surface Thickness	
		Thin	Thick
Rut Depth	Mean, mm	6	6
	Std. Deviation, mm	4	4
	COV, %*	74	72
IRI	Mean, m/km	0.970	0.884
	Std. Deviation, m/km	0.345	0.281
	COV, %	36	32
Fatigue Cracking	Mean, m^2	4.0	1.4
	Std. Deviation, m^2	20.0	7.5
	COV, %	494	535
Transverse Cracking	Mean, m	1.5	1.4
	Std. Deviation, m	7.3	6.5
	COV, %	499	474

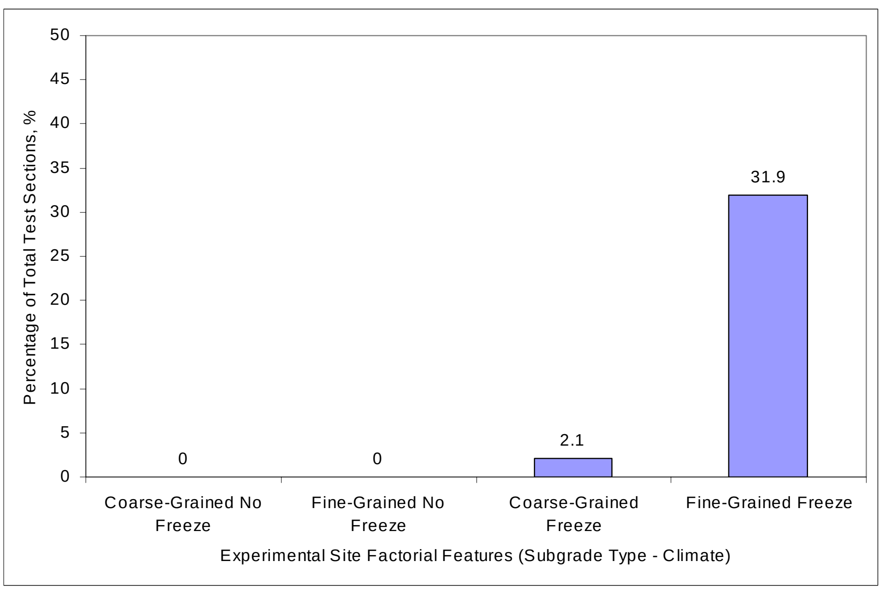


Figure 26. Percentage of the core test sections that exceed an IRI value of 1.2 m/km.

More transverse cracking has occurred on HMA pavements supported by fine-grained soils than on those supported by coarse-grained soils. This observation is consistent with some of the previous empirical models that have been developed for transverse cracking. However, the average lengths of transverse cracking could be biased toward the fine-grained soils because most of the greatest lengths of transverse cracking were observed on test sections from the Iowa project.

Base Type and Thickness

Greater rut depths have been measured on HMA pavements with unbound aggregate base layers than on those with ATB layers (table 24). Figure 27 shows the percentage of core test sections with rut depths exceeding 8 mm. As shown in figure 27, rutting in 33 percent of the core test sections with unbound aggregate base layers has exceeded 8 mm while rutting in only 18 percent of those test sections with dense-graded ATB layers has exceeded 8 mm. This observation suggests that a portion of the rutting measured at the surface is a result of permanent deformations in the unbound aggregate base layer. This observation is consistent with a finding made by the authors from studying the GPS test sections.(15)

The IRI computed from the longitudinal profiles is greater for those HMA pavements with unbound aggregate base layer than for those with ATB layers. Figure 28 shows the percentage of core test sections exceeding an IRI value of 1.2 m/km for the two different base types. The HMA pavements with a thick base layer are smoother than those with a thin base layer.

The HMA pavements with unbound aggregate layers have slightly more fatigue cracking than those with ATB layers. Figure 28 shows a comparison of the percentage of the core test sections with an IRI value greater than 1.2 m/km. As shown, the pavements with unbound aggregate base layers have a much higher percentage of fatigue cracking exceeding 1.2 m/km. This observation is consistent with the authors' previous experience.(16)

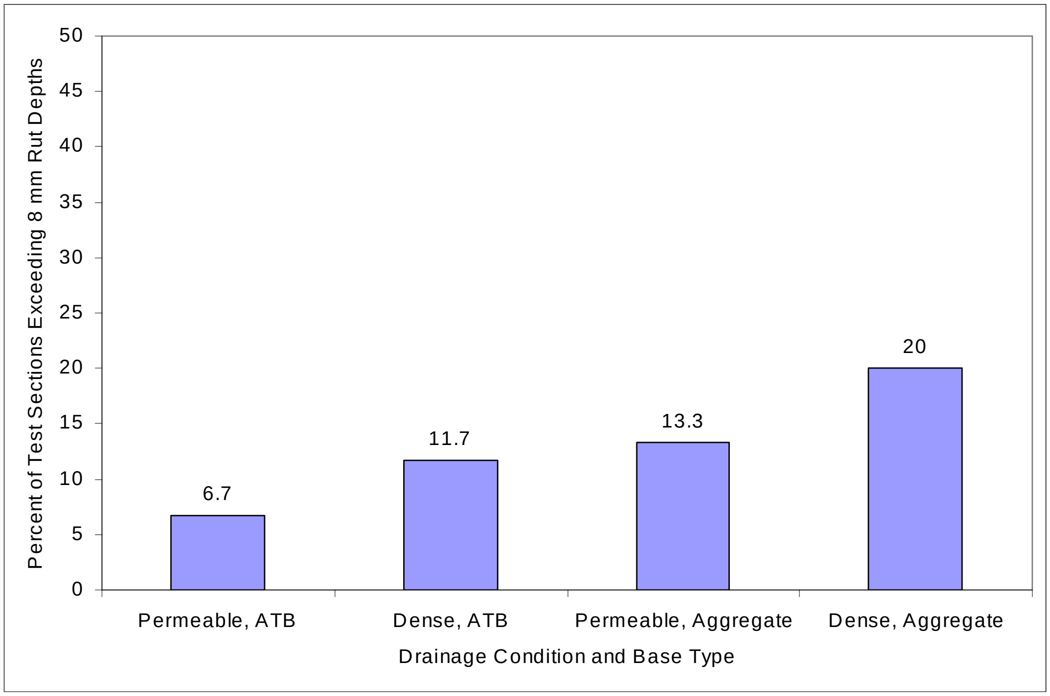


Figure 27. Percentage of the core test sections that exceed 8 mm of rutting.

Drainage Condition

The HMA pavements with the permeable asphalt drainage layers are slightly smoother than those built without any drainage layer. However, the percentages of the core test sections with IRI values exceeding 1.2 m/km are about the same (refer to figure 28). In addition, a lower percentage of test sections with permeable asphalt drainage layers have rut depths exceeding 8 mm (refer to figure 27).

In general, the percentage of core test sections with fatigue cracking is slightly less for those test sections with permeable asphalt layers than for those without permeable base layers (refer to figure 29). However, the test sections with the thick HMA surface layer exhibited a greater average area of fatigue cracking than did the companion sections with the thin HMA surface layer. The Kansas project further confounds these results. As mentioned earlier, construction difficulties occurred on this project as a result of wet weather and difficulties in compacting the highly variable subbase (refer to table 19). The difficulty in compacting the subbase layer and the variable densities may have caused a weakness in all of those test sections.

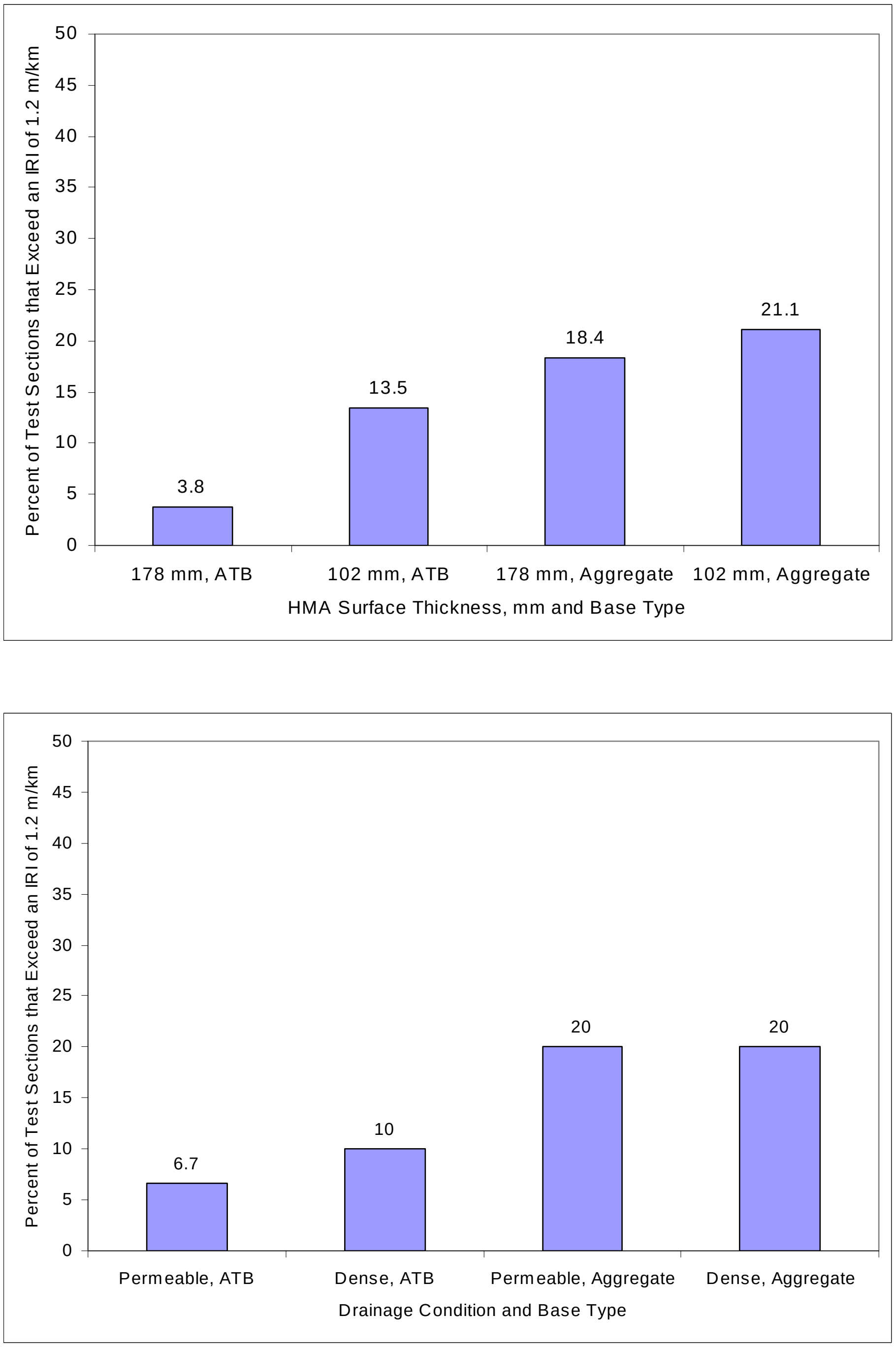


Figure 28. Percentage of test sections that exceed an IRI value of 1.2 m/km.

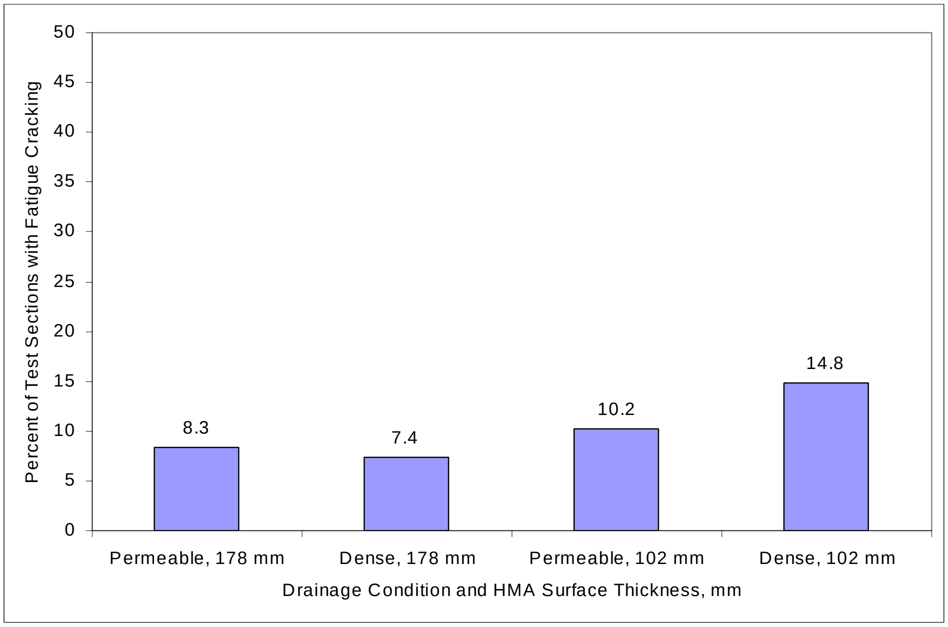


Figure 29. Percentage of core test sections that have fatigue cracking.

HMA Surface Thickness

As expected, the pavements with thick HMA surface layers have much less fatigue cracking, as shown in figure 29 and tabulated in table 26. Fewer core test sections with thick HMA layers exceed an IRI value of 1.2 m/km (refer to figure 28) than those with thinner HMA. Figure 28 graphically shows that 22 percent of the test sections with thick HMA layer have exceeded an IRI value of 1.2 m/km, while almost 34 percent of the test sections with thin HMA surface layers have exceeded that value.

SUMMARY

Some of these differences in performance may not be statistically significant at this time (for example, more fatigue cracking on thin HMA layers), but they demonstrate that the early observations from the SPS-1 experiment are consistent with previous experience. In other words, these early observations show the potential value of the SPS-1 experiment and that the experimental objectives and expectations can be met in the future with accumulated traffic loadings and increased age.

The construction and deviation reports also were found to be extremely valuable in explaining possible anomalies in the experiment and performance differences from the other projects and test sections. Use of these reports should reduce the possibility of biased conclusions. However, in order to extract the full benefit of this experiment, the planned materials testing program must be completed and the truck traffic data must be collected on those projects that have no data at this time.

The above findings are considered the most important relative to the overall success of the SPS-1 experiment. However, following are other findings that also confirm the reasonableness of the SPS-1 experimental data:

- Higher rut depths have occurred on those test sections with unbound aggregate base layers than on sections with dense ATB or permeable ATB.
- Rutting appears to be related more to the HMA mixture properties than to the structural characteristics.
- Extensive and accelerated fatigue cracking will occur at the surface when the base or subbase layers have not been properly compacted.
- Greater amounts of fatigue cracking occur on pavements with a thin HMA layer.
- Greater lengths of transverse cracking generally occur as the pavements age, but the extent is more related to the binder and/or HMA mixture properties.
- Those pavements built over coarse-grained soils and in a no-freeze environment are smoother and stay smoother over a longer period of time than those built over fine-grained soils in a freezing environment.
- Those pavements built over fine-grained subgrades and in a wet-freeze environment are substantially rougher than those built in other climates and on other subgrades.
- A greater percentage of sections with dense bases have rut depths that exceed 8 mm than the test sections with PATB layers (32 percent compared to 20 percent of sections with permeable asphalt drainage layers).
- A slightly lower percentage of core test sections with permeable asphalt layers exhibit fatigue cracking (compared to those without permeable base layers).

6. SUMMARY AND CONCLUSIONS

The SPS-1 experiment, entitled *Strategic Study of Structural Factors for Flexible Pavements*, is one of the key experiments of the LTPP program. The main objective of this experiment is to determine the relative influence and long-term effectiveness of the HMA pavement strategic factors that affect performance. Most of the site factorial cells have companion projects within each cell and it is believed that the construction deviations and discrepancies will not have a detrimental impact on the ability of the experiment to accomplish its original objectives.

This report has presented the results from the first comprehensive review and evaluation of the SPS-1 experiment. Issues of experimental design, construction quality, data availability and completeness, and early performance trends have been addressed.

The unavailable data identified in this report do not necessarily mean that the data were not collected or submitted by the SHAs that built the individual projects. There can be several instances where good data can be delayed before reaching Level E status. The following are some examples of why some data elements could be shown as unavailable when the data actually were collected:

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

The LTPP program is continuing on a systemwide basis to resolve all unavailable data so that they will be available to future studies. Some data have already been located and forwarded to the IMS during the course of this study. The key findings from this detailed review are summarized in this chapter.

SPS-1 EXPERIMENT STATUS

As of January 2000, 18 SPS-1 projects have been constructed throughout the United States (refer to figure 1). The full factorial of the original experiment design has been completely filled, with the exception of two site cells that do not have companion projects. The missing site factorial cells are the coarse-grained soils in a dry-no-freeze climate and the fine-grained soils in a wet-no-freeze climate (site cells 2 and 8 in table 3). These two missing companion projects are not believed to be critical. The completeness of the experimental factorial is a major benefit in calibrating and validating performance prediction models for new flexible pavements. To completely fill the factorial, the following projects would need to be constructed:

- One site to match the Arizona site in a dry-no-freeze environmental zone with coarse-grained subgrade.
- One site to match the Alabama and Louisiana sites in the wet-no-freeze environmental zone with fine-grained subgrade.

All of the SPS-1 projects have 12 core test sections and some of the projects have additional supplemental test sections that were built by the agency. A total of 216 core test sections and 32 supplemental test sections are available from this experiment. This number of test sections should provide excellent data for future studies.

The primary value of the supplemental sections will be to serve as a direct comparison to the core test sections within that specific SPS-1 project. However, the supplemental sections built at each site can be used in regional or national studies through the application of mechanistic analysis principles. Therefore, efforts should be made to ensure that their construction and monitoring data are collected and stored in the IMS for future use.

An important issue in the experimental factorial is the imbalance in the number of projects between the different soil classifications. Eleven projects have been built over fine-grained soils while only seven have been built over coarse-grained soils. This imbalance is not believed to be critical, but should be considered when analyzing the data to determine the effects of the subgrade on performance. The other important observation from the experiment is that the ages of the projects are reasonably distributed between the different cells of the site factorial (table 3).

DESIGN VERSUS ACTUAL CONSTRUCTION

Experimental design factors were compared to the actual values measured during construction that were included in the IMS database. This includes both the site condition factors and pavement design features. Most SPS-1 sections follow the experiment design for the large majority of the design factors. Overall, very few construction deviations have been reported for the SPS-1 projects, with the exception of layer thickness.

Most layer thickness measurements deviate more from the experiment design than allowed by the project requirements for each layer. However, none of the thickness data for the thin and thick layers overlap. The following summarizes notable deviations when comparing the designed to the as-constructed values.

- Kansas—The subbase layer became wet during construction and had to be stabilized by the use of fly ash. The resulting density of that layer was highly variable.
- Nebraska—The amount of fines in the permeable aggregate layer was excessive and will probably have an effect on the drainage capability of that layer.

The other construction deviations are primarily related to the HMA layers. For example, the stability of the HMA mixture placed along the Arkansas project was less than the value specified in the project documents. In addition, the percentage passing the number 4 sieve for the HMA mixture and the percentage passing the number 200 sieve for the dense-graded aggregate base exceeded the specified values for many of the test sections. These are considered minor deviations and should not be critical to the overall experiment.

DATA AVAILABILITY AND COMPLETENESS

The data availability and completeness for the SPS-1 experiment are good overall (more than 95 percent of all data types collected are at Level E) with the exception of two major data elements—materials testing and traffic data. Furthermore, a significant amount of monitoring data must still be collected and/or checked to fill in the missing gaps of the time-history data for selected projects.

Four projects (Florida, Montana, Oklahoma, and Wisconsin) do not have the initial transverse profile data and are missing some of the time intervals to establish the performance trends. The Montana and Wisconsin projects are less than 2 years in age while the other two have been in-place for more than 2 years. Transverse profiles were measured shortly after construction for the Montana, Oklahoma, and Wisconsin projects, but these data are not at Level E in the IMS. The reasons data have not achieved Level E status need to be ascertained and the situation rectified before detailed analyses of the SPS-1 experiment can be completed.

The critical data deficiencies for the SPS-1 experiment are summarized below:

- Traffic data are not available at Level E for 50 percent of the SPS-1 sites and five of the sites do not have traffic monitoring equipment installed at the site.
- Materials test data are very deficient for most of the pavement materials and subgrade soils. The resilient modulus and other fundamental properties of these materials need to be measured and entered into the database if these sites are to be used for mechanistic studies. The testing programs for many of the projects are still under way and data are continually being forwarded to the RCOs for processing.

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

Construction Reports/Data

The construction and deviation reports are extremely valuable in reviewing and explaining performance anomalies of the individual test sections. Construction and deviation reports were available for review for all of the projects with the exception of Michigan, Wisconsin, and Montana. The construction report has been recently submitted for the Wisconsin project and the one for the Montana project is in the process of being prepared.

Materials Data

The materials data are partially complete for all of the projects with the exception of the relatively new projects. However, none of the projects were found to have all testing completed. Tables 9 through 13 summarize selected test data by material type for each of the projects and show that extensive test data were unavailable at the time of the data extraction. In fact, none of the projects have any indirect tensile resilient modulus, strength, and creep compliance test data.

Materials test data are a key data element, especially for use in mechanistic studies (such as NCHRP 1-37A) because the test results are used to determine the material physical properties needed for distress predictions and to help explain performance anomalies. Without the materials tests, the SPS-1 experiment will be severely limited in its application to future studies. As stated above, the materials testing is currently under way and materials test data are being submitted to the RCOs on a periodic basis. Completion of the materials testing program should be a high priority to ensure that the full benefit of the SPS-1 experiment can be realized.

Climatic Data

The SPS-1 experimental design called for a project to be located in one of four different climates to ensure a diverse range of climatic factors (refer to table 3). The climatic data are obtained from actual measurements of weather data for the specific sites that are monitored with time and from historical data from nearby weather stations. All projects were found to be in compliance with the appropriate cell requirements based on the NOAA and historical climatic data. AWS equipment is installed at every SPS-1 project site. Table 15 listed the number of days of data from the AWS at each project site, and shows that there is much more data in the IMS for the older projects.

Traffic Data

The SPS-1 experimental design called for continuous WIM monitoring, as permitted by WIM scale operating divisions. Table TRF_MONITOR_BASIC_INFO was examined to identify the SPS-1 records with WIM, AVC, and annual ESAL estimates.

Table 15 summarized the amount of data for the SPS-1 sites and identified those projects with no traffic data at Level E. In summary, nine (50 percent) of the SPS-1 sites do not have any traffic data in the IMS while only five projects do not have any WIM or AVC equipment installed at the site. Most of the older projects have the traffic monitoring equipment installed at the site, while the newer projects do not have the monitoring equipment and are missing traffic data.

All of the projects have an annual estimate of the number of ESALs, but the reliability of this data is unknown for nearly 50 percent of the projects.

Performance Indicator Data

Several types of monitoring data are included in the LTPP IMS. These monitoring data include: distresses (from both manual and video surveys), longitudinal profiles, transverse profiles, deflection, and friction. Table 16 provided a summary of the number of distress and other performance indicator measurements made at each of the SPS-1 project sites. Table 17 provided a summary of the average number of years between the surveys for each performance indicator, except for friction.

The data that were unavailable at the time of the data extraction include four projects without transverse profile data and two of those projects were less than 2 years old. The following summarizes the data that should be measured in the near future, if it has not already been collected by the RCOs:

- Longitudinal profiles: Arkansas, New Mexico, and Oklahoma
- Transverse profiles: Alabama, Arkansas, Florida, Oklahoma, Montana, and Wisconsin
- Distress surveys: Iowa, Arkansas, Florida, Nebraska, and Alabama
- Deflection surveys: Florida, New Mexico, Delaware, Iowa, and Texas

In summary, the amount of performance indicator data is good. The time-series data for each measure of performance will be a significant benefit for future studies regarding the design and performance of new flexible pavements.

Friction Data

With few exceptions, friction surveys have not been performed on the SPS-1 projects. This testing is not considered essential to the SPS-1 experiment. Thus, the missing friction data will have no impact on future studies on structural behavior and performance.

Summary

Table 27 summarizes the unavailable and limited data for the SPS-1 experiment as of January 2000.

EARLY PERFORMANCE TRENDS

Most of the SPS-1 projects are relatively young and show little or no distress. As of January 2000, less than 10 percent of the test sections have distress magnitudes that exceed values believed to be necessary to complete meaningful comparisons. Based on the statistical analyses and comparisons documented in chapter 5, the key experimental factors were found to have an effect on the performance indicators. Caution should be used in extrapolating these early findings because the long-term performance trends could be significantly different from these early observations.

The specific experimental expectations of the SPS-1 experiment were to determine the primary effects and interactions of the following key design features:

- HMA thickness.
- Base thickness.
- Base type.
- Drainage condition.

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

- Fine-grained and coarse-grained soils.
- Wet climates and dry climates.
- Freeze or cold climates and no-freeze or warm climates.

Table 27. Summary of missing or limited data for the SPS-1 experiment.

Subgrade Soil Type	Pav't. Structure, Cell Numbers	Climate, Moisture-Temperature			
		Wet-Freeze	**Wet-No-Freeze**	**Dry-Freeze**	**Dry-No-Freeze**
Fine-Grained	1–12	**IA(1)-7.0:** Limited AWS climatic data. Limited WIM/AVC traffic data. Limited distress surveys. Subgrade—Missing classification, moisture density (M-D), & permeability data. Aggr. Base—Missing resilient modulus & permeability data & limited classification & M-D data. ATB—Limited mix & asphalt data & missing moist. susc. data. HMA—Missing mix, moist. susc., asphalt & aggregate data.	**LA(0)-2.1:** No WIM equipment installed. Missing recent longitudinal profile. Subg.—Missing permeability data. Aggr. Base—Missing M-D, classification, & permeability data & limited resilient modulus data. ATB—Missing mix, moist. susc., aggregate & asphalt data. HMA—Missing mix, moist. susc., asphalt & aggregate data.	**KS(6)-5.8:** Limited WIM/AVC traffic data. Missing recent deflection survey & transverse profile. Aggr. Base—Missing classification, M-D, resilient modulus, & permeability data. ATB—Missing mix, aggregate, asphalt, & moist. susc. data. HMA—Missing moist. susc., mix, asphalt & aggregate data.	**NM(0)-3.7:** No WIM equipment installed. Missing recent deflection survey & longitudinal profile. Aggr. Base—Missing classification, M-D, & resilient modulus data.
		OH(2)-4.6: No WIM equipment installed. Subg.—Missing classification, M-D, and resilient modulus data & limited permeability data. Aggr. Base—Limited classification & permeability data & missing M-D & resilient modulus data. ATB— Missing moist. susc. data & limited mix, aggregate & asphalt data. HMA—Missing moist. susc. data & limited mix, asphalt & aggregate data.	**AL(3)-6.4:** No WIM equipment installed. Missing recent distress survey & transverse profile. Subg.—Missing permeability data. Aggr. Base—Missing resilient modulus & permeability data & limited classification & M-D data. ATB—Missing asphalt, aggregate, & moist. susc. data & limited mix data. HMA—Missing moist. susc., asphalt & aggregate data & limited mix data.		

Table 27. Summary of missing or limited data for the SPS-1 experiment, continued.

Subgrade Soil Type	Pav't. Structure, Cell Numbers	Climate, Moisture-Temperature			
		Wet-Freeze	**Wet-No-Freeze**	**Dry-Freeze**	**Dry-No-Freeze**
	13–24	**MI(1)-4.0:** Limited AWS climatic data. Limited WIM/AVC traffic data. Missing recent deflection survey. Subg.—Missing permeability data & limited classification, M-D, & resilient modulus data. Aggr. Base—Missing resilient modulus & permeability data, & limited classification & M-D data. ATB—Missing mix, aggregate, asphalt, & moist. susc. data. HMA—Missing mix, moist. susc., asphalt & aggregate data.	No Projects	**NB(1)-4.1:** Limited WIM/AVC traffic data. Subg.—Limited resilient modulus & permeability data. Aggr. Base—Missing resilient modulus & permeability data & limited classification data. ATB—Missing moist. susc. data & limited aggregate & asphalt data. HMA—Missing moist. susc. data & limited mix, asphalt & aggregate data.	**TX(8)-2.3:** Limited AWS climatic data. Subg.—Missing M-D & permeability data & limited classification data. Aggr. Base—Missing M-D, classification, & permeability data. ATB—Missing mix, moist. susc., aggregate & asphalt data. HMA—Missing mix, moist. susc., asphalt & aggregate data.
		VA(1): Limited WIM/AVC traffic data. Missing recent deflection survey. Subg.—Missing resilient modulus data. Aggr. Base—Missing M-D, resilient modulus & permeability data. ATB—Limited asphalt data. HMA—Limited mix, moist. susc., asphalt & aggregate data.			**OK(2)-2.1:** No WIM equipment installed. Subg.—Missing M-D & permeability data & limited classification data. Aggr. Base—Missing M-D, classification, resilient modulus, & permeability data.
Coarse-Grained	1–12	**DE(2)-3.2:** No WIM equipment installed. Subg.—Missing classification, M-D, and permeability data. Aggr. Base—Missing classification, M-D, & resilient modulus data & limited permeability data. ATB—Missing moist. susc. & asphalt data & limited mix & aggregate data. HMA—Missing moist. susc. data & limited mix data.	**FL(1)-3.7:** Limited WIM/AVC traffic data. Missing transverse profile data. Missing recent deflection survey & longitudinal profile. Subg.—Missing gradation & permeability data & limited resilient modulus data. Aggr. Base—Missing resilient modulus & permeability data & limited classification & M-D data.	**NV(0)-4.0:** No AWS equipment installed. Limited WIM/AVC traffic data. Subg.—Limited permeability data. Aggr. Base—Missing M-D & resilient modulus data & limited classification data. ATB—Missing moist. susc., asphalt, & aggregate data & limited mix data. HMA—Missing moist. susc., asphalt & aggregate data & limited mix data.	No Projects

Table 27. Summary of missing or limited data for the SPS-1 experiment, continued.

Subgrade Soil Type	Pav't. Structure, Cell Numbers	Climate, Moisture-Temperature			
		Wet-Freeze	**Wet-No-Freeze**	**Dry-Freeze**	**Dry-No-Freeze**
	13–24	**WI(0)-1.8:** No construction report. No AWS equipment installed. No WIM equipment installed. Missing recent deflection survey & transverse profile. Subg.—Missing classification, M-D, resilient modulus, & permeability data. Aggr. Base—Missing classification, M-D, resilient modulus & permeability data. ATB—Missing mix, moist. susc., asphalt, & aggregate data. HMA—Missing mix, moist. susc., asphalt, & aggregate data.	**AR(1)-5.7:** Limited WIM/AVC traffic data. Missing recent distress survey & longitudinal & transverse profiles. Subg.—Missing resilient modulus & permeability data. Aggr. Base—Missing M-D, resilient modulus, classification, & permeability data. ATB—Missing mix, asphalt, aggregate, & moist. susc. data. HMA—Missing moist. susc., asphalt & aggregate data & limited mix data.	**MT(0)-0.8:** No construction report. No WIM equipment installed. Subg.—Missing classification, M-D, resilient modulus, & permeability data. Aggr. Base—Missing classification, M-D, resilient modulus, & permeability data. ATB—Missing mix, moist. susc., asphalt & aggregate data. HMA—Missing mix, moist. susc., asphalt & aggregate data.	**AZ(5)-6.0:** Subg.—Limited resilient modulus and missing permeability data. Aggr. Base—Missing permeability & limited resilient modulus data. HMA—Missing moist. susc. data & limited asphalt data.

Note: All projects are missing indirect tensile resilient modulus, indirect tensile strength, and indirect tensile creep compliance tests. The values in parentheses are the number of supplemental test sections for each project; the other value provided for each project is the age of that project in years.

This evaluation has shown that several problems will clearly limit the results that can be obtained from the SPS-1 experiments. The misinterpretation of the different distress types over time by the distress surveyors and the potential measurement error of low levels of distress increase the difficulty of interpreting performance trends and of determining the effects between the experimental factors. The misinterpretation of distress types leads to wide variations in distress quantities over time for a given section (e.g., longitudinal and transverse cracking are sometimes called block cracking). The measurement error also contributes to wide variations in distress quantities over time for a given section. Both of these problems make data analysis very difficult. This problem may lead to the need to provide "smooth" curves for specific distress types for each section for analysis purposes.

Other major limitations are related to the value of the SPS-1 experiment, including the missing materials test data and traffic data. 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. Table 28 summarizes the limitations and action items to correct these deficiencies related to each of the SPS-1 projects.

The following list highlights some early performance trends from the SPS-1 experiment:

- Higher rut depths have occurred on those test sections with unbound aggregate base layers than on sections with dense ATB or permeable ATB.
- Rutting appears to be related more to the HMA mixture properties than to the pavement's structural characteristics.
- Extensive and accelerated fatigue cracking will occur at the surface when the base or subbase layers have not been properly compacted.
- Greater amounts of fatigue cracking occur on pavements with thin HMA layers.
- Greater lengths of transverse cracking generally occur as the pavements age, but the extent is more related to the binder and/or HMA mixture properties.
- Those pavements built over coarse-grained subgrades and in a no-freeze environment stay smoother over a longer period of time than those built over fine-grained soils in a freezing climate.
- Those pavements built over fine-grained subgrades and in a wet-freeze environment are substantially rougher than those in other climates and with other subgrades.
- Sections with permeable asphalt drainage layers have a lower percentage of test sections with rut depths exceeding 8 mm (20 percent) than sections with dense bases (32 percent).
- The percentage of core test sections with fatigue cracking is slightly less for those test sections with permeable asphalt layers than for those without permeable base layers.

Table 28. Deficiencies and action items for each SPS-1 project.

SPS-1 Project	Deficiency	Suggested Action
Alabama, Delaware, Ohio, Louisiana, Montana,(1) Oklahoma, New Mexico, Texas, and Wisconsin	No traffic data (WIM and/or AVC).	Collect and/or process traffic data.
Alabama, Delaware, Louisiana, Oklahoma and New Mexico	No traffic measuring equipment installed at site.	Install traffic WIM and AVC measuring equipment.
Michigan, Montana(2)	No construction reports available.	Ensure that the construction reports become available for future studies—even if the contractor, SHA personnel, and other personnel on site during construction have to be interviewed from memory.
Nevada(3) and Wisconsin	No AWS data.	Collect and/or process climatic data.
Nebraska, Wisconsin, Michigan and Montana	Construction data—rod & level measurements.	Process data that was collected during construction.
Alabama, Arkansas, Delaware, Iowa, Kansas, Louisiana, Michigan, Montana, Nevada, Oklahoma, Ohio,(4) Wisconsin,(4) and Texas	Insufficient test data available for the essential material properties.	Complete the test program. Use backcalculated elastic layer modulus until laboratory test data become available.
All Projects	Layer thickness deviates from the planned thickness more than allowed by the project requirements.	None—Adjust or normalize the performance to account for the thickness difference between 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.
Florida, Montana,(5) Oklahoma, and Wisconsin	No transverse profile data.	Take immediate action to collect and/or process these data.
Arkansas and Louisiana	Transverse profile measured only once at these sites.	Take immediate action to collect these data.
Louisiana, New Mexico, and Oklahoma	Longitudinal profile measured only once at these sites.	Take immediate action to collect these data.
Arkansas, Florida, Iowa, and Wisconsin	Only one manual survey performed at these sites.	Take immediate action to collect these data.

Notes: (1) WIM equipment was installed at the Montana site. The traffic data are on hold pending the new traffic processing software.
(2) The construction report for the Montana project is in draft form and awaiting additional construction information.
(3) AWS equipment was installed at the Nevada project, but is not at Level E in the IMS.
(4) Materials testing has been completed for the Ohio and Wisconsin projects, but that data are not at Level E.
(5) Transverse profiles were measured at the same time that the distress surveys were performed on the Montana project, but these data are not at Level E in the IMS.

EXPECTATIONS FROM THE STATES

Two national workshops were held where input was received from the States on the SPS-1 experiment. The meetings were held on November 2–3, 1999, in Columbus, OH, and on April 27, 2000, in Newport, RI. Several State agencies made presentations on the status of their SPS-1 project and their expectations from the SPS-1 experiment. Panel discussions on the future direction and analysis of the SPS-1 data were held at both conferences. Those discussions are summarized in this section.

In general, the States seem to be satisfied with the experiment and believe that it will produce valuable information on the different design factors and features. Many States have been conducting or are planning their own analyses on their SPS-1 project. Some of these analyses have already yielded useful results; however, the States would like to see a focus on implementation.

First and foremost, the States want a research-quality database from the SPS-1 experiment. Secondly, the States want to be able to determine the effects of the design features on pavement performance and the effectiveness of the SPS-1 experiment design factors, such as:

- Drainage—Is it effective and, if so, when and under what conditions should free draining layers or edge drains be used?
- Base Type and Thickness—What base types provide the better performance and how should they characterize the base material's structural strength?
- HMA Thickness—How thick should the surface be and what properties of the HMA have a significant effect on performance?
- Subgrade Soil Type—What effect does the soil type have on pavement performance?

In addition to the structural design features, the States also want to know what major site condition factors influence performance of new flexible pavements, including:

- Climate.
- Traffic Volume and Weights.
- Subgrade Soil Type and Properties.

Other expectations from the States include:

- Evaluation of existing performance prediction equations.
- Better design procedures.
- Better understanding of the distress mechanisms.
- Validation and confirmation of pavement analysis methods.
- Calibration of mechanistic-empirical distress prediction models.
- Comparison of laboratory measured and field derived (backcalculated) material properties.
- Effects of soil type, base type, drainage, and climate on long-term subgrade moisture conditions and how those conditions may change with time and season.
- Cost effectiveness of drainable bases and underdrains.

- Using stiffness rather than density for subgrade and base acceptance.

As to the future analysis plan for SPS-1, the States believe that it is worthwhile first to fill in the missing data—specifically obtain traffic and material test data. Some presenters at the SPS conference requested that fundamental studies be conducted to determine how the SPS-1 sections are responding to load and environmental stresses and loads. It also was suggested that an integrated analysis plan be developed for future research.

CAN THE SPS-1 EXPERIMENT MEET EXPECTATIONS?

The specific experiment expectation of the SPS-1 was to determine the main effects and interactions of the following key design features.

- HMA thickness.
- Base type including PATB, ATB, and untreated aggregate base materials.
- Base thickness.
- Drainable bases.

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

- Fine-grained and coarse-grained soils.
- Wet-freeze, wet-no-freeze, dry-freeze, and dry-no-freeze climates.

This data review and evaluation of early performance trends has shown that several significant data issues will limit the results that can be obtained from the SPS-1 experiment. The missing traffic data and key materials data must be obtained before meaningful global analysis can be performed. A few of the SPS-1 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 results cannot be obtained from the SPS-1 experiment. Some important early trends have already been identified that will be useful for the design and construction of HMA pavements, even though all projects are less than 7 years old. Thus, it is concluded from this comprehensive study of the SPS-1 experiment that the expectations from the State agencies and HMA industry can be met.

RECOMMENDATIONS FOR FUTURE ACTIVITIES

As stated in chapter 1, the key objective of the SPS-1 experiment is to determine the relative influence of different structural factors on flexible pavement performance. It is believed that the experiment will be able to achieve this key objective with time. Since the oldest SPS-1 project is just over 7 years (most are 3 to 5 years old), only a small percentage of the SPS-1 test sections have significant levels of distress and only a few have been taken out service. The real benefit from this experiment will occur within the next 5 years, as a greater percentage of test sections exhibit higher levels of distress—magnifying the effect of the experimental and other structural factors on performance.

This SPS-1 assessment report focused on the quality and completeness of the SPS-1 construction and monitoring data, and on the adequacy of the experiment to achieve the original experimental expectations and objectives. Some data are unavailable, but not enough to significantly limit the value of the results from this experiment. Detailed analysis of the effect of different design factors on performance was outside the scope of work for this study. Thus, future studies using the SPS-1 experimental data should be planned and prioritized so they can be initiated as the SPS-1 projects exhibit higher levels of distress.

These future studies should be planned for in two stages that focus on local and national expectations from the experiment. The first stage is to conduct a detailed assessment or case study on each structural cell in the experiment to support local interests and expectations. The second stage takes selected data elements to evaluate the effect of different structural features across the whole experiment. Both stages are discussed briefly in the following sections.

Initial Stage—Analysis of Local Expectations or Individual Factorial Cells

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

- Resolve construction and monitoring 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. 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-1 project specifications, if any, on pavement performance and response.

- Develop findings on comparisons made between the companion 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 analysis 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-1 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 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 of the future studies that can be pursued at the national level using all of the SPS-1 experimental data are summarized in tables 29 through 42. 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-1 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-1 experiment and the second category objectives are related to other experimental factors.

The following second-stage analysis objectives are recommended for the SPS-1 experiment, which are presented in more detail in tables 29 through 42:

<u>Future Analysis Objectives Related to Main Experimental Factors (table number)</u>

29. Perform test section-by-test section analyses of the projects included in the SPS-1 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 for the companion project. This objective is the initial analysis of the individual factorial cells.
30. Determine the effect of the main SPS-1 experimental factors on the performance of flexible pavements.
31. Quantify the benefits of a good drainage system for flexible pavements.
32. Determine the effect of layer thickness variations on long-term pavement performance and initial ride quality.
33. Determine and quantify the effect of base material selection and type on the performance of flexible pavements.
34. Estimate the effect of seasonal conditions or changes on the modulus of unbound pavement materials and subgrade soils.

35. Quantify the effect of soil type on pavement performance measures (specifically ride quality) and minimum pavement thickness over the foundation.

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

36. Determine the effect of base condition (such as moisture content, compaction, and degree of saturation) on the performance of flexible pavements.
37. Determine the effect of HMA compaction and material properties (gradation and resilient modulus) on pavement performance.
38. Quantify the remaining life of cracked or damaged HMA layers.
39. Quantify the applicability of the subgrade protection criteria—limiting the subgrade vertical compressive strain and deflection.
40. 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 initiating at the surface of the pavement.
41. Compare and quantify any differences between backcalculated modulus values using "MODCOMP" and laboratory measured resilient modulus.
42. Conduct mechanistic analyses of the SPS-1 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.

Table 29. Identification of future research studies from the SPS-1 experiment—initial analysis of the individual factorial cells and companion projects.

<table>
<tr><td colspan="2">OBJECTIVE NO. 1
Perform test section-by-test section of the SPS-1 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 and those of the companion project. (Expected timeframe—2001 to 2002).</td></tr>
<tr><td>TOPIC AREA
Pavement design and performance prediction.
Impact of specific design features on performance.</td><td>PROBABILITY OF SUCCESS
High</td></tr>
<tr><td>LTPP STRATEGIC PLAN
7.A, 7.B, 7.C</td><td>SUPPLEMENTAL EXPERIMENTS</td></tr>
<tr><td>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-1 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 companion 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.</td><td>POTENTIAL PRODUCT USE
Future analysis projects.</td></tr>
<tr><td colspan="2">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-1 project specifications, if any, on pavement performance and response.
• Develop findings regarding comparisons made between the companion 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.</td></tr>
</table>

Table 30. Identification of future research studies from the SPS-1 experiment—overall effect of the main experimental factors on performance.

<table>
<tr><td colspan="2">OBJECTIVE NO. 2
Determine the effect of the main SPS-1 experimental factors on the performance of the flexible pavements. (Expected timeframe—2002 to 2003).</td></tr>
<tr><td>TOPIC AREA
Pavement design and performance prediction.
Impact of specific design features on performance.</td><td>PROBABILITY OF SUCCESS
High</td></tr>
<tr><td>LTPP STRATEGIC PLAN
7.A, 7.B, 7.C</td><td>SUPPLEMENTAL EXPERIMENTS</td></tr>
<tr><td colspan="2">END PRODUCT
Impact of specific design features and level of significance on pavement performance and the occurrence of pavement distress.
Determine the effect of drainage on performance and identify the site conditions (type of subgrade soil, climate, traffic) where permeable bases will and will not contribute to improved performance.
Identify the flexible pavement design features and properties that are compatible with permeable base drainage and contribute to improved performance.
Identify the site conditions where different base types will contribute to improved pavement performance.
Determine the significance of seasonal changes on the response of the pavement and materials related to performance and incremental deterioration.
Confirm and quantify the effect of the subgrade on pavement performance and minimum pavement thickness above the subgrade.</td></tr>
<tr><td colspan="2">POTENTIAL PRODUCT USE
Design new or reconstructed cost-effective and reliable flexible pavements.
Calibration and validation of new pavement design procedures/methods and distress prediction models.</td></tr>
<tr><td colspan="2">GENERAL TASKS
Review results and findings from each SPS-1 test section and companion 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, that aid them in determining the end products above.</td></tr>
</table>

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 31. Identification of future research studies from the SPS-1 experiment—benefits of drainage.

<table>
<tr><td colspan="2">OBJECTIVE NO. 3
Quantify the benefits of a good drainage system for flexible pavements. (Expected timeframe—2004 to 2005).</td></tr>
<tr><td>TOPIC AREA
Design and performance predictions.</td><td>PROBABILITY OF SUCCESS
Moderate to high(1)</td></tr>
<tr><td>LTPP STRATEGIC PLAN
7.A, 7.B, 7.C</td><td>SUPPLEMENTAL EXPERIMENTS
GPS test sections with drainage features</td></tr>
<tr><td>END PRODUCT
Impact of a positive drainage system on pavement performance and the occurrence of pavement distress.

A decision tree to identify those site conditions requiring drainage for enhancing the performance of flexible pavements and for selecting the drainage design features.</td><td>POTENTIAL PRODUCT USE
Design engineers for designing new pavements.</td></tr>
<tr><td colspan="2">GENERAL TASKS
• Review specific findings from each SPS-1 project related to the initial stage of the analysis.
• Subdivide data or test sections into those test sections with and without drainage features.
• Classify each site as to requiring drainage or not requiring drainage.
• Complete a regression analysis to determine any differences in performance and establish the relative differences between the two conditions.
• Complete an analysis of variance and other analyses to relate the site conditions to the effect of the drainage feature on improving performance.</td></tr>
</table>

(1) The probability of success will increase if field investigative studies are initiated to quantify the workability of the drainage system. Without the confirmation on the drain ability of the drainage system, major assumptions will have to be made regarding the quantification of the benefits from drainage.

Table 32. Identification of future research studies from the SPS-1 experiment—effect of thickness variations on performance.

OBJECTIVE NO. 4 Determine the effect of thickness variations on long-term pavement performance and initial ride quality. (Expected timeframe—2003 to 2004).	
TOPIC AREA Design	***PROBABILITY OF SUCCESS*** Moderate to high[(1)]
LTPP STRATEGIC PLAN 2.D, 7.B	***SUPPLEMENTAL EXPERIMENTS*** SPS-5 experiment
END PRODUCT Impact of layer thickness and the variation of thickness on pavement 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-1 project related to the initial stage. • Establish the thickness variability along each test section. • Complete a regression study of the variation in 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.	

[(1)] 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-1 projects.

Table 33. Identification of future research studies from the SPS-1 experiment—effect of base material type on pavement performance.

OBJECTIVE NO. 5 Determine the effect of base material selection and type on the performance of flexible pavements. (Expected timeframe—2003 to 2004).	
TOPIC AREA Design	***PROBABILITY OF SUCCESS*** High
LTPP STRATEGIC PLAN 2.A, 2.D, 7.A, 7.B, 7.C	***SUPPLEMENTAL EXPERIMENTS*** GPS-1 and GPS-2 experiments
END PRODUCT Impact of the base material type and condition on pavement performance and the occurrence of pavement distress. A decision tree and/or specifications for selecting base material types (material specifications) and when to stabilize the base layer.	***POTENTIAL PRODUCT USE*** To assist design engineers in selecting different base materials for specific site conditions and traffic levels and to determine the conditions when base stabilization will provide the most benefit.
GENERAL TASKS • Review specific findings from each SPS-1 project related to the initial analysis stage. • Conduct a regression study or analyses of the SPS-1 data to determine the effect of base thickness and type on performance. • Evaluate the effect of material noncompliance on performance and make adjustments for those test sections with noncomplying materials. • Determine the increase in performance or service life for the stabilized bases and the effect of base thickness on pavement life.	

Table 34. Identification of future research studies from the SPS-1 experiment—effect of seasonal changes on pavement response and material responses related to performance.

<table>
<tr><td colspan="2">OBJECTIVE NO. 6
Effect of seasonal conditions or changes on the response of the pavement structure and material response or modulus of unbound pavement materials and subgrade soils as related to pavement performance. (Expected timeframe—2004 to 2005).</td></tr>
<tr><td>TOPIC AREA
Materials characterization and pavement management.</td><td>PROBABILITY OF SUCCESS
High</td></tr>
<tr><td>LTPP STRATEGIC PLAN
2.A, 3.C, 3.E</td><td>SUPPLEMENTAL EXPERIMENTS
GPS-1 and GPS-2</td></tr>
<tr><td>END PRODUCT
Improvement of environmental effects and considerations in pavement design, material 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.</td><td>POTENTIAL PRODUCT USE
Allow designers and pavement management engineers to identify typical times of low modulus values.</td></tr>
<tr><td colspan="2">GENERAL TASKS
• Review specific findings from each SPS-1 project related to the initial analysis stage.
• Categorize the pavement structure with different soil types and base/subbase types and thicknesses 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).</td></tr>
</table>

Table 35. Identification of future research studies from the SPS-1 experiment—effect of soil type and stiffness on pavement performance.

<table>
<tr><td colspan="2">OBJECTIVE NO. 7
Quantify the effect of soil type on pavement performance measures (specifically ride quality) and minimum pavement thickness over the foundation. (Expected timeframe—2003 to 2004).</td></tr>
<tr><td>TOPIC AREA
Materials characterization and pavement design.</td><td>PROBABILITY OF SUCCESS
High</td></tr>
<tr><td>LTPP STRATEGIC PLAN
2.A, 3.A, 7.B, 7.C</td><td>SUPPLEMENTAL EXPERIMENTS
GPS-1 and GPS-2</td></tr>
<tr><td>END PRODUCT
Improvement in materials characterization of soils for design and development/confirmation of design criteria to protect the subgrade soils.

Minimum pavement thickness design criteria for selected soil types to protect and maintain ride quality.</td><td>POTENTIAL PRODUCT USE
Minimum pavement design standards over specific soil types and identification of minimum pavement thickness to maintain selected ride quality.</td></tr>
<tr><td colspan="2">GENERAL TASKS
• Review specific findings from each SPS-1 project related to the initial analysis stage.
• Categorize the pavement structure with different soil types and base/subbase type and thickness 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).
• Conduct statistical analyses to determine the significant properties or soil types to determine their correspondence with surface cracking, ride quality as measured by IRI, type of pavement structure, layer thickness, and various climatic parameters (such as rainfall).
• Based on statistical and mechanistic analyses, identify the minimum layer thickness to maintain a selected ride quality level and minimize the occurrence of pavement distress.</td></tr>
</table>

Table 36. Identification of future research studies from the SPS-1 experiment—effect of base condition on pavement performance.

<table>
<tr><td colspan="2">OBJECTIVE NO. 8
Determine the effect of base condition (such as moisture content, compaction, and degree of saturation) on the performance of flexible pavements. (Expected timeframe—2003 to 2004).</td></tr>
<tr><td>TOPIC AREA
Design and construction.</td><td>PROBABILITY OF SUCCESS
Moderate to high[(1)]</td></tr>
<tr><td>LTPP STRATEGIC PLAN
2.A, 2.B, 2.D, 2.E, 3.A, 7.A, 7.B, 7.C</td><td>SUPPLEMENTAL EXPERIMENTS
GPS-1 and GPS-2 experiments</td></tr>
<tr><td>END PRODUCT
Improvement of materials characterization, and impact of unbound aggregate base layer specifications and condition after construction on pavement performance and the occurrence of pavement distress.

A tabulation of base condition (density, moisture content, gradation, and other physical properties) to design values—modulus and moisture sensitivity.</td><td>POTENTIAL PRODUCT USE
Development of performance related specifications and design/construction criteria or properties as related to performance, and assistance in developing pay reduction factors.</td></tr>
<tr><td colspan="2">GENERAL TASKS
Review specific findings from each SPS-1 project related to the initial analysis stage.
Evaluate the as-built moisture contents, density, gradations, and quality of base material and categorize the different test sections with significant differences.
Evaluate the structural response (deflections) and backcalculated layer modulus of the base layer.
Correlate the physical properties and response properties to the condition of the base.
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 base properties and performance.</td></tr>
</table>

[(1)] The probability of success will increase as the materials test data are completed and become available for all pavement layers and for the subgrade soils.

Table 37. Identification of future research studies from the SPS-1 experiment—effect of HMA properties on pavement performance.

OBJECTIVE NO. 9 Determine the effect of HMA compaction and material properties (gradation and resilient modulus) on pavement performance. (Expected timeframe—2003 to 2004).	
TOPIC AREA Design 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-5, GPS-1, GPS-2 and SPS-9 experiments
END PRODUCT Improvement of HMA mixture characterization and impact of HMA properties after construction and specifications on pavement performance 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, the development of pay reduction factors, and development of material specifications to be used in construction (layer acceptance) and in design for determining layer thicknesses.
GENERAL TASKS • Review specific findings from each SPS-1 project related to the initial analysis stage. • Determine the physical properties at construction for each HMA layer of each test section. • Compare the backcalculated 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 selected or combined 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-1 experiment—quantification of remaining life of cracked or damaged HMA layers.

<table>
<tr><td colspan="2">OBJECTIVE NO. 10
Quantification of the remaining life of cracked or damaged asphalt concrete layers. (Expected timeframe—2004 to 2005).</td></tr>
<tr><td>TOPIC AREA
Pavement management and overlay design.</td><td>PROBABILITY OF SUCCESS
High</td></tr>
<tr><td>LTPP STRATEGIC PLAN
4.B, 5.B, 5.C, 6.B</td><td>SUPPLEMENTAL EXPERIMENTS
SPS-5, SPS-9, GPS-1, GPS-2, GPS6A & B experiments</td></tr>
<tr><td>END PRODUCT
Improvement in HMA layer characterization and guidance for maintenance and rehabilitation strategy selection and HMA overlay performance prediction.

A reduced modulus scale that is representative of a cracked HMA layer. This scale would be deflection and distress based so that the results from distress surveys can be used to estimate the remaining life of an HMA surface.</td><td>POTENTIAL PRODUCT USE
Pavement management studies to determine the expected time for maintenance and/or rehabilitation, and overlay designs and rehabilitation studies.</td></tr>
<tr><td colspan="2">GENERAL TASKS
• Review specific findings from each SPS-1 project related to the initial analysis stage.
• Backcalculate 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.</td></tr>
</table>

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

Table 39. Identification of future research studies from the SPS-1 experiment—identify those properties and conditions most conducive to the development of surface initiated fatigue cracks.

<table>
<tr><td colspan="2">OBJECTIVE NO. 11
Confirm the hypothesis of surface initiated fatigue cracks and identify those properties or conditions most conducive to the development of surface initiated fatigue cracks.</td></tr>
<tr><td>TOPIC AREA
Design</td><td>PROBABILITY OF SUCCESS
Moderate to high(1)</td></tr>
<tr><td>LTPP STRATEGIC PLAN
2.A, 5.C, 7.B</td><td>SUPPLEMENTAL EXPERIMENTS
GPS-2 experiment</td></tr>
<tr><td>END PRODUCT
Improvement in HMA mixture characterization for distress prediction, and development of new pavement response model and performance/distress prediction models applicable to pavement 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.</td><td>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.</td></tr>
<tr><td colspan="2">GENERAL TASKS
• Review specific findings from each SPS-1 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) for which surface initiated fatigue cracks are most likely to develop.</td></tr>
</table>

(1) 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-1 experiment—applicability of the subgrade protection criteria for use in design of flexible pavements.

<table>
<tr><td colspan="2">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. (Expected timeframe—2004 to 2005).</td></tr>
<tr><td>TOPIC AREA
Design</td><td>PROBABILITY OF SUCCESS
Moderate to high(1)</td></tr>
<tr><td>LTPP STRATEGIC PLAN
5.A, 5.B, 5.C, 7.C</td><td>SUPPLEMENTAL EXPERIMENTS
GPS-1 and GPS-2 experiments</td></tr>
<tr><td>END PRODUCT
Improvement in subgrade soil characterization for design, and development/confirmation of design criteria to protect the subgrade soil and foundation layers.

Limiting subgrade vertical strain and deflection criteria if found to be appropriate.</td><td>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.</td></tr>
<tr><td colspan="2">GENERAL TASKS
• Review specific findings from each SPS-1 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.</td></tr>
</table>

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

Table 41. Identification of future research studies from the SPS-1 experiment—confirm the C-values or differences between laboratory measured resilient modulus and backcalculated elastic layer modulus.

<table>
<tr><td colspan="2">OBJECTIVE NO. 13
Compare and quantify any differences between backcalculated modulus values using "MODCOMP" and laboratory measured resilient modulus. (Expected timeframe—2003 to 2004).</td></tr>
<tr><td>TOPIC AREA
Materials and pavement design.</td><td>PROBABILITY OF SUCCESS
High</td></tr>
<tr><td>LTPP STRATEGIC PLAN
2.B</td><td>SUPPLEMENTAL EXPERIMENTS
GPS-1 and GPS-2</td></tr>
<tr><td>END PRODUCT
Improvement in pavement and subgrade soils material characterization for pavement design and evaluation.

A table or graph showing the differences (ratios between laboratory and backcalculated modulus values).

Confirmation of the C-value and the factors that affect its magnitude.</td><td>POTENTIAL PRODUCT USE
To define those conditions in which the laboratory and field derived values are different for use in design and rehabilitation studies.</td></tr>
<tr><td colspan="2">GENERAL TASKS
• Review specific findings from each SPS-1 project related to the initial analysis stage.
• Determine or extract the backcalculated modulus values for each layer of the pavement and subgrade and confirm the reasonableness of those values. Remove those sites for which compensating errors have occurred in the solutions.
• Extract the resilient modulus test data for all pavement layers.
• Determine the resilient modulus for each layer and subgrade from laboratory measurements for the conditions during each deflection survey.
• Compare the backcalculated values to the laboratory-measured values at similar stress states and temperatures.</td></tr>
</table>

Table 42. Identification of future research studies from the SPS-1 experiment—mechanistic analysis of the SPS-1 sites.

<table>
<tr><td colspan="2">OBJECTIVE NO. 14
Conduct mechanistic analyses of the SPS-1 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. (Expected timeframe—2003 to 2005).</td></tr>
<tr><td>TOPIC AREA
Pavement design and construction.</td><td>PROBABILITY OF SUCCESS
Moderate to high</td></tr>
<tr><td>LTPP STRATEGIC PLAN
2.D, 7.B</td><td>SUPPLEMENTAL EXPERIMENTS</td></tr>
<tr><td>END PRODUCT
Evaluation and/or development of new pavement response and performance prediction models applicable to pavement 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.</td><td>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.</td></tr>
<tr><td colspan="2">GENERAL TASKS
Review specific findings from each SPS-1 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.</td></tr>
</table>

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 current data.
    - WIM and AVC traffic monitoring should receive close attention.
    - Resolve irregular distress measurements over time for each SPS-1 section.
- Collect new data.
    - Dynamic modulus of AC to predict fatigue and other load related distresses.
    - Indirect tensile creep tests to predict low temperature cracking.
    - Video surveys of edge drains to ensure they are working.
    - Coring along the cracks in HMAC to determine the initiation of the crack and direction of its propagation (top-down or bottom-up cracking).
    - Trenching of test sections to measure rutting in each layer. The initial evaluation shows that more rutting is occurring in sections with unbound base material, which indicates that the rutting is probably occurring in the base layer.

It is recommended that the following specific data analyses be conducted on SPS-1 data:

- Conduct immediate analysis of each SPS-1 site to clean up data, develop findings, and prepare report for each site, including the supplemental sections.
- After individual SPS-1 analyses are completed, conduct global analyses in coordination with LTPP Strategic Plan objectives and products:
    - Relationships to enable interchangeable use of laboratory and field derived material parameters.
    - Procedures for determining as-built material properties.
    - Information about the relationship between as-designed and as-built material characteristics.
    - Estimate of material design parameters from other materials data.
    - Recommendations for climatic data collection in order to predict pavement performance adequately.
    - Models relating to functional and structural performance.
    - Calibrated relationships (transfer functions) between pavement response and individual distress types.
    - Quantitative information on the impact of design features on measured pavement responses (deflections, load-transfer, strains, etc.).
    - Quantitative information on the impact of design features on pavement distress (subdrainage, base thickness, base type, and surface thickness).

APPENDIX A. SPS-1 PROJECT SUMMARIES

Appendix A includes an overview and summary of each SPS-1 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). Any deviations from the initial project nomination and any difficulties reported during construction are identified and briefly discussed. In addition, a summary of the materials data that are available is provided herein. 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 the construction and the 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 regards to fulfillment of the original experimental objectives and expectations. A definition of this numerical scale is given below.

- 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 was built on U.S. 280 east of Opelika, AL, in 1992. U.S. 280 is a four-lane road with an estimated 16 percent trucks.[17] It was estimated that this project would receive 237,000 ESALs annually. The project was constructed with AC shoulders.

The project was planned for the wet-no-freeze environmental zone with a fine-grained subgrade and would fill column N of the experiment factorial (refer to table 1). The subgrade found on the project varied from lean clay with sand to sandy silt. All samples showed that the subgrade fell into the fine-grained category. The project site receives 1,340 mm of rainfall each year on average and has an annual freeze index of 9 °C-days, which is considered to be a wet-no-freeze climate.

This project includes sections 010101 through 010112 in the experiment design and also includes three supplemental sections. Table 43 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

During construction, a mechanical problem was encountered with the track paver used to place the HMA material. The paver was repaired and the paving operations were restarted. Just after paving operations began again, rain began to fall. The rain delay caused some of the material to be laid at temperatures below the optimum compaction range.

Several days later, further mechanical problems were encountered with the paver. At this point, the track paver had to be abandoned. A construction joint was placed in section 010111 and paving operations were continued using a rubber-tired paver. Although great care was taken when paving on top of the PATB layer, some deformation was noticed on the layer when temperatures reached 29 °C. In addition, some heavy vehicle traffic was noted on top of the PATB layer prior to the placement of the ATB layer. The contractor was notified of the problem and construction traffic was limited from that time forward until the PATB layer was protected adequately. No other problems were noted during construction of the project.

Project Deviations

This project was not recorded as having any significant deviations. Appendix B contains a set of tables that compares the guidelines for construction of an SPS-1 project to actual as-built project information. Several of the sections deviated from the thickness requirements by more than 6 mm, which is the requirement set by FHWA. The DGAB contained more material passing the No. 200 sieve than allowed. The other requirements for which data was present in the IMS indicated that this project did follow the recommended guidelines.

Data Completeness

Table 43 summarizes the monitoring data that were available for this project. As shown in this table, the longitudinal profile, transverse profile, distress, and FWD data meet the biennial data collection requirements. The requirements for initial data collection for these elements were met.

Table 44 provides a summary of the testing data available for this project. While most of the testing has been completed on the subgrade, the remaining layers still require a substantial amount of testing.

This project does not have any traffic data. This section has neither WIM data nor ESAL estimates from the State. The ESAL estimates from the State have been used previously to fill in years where WIM data was not collected.

The AWS for this project includes 1,394 days of data although the project has been completed for 2,282 days. However, the directive requiring the installation of the AWS was not published until September 12, 1994, more than 1 year after the completion of the Alabama SPS-1 project. This project has a complete set of climatic data from the NOAA database.

Table 43. Summary of key project monitoring data for the Alabama SPS-1.

Alabama SPS-1 Project Key Information Summary

Age as of Aug. 1999:	6.4 years	**Construction Date:**	3/1/93
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - No Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	1394 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	None
Construction Problems:	Mechanical problems with paver. Unnecessary construction traffic on PATB layer.	**Weighing-In-Motion:**	None

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm				Percent Complete		
ID	**Design**	**Actual**	**Design**	**Actual**	**Type**	**Drainage**	**Surface**	**Base**	**Subgrade**
0101	178		203		DGAB	No	10	40	86
0102	102		305		DGAB	No	10	40	86
0103	102		203		ATB	No	10	8	86
0104	178		305		ATB	No	10	8	86
0105	102		203		ATB/DGAB	No	10	8/40	86
0106	178		305		ATB/DGAB	No	10	8/40	86
0107	102		203		PATB/DGAB	Yes	10	0/40	86
0108	178		305		PATB/DGAB	Yes	10	0/40	86
0109	178		406		PATB/DGAB	Yes	10	0/40	86
0110	178		203		ATB/PATB	Yes	10	8/0	86
0111	102		305		ATB/PATB	Yes	10	8/0	86
0112	102		406		ATB/PATB	Yes	10	8/0	86
0161	102		305		ATB/Soil Aggregate	No	---	---	---
0162	102		254		ATB	No	---	---	---
0163	102		406		ATB/PATB/DGAB	Yes	---	---	---

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

			Distress		Rut				
ID	**IRI (Date at Initial.)**	**FWD**	**Manual**	**PASCO**	**Depth**	**Friction**	**Traffic**	**Comments**	**Adequacy Code**
0101	11 (10/3/95)	32	8	2	4	2	0	Track Paver	3
0102	12 (8/25/94)	31	8	2	5	2	0	Track Paver	3
0103	3 (1/10/96)	4	3	2	2	2	0	Track Paver	3
0104	5 (1/10/96)	5	3	2	2	2	0	Track Paver	3
0105	3 (1/10/96)	4	3	2	2	2	0	Track Paver	3
0106	4 (8/25/94)	4	3	2	2	2	0	Track Paver	3
0107	4 (8/25/94)	4	3	2	2	2	0	Track Paver	3
0108	5 (8/25/94)	5	3	2	2	2	0	Track Paver	3
0109	3 (1/10/96)	4	3	2	2	2	0	Track Paver	3
0110	4 (1/10/96)	5	3	2	2	2	0	Track Paver	3
0111	3 (1/10/96)	4	3	2	2	2	0	Construction Joint	3
0112	4 (8/25/94)	4	3	2	2	2		Rubber-Tired Paver	3
0161	3 (1/10/96)	4	3	2	0	2	0	Rubber-Tired Paver	1.5
0162	4 (8/25/94)	4	3	2	0	2	0	Rubber-Tired Paver	1.5
0163	4 (8/11/93)	4	3	2	0	2	0	Rubber-Tired Paver	1.5

NOTE: IRI data were collected on all test sections on 8/11/93. However, most of the data were electively withheld from entry into the database.

Table 44. Summary of available materials testing data on the Alabama SPS-1.

Alabama SPS-1 Materials Testing Summary			
Test	Minimum No. per Layer	Number Conducted	Percent at Level E
Subgrade:			
Sieve Analysis	7	7	100.0
Hydrometer Analysis	7	7	100.0
Atterberg Limits	7	7	100.0
Moisture-Density Relations	7	7	100.0
Resilient Modulus	6	7	100.0
Natural Moisture Content	7	7	100.0
Permeability	3	0	0.0
Unbound Base:			
Sieve Analysis	3	3	100.0
Atterberg Limits	3	0	0.0
Moisture-Density Relations	3	3	66.7
Resilient Modulus	3	0	0.0
Permeability	3	0	0.0
Natural Moisture Content	3	1	100.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	0	0.0
Aggregate Gradation	3	0	0.0
Asphalt Treated Base:			
Core Examination	42	28	64.3
Bulk Specific Gravity	42	9	55.6
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	1	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0
Asphalt Surface:			
Core Examination	68	42	76.2
Bulk Specific Gravity	68	33	81.8
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	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

ARIZONA

This project was built on U.S. 93 north of Kingman, AZ in 1993. U.S. 93 is a four-lane road with an estimated 34 percent trucks. It was estimated that this project would receive approximately 3.7 million ESALs over a 20-year design period.

The project was planned for the dry-no freeze environmental zone with a coarse-grained subgrade and would fill column Y of the experiment factorial. This project has an average annual freeze index of 1 °C-days. On average, 241 mm of rain falls each year on the project. The subgrade ranged from a clayey sand with gravel to a well-graded gravel with silt and sand. All samples of the subgrade were coarse-grained materials.

This project includes sections 040113 through 040124 in the experiment design and four State supplemental sections. Section 040159 was renumbered as 04A901. Table 45 contains a summary of the available data for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

An inordinate amount of rain fell on the subgrade during preparation and prior to paving. The subgrade became excessively saturated. Portions of the fill material began pumping. However, these areas were replaced prior to paving operations.(18)

Project Deviations

Several sections were built with a thickness outside the 6-mm range allowed by the construction guidelines. In particular, Section 040122 was to be constructed with a base of ATB over PATB. The data show that this section includes a layer of DGAB.

The DGAB on Sections 040119 and 040122 did not meet the gradation requirements. The lift thickness used on Sections 040114 and 040121 was larger than that noted in the construction guidelines. Also, the gradation requirements were not met for the surface HMA mix.

Data Completeness

Table 46 provides information about the materials data available for this project. The materials testing on this project appears to be essentially complete, with the following exceptions:

- The permeability test has not been run on the DGAB or the subgrade layer.
- Resilient modulus testing has not been completed on the DGAB nor is the moisture content information available for this layer.
- Finally, the ATB and HMA surface layers do not have results from the moisture susceptibility test or the NAA test for fine aggregate particle shape.

On average, the monitoring requirements have been met for the longitudinal profile, FWD, distress, and rut depth monitoring as shown in table 45. However, the requirements for the initial monitoring were not met.

Traffic data are available for 5 years of monitoring. For all of the sections within the project, 1,544 days worth of WIM data are available.

This project has approximately 1,480 days of AWS data of the 2,129 days after construction. However, this project was completed approximately 1 year prior to the requirement for an AWS. This project has 17 years of data from the NOAA database.

Table 45. Summary of key project monitoring data for the Arizona SPS-1.

Arizona SPS-1 Project Key Information Summary

Age as of Aug. 1999:	6.0 years	**Construction Date:**	8/1/93
Subgrade type:	Coarse Grained	**Climatic Zone:**	Dry - No Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	1480 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	1544 Days
Construction Problems:	Rain delays during subgrade prep	**Weighing-In-Motion:**	1588 Days

Site key information summary

ID	Surface Thickness, mm		Base Thickness, mm		Base		Materials Testing Percent Complete		
	Design	Actual	Design	Actual	Type	Drainage	Surface	Base	Subgrade
0113	102	114	203	191	DGAB	No	73	50	76
0114	178	173	305	305	DGAB	No	73	50	76
0115	178	168	203	216	ATB	No	73	73	76
0116	102	104	305	307	ATB	No	73	73	76
0117	178	193	203	213	ATB/DGAB	No	73	73/50	76
0118	102	102	305	300	ATB/DGAB	No	73	73/50	76
0119	178	160	203	221	PATB/DGAB	Yes	73	73/50	76
0120	102	102	305	302	PATB/DGAB	Yes	73	100/50	76
0121	102	104	407	406	PATB/DGAB	Yes	73	100/50	76
0122	102	107	203	358	ATB/PATB/DGAB	Yes	73	73/100/50	76
0123	178	173	305	297	ATB/PATB	Yes	73	73/100	76
0124	178	170	407	401	ATB/PATB	Yes	73	73/100	76
0160									
0161									
0162									
0163									

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

ID	IRI (Date at Initial.)	FWD	Distress Manual	Distress PASCO	Rut Depth	Friction	Traffic	Comments	Adequacy Code
0113	12 (1/27/94)	31	13	1	12	0	4		5
0114	12 (1/27/94)	28	13	1	11	0	5		5
0115	5 (1/27/94)	6	3	1	4	0	5		5
0116	5 (1/27/94)	6	3	1	3	0	5		5
0117	5 (1/27/94)	6	3	1	3	0	5		5
0118	5 (1/27/94)	7	3	1	3	0	5		5
0119	5 (1/27/94)	6	3	1	4	0	5		5
0120	5 (1/27/94)	6	3	1	3	0	5		5
0121	5 (1/27/94)	6	3	1	3	0	5		5
0122	5 (1/27/94)	6	3	1	3	0	5		5
0123	5 (1/27/94)	6	3	1	3	0	5		5
0124	5 (1/27/94)	6	3	1	3	0	5		5
0160	5 (1/27/94)	7	0	0	1	0	5		2
0161	5 (1/27/94)	4	3	1	3	0	5		2
0162	5 (1/27/94)	4	3	1	3	0	5		2
0163	5 (1/27/94)	4	3	1	3	0	5		2

Table 46. Summary of available materials data on the Arizona SPS-1.

Arizona SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	16	75.0
Hydrometer Analysis	6	16	75.0
Atterberg Limits	6	16	75.0
Moisture-Density Relations	6	16	75.0
Resilient Modulus	6	2	100.0
Natural Moisture Content	6	16	75.0
Permeability	3	0	0.0
Unbound Base:			
Sieve Analysis	3	5	60.0
Atterberg Limits	3	5	60.0
Moisture-Density Relations	3	5	60.0
Resilient Modulus	3	0	0.0
Permeability	3	0	0.0
Natural Moisture Content	3	0	0.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	3	100.0
Aggregate Gradation	3	3	100.0
Asphalt Treated Base:			
Core Examination	34	40	100.0
Bulk Specific Gravity	34	34	100.0
Maximum Specific Gravity	3	4	100.0
Asphalt Content	3	4	100.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	8	100.0
Aggregate Gradation	3	4	100.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	4	100.0
Specific Gravity of Asphalt Cement	6	4	100.0
Viscosity of Asphalt Cement	6	4	100.0
Asphalt Surface:			
Core Examination	60	90	86.7
Bulk Specific Gravity	60	72	83.3
Maximum Specific Gravity	3	4	75.0
Asphalt Content	3	4	75.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	9	77.8
Aggregate Gradation	3	5	80.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	4	75.0
Specific Gravity of Asphalt Cement	6	4	75.0
Viscosity of Asphalt Cement	6	4	75.0

ARKANSAS

The Arkansas project was built on U.S. 63 southeast of Jonesboro, AR, in 1992. U.S. 63 is a four-lane road with an estimated 20 percent trucks.[19] It was estimated that this project would annually receive 170,000 ESALs. The project was constructed with AC shoulders.

The project was planned for the wet-no freeze environmental zone with a coarse-grained subgrade and would fill column Q of the experiment factorial. This project has an average annual freeze index of 47 °C-days. On average, 1,224 mm of rain falls each year on the project. The subgrade samples were classified as either poorly graded silt with sand or silty sand. All samples of the subgrade were coarse-grained materials.

This project includes sections 050113 through 050124 in the experiment design. The State did not build any supplemental sections at this site. Table 47 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

During placement of the edge drains, the contractor discovered that there was insufficient fabric available to overlap on to the pavement as specified. The edge drain was removed and replaced in accordance with the specifications.

Rain also caused delays during construction. It was noted in the construction report, however, that the surfaces were allowed to dry prior to resuming construction in each case.

Project Deviations

Several sections did not meet the maximum 6-mm variation from the specified thickness. In particular, the average thickness of the DGAB on Section 010114 was less than half of the required thickness. A review of the minimum and maximum thicknesses from the rod and level surveys illustrates that none of the sections met the required thicknesses.

A further review of the construction data shows that the surface HMA mix did not meet the mix design requirements. The mix design was to meet a minimum stability of 8 kN with a flow between 2 mm and 4 mm. The surface mix on this project had a stability of 7.9 kN and a flow of 1.8 mm.

Data Completeness

Table 48 provides a review of the availability of materials testing data on this project. Very little of the testing has been completed for this project. The only subgrade testing that has not been completed is the resilient modulus and permeability testing. Other than these, the only testing that has been completed are the core examinations on the ATB and HMA surface layers.

Table 47. Summary of key project monitoring data for the Arkansas SPS-1.

Arkansas SPS-1 Project Key Information Summary

Age as of Aug. 1999:	5.7 years	**Construction Date:**	12/1/93
Subgrade type:	Coarse Grained	**Climatic Zone:**	Wet - No Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	1100 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	89 Days
Construction Problems:	Rain delays. Problems with placement of filter fabric	**Weighing-In-Motion:**	89 Days

Site key information summary

ID	Surface Thickness, mm		Base Thickness, mm		Base Type	Drainage	Materials Testing Percent Complete		
	Design	Actual	Design	Actual			Surface	Base	Subgrade
0113	102		203		DGAB	No	9	0	62
0114	178		305		DGAB	No	9	0	62
0115	178		203		ATB	No	9	9	62
0116	102		305		ATB	No	9	9	62
0117	178		203		ATB/DGAB	No	9	9/0	62
0118	102		305		ATB/DGAB	No	9	9/0	62
0119	178		203		PATB/DGAB	Yes	9	0/0	62
0120	102		305		PATB/DGAB	Yes	9	0/0	62
0121	102		407		PATB/DGAB	Yes	9	0/0	62
0122	102		203		ATB/PATB	Yes	9	9/0	62
0123	178		305		ATB/PATB	Yes	9	9/0	62
0124	178		407		ATB/PATB	Yes	9	9/0	62

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

ID	IRI (Date at Initial.)	FWD	Distress Manual	Distress PASCO	Rut Depth	Friction	Traffic	Comments	Adequacy Code
0113	2 (7/7/95)	5	1	1	1	0	1		1
0114	2 (7/7/95)	5	1	1	1	0	1		1
0115	2 (7/7/95)	4	1	1	1	0	1		1
0116	2 (7/7/95)	4	1	1	1	0	1		1
0117	2 (7/7/95)	5	1	1	1	0	1		1
0118	2 (7/7/95)	5	1	1	1	0	1		1
0119	2 (7/6/95)	5	1	1	1	0	1		1
0120	2 (7/6/95)	5	1	1	1	0	1		1
0121	1 (7/6/95)	5	1	1	1	0	1		1
0122	2 (7/6/95)	4	1	1	1	0	1		1
0123	2 (7/6/95)	4	1	1	1	0	1		1
0124	2 (7/6/95)	4	1	1	1	0	1		1

The longitudinal profile, FWD testing, and distress surveys all met the requirements for long-term monitoring. However, the transverse profile measurements have not met this requirement. In addition, none of the monitoring was conducted within the time requirements for the initial site visit.

Traffic data are available for 1 year on this project. These data include 89 days of continuous WIM measurements.

This project includes more than 1,100 days of AWS data of the 2,007 days after construction. This project was completed prior to the directive requiring the installation of an AWS. This project also has 17 years of climatic data from the NOAA database.

Table 48. Summary of available materials testing data on the Arkansas SPS-1.

Arkansas SPS-1 Materials Testing Summary			
Test	Minimum No. per Layer	Number Conducted	Percent at Level E
Subgrade:			
Sieve Analysis	6	5	100.0
Hydrometer Analysis	6	5	100.0
Atterberg Limits	6	5	100.0
Moisture-Density Relations	6	5	100.0
Resilient Modulus	6	0	0.0
Natural Moisture Content	6	23	100.0
Permeability	3	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 Modulous	3	0	0.0
Permeability	3	0	0.0
Natural Moisture Content	3	0	0.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	0	0.0
Aggregate Gradation	3	0	0.0
Asphalt Treated Base:			
Core Examination	34	33	100.0
Bulk Specific Gravity	34	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	1	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0
Asphalt Surface:			
Core Examination	60	59	100.0
Bulk Specific Gravity	60	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	1	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	5	0	0.0
NAA Test for Fine Aggregate Particle Shape	5	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0

DELAWARE

The Delaware project was built on U.S. 113 close to Ellendale, DE, in 1995. U.S. 113 is a four-lane road with an estimated 10 percent trucks.[20] It was estimated that this project would annually receive 203,200 ESALs. The project was constructed with AC shoulders.

The project was planned for the wet-freeze environmental zone with a coarse-grained subgrade and would fill column L of the experiment factorial. This project has an average annual freeze index of 58 °C-days. On average, 1,145 mm of rain falls each year on the project. The subgrade samples were classified as poorly graded sand. All samples of the subgrade were coarse-grained materials.

This project includes Sections 011001 through 011012 in the experiment design and two supplemental sections. Table 49 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

Some of the shoulder probes were unable to be completed at the required depth of 6 m due to a high water table. In addition, some of the Shelby tubes were unable to collect samples of the subgrade soils for no obvious reason. The ditches on the sides of the project were shallow, which prevented the outlets for the edge drains from being placed at the recommended 76-m spacing.

Project Deviations

The average thickness of at least one layer on all of the sections, except Sections 011001 and 011002, deviated from the design thickness by more than 6 mm. The maximum and minimum for every layer for every section deviated from the design thickness by more than the allowable 6 mm.

The gradation of the aggregate in the HMA surface mix did not meet the required less than 40 percent passing the No. 4 sieve. The other requirements listed were generally followed.

Data Completeness

Table 50 contains a summary of the materials testing data available for this project. The materials testing on this project is partially complete. The only test results available for the subgrade are the resilient modulus tests. The base layer only has permeability testing completed. The only tests remaining for the HMA layers are the moisture susceptibility and the maximum theoretical specific gravity.

Table 49. Summary of key project monitoring data for the Delaware SPS-1.

Delaware SPS-1 Project Key Information Summary			
Age as of Aug. 1999:	3.2 years	**Construction Date:**	5/1/96
Subgrade type:	Coarse Grained	**Climatic Zone:**	Wet - Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	1200 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	None
Construction Problems:	High water table	**Weighing-In-Motion:**	None

Site key information summary

ID	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
	Design	Actual	Design	Actual			Surface	Base	Subgrade
0101	178	180	203	206	DGAB	No	75	12	14
0102	102	104	305	300	DGAB	No	75	12	14
0103	102	122	203	203	ATB	No	75	25	14
0104	178	170	305	305	ATB	No	75	25	14
0105	102	112	203	198	ATB/DGAB	No	75	25/12	14
0106	178	170	305	315	ATB/DGAB	No	75	25/12	14
0107	102	122	203	196	PATB/DGAB	Yes	75	67/12	14
0108	178	178	305	279	PATB/DGAB	Yes	75	67/12	14
0109	178	185	407	414	PATB/DGAB	Yes	75	67/12	14
0110	178	183	203	196	ATB/PATB	Yes	75	25/67	14
0111	102	94	305	320	ATB/PATB	Yes	75	25/67	14
0112	102	114	407	399	ATB/PATB	Yes	75	25/67	14
0159	152		356		ATB/DGAB	No	---	---	---
0160	152		305		ATB/CASB	No	---	---	---

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

ID	IRI (Date at Initial.)	FWD	Distress		Rut	Friction	Traffic	Comments	Adequacy
			Manual	PASCO	Depth				Code
0101	7 (12/5/96)	1	3	0	2	0	0		3
0102	9 (12/5/96)	18	7	0	6	0	0		3
0103	7 (12/5/96)	1	3	0	2	0	0		3
0104	7 (12/5/96)	1	3	0	2	0	0		3
0105	7 (12/5/96)	2	4	0	3	0	0		3
0106	7 (12/5/96)	1	3	0	2	0	0		3
0107	7 (12/5/96)	1	3	0	2	0	0		3
0108	7 (12/5/96)	1	3	0	2	0	0		3
0109	7 (12/5/96)	1	3	0	2	0	0		3
0110	7 (12/5/96)	1	3	0	2	0	0		3
0111	7 (12/5/96)	1	3	0	2	0	0		3
0112	7 (12/5/96)	1	3	0	2	0	0		3
0159	7 (12/5/96)	1	3	0	2	0	0		1
0160	7 (12/5/96)	1	3	0	2	0	0		1

On average, the data collected for longitudinal profile, FWD, distress, and transverse profile follow the long-term frequency requirements. The distress and transverse profiles meet the time requirements for the initial monitoring. The first round longitudinal profile and FWD testing were not completed within the requirements for the initial monitoring.

No traffic data has been collected for this project.

This project has almost 1,200 days of AWS data. However, the project has been opened for only 1,125 days. The project includes more data from the AWS than is required. It also includes 17 years of data from the NOAA database.

Table 50. Summary of available materials testing data on the Delaware SPS-1.

Delaware SPS-1 Materials Testing Summary			
Test	Minimum No. per Layer	Number Conducted	Percent at Level E
Subgrade:			
Sieve Analysis	7	7	0.0
Hydrometer Analysis	7	7	0.0
Atterberg Limits	7	7	0.0
Moisture-Density Relations	7	7	0.0
Resilient Modulus	7	6	87.5
Natural Moisture Content	7	7	0.0
Permeability	3	0	0.0
Unbound Base:			
Sieve Analysis	3	0	0.0
Atterberg Limits	3	2	0.0
Moisture-Density Relations	3	2	0.0
Resilient Modulous	3	0	0.0
Permeability	3	2	50.0
Natural Moisture Content	3	2	0.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	2	100.0
Aggregate Gradation	3	2	0.0
Asphalt Treated Base:			
Core Examination	36	9	55.6
Bulk Specific Gravity	36	7	42.9
Maximum Specific Gravity	3	1	100.0
Asphalt Content	3	2	100.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	2	100.0
Aggregate Gradation	3	2	50.0
NAA Test for Fine Aggregate Particle Shape	3	1	100.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0
Asphalt Surface:			
Core Examination	68	21	81.0
Bulk Specific Gravity	68	50	86.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	5	80.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	10	50.0
Aggregate Gradation	3	5	80.0
NAA Test for Fine Aggregate Particle Shape	3	5	80.0
Penetration of Asphalt Cement	6	7	28.6
Specific Gravity of Asphalt Cement	6	7	85.7
Viscosity of Asphalt Cement	6	7	0.0

FLORIDA

The Florida project was built on U.S. 27 south of South Bay, FL, in 1995. U.S. 27 is a four-lane road with an estimated 40 percent trucks.[21] It was estimated that this project would annually receive 1,463,000 ESALs. The project was constructed with AC shoulders.

The project was planned for the wet-no freeze environmental zone with a coarse-grained subgrade and would fill column P of the experiment factorial. This project has an average annual freeze index of 0 °C-days. On average, 1,325 mm of rain falls each year on the project. The subgrade samples were classified as either poorly graded sand with silt and gravel or silty sand with gravel. All samples of the subgrade were coarse-grained materials.

This project includes Sections 120101 through 120112 in the experiment design and one supplemental test section. Table 51 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

Rain caused delays in construction throughout the project. The DGAB had to be reworked multiple times to reach the density requirements. No other construction difficulties were encountered.

Project Deviations

Sections 120106, 120108, 120109, 120110, 120111, and 120112 each had one layer that on average varied from the design thickness by more than 6 mm. For all of the sections, the maximum and minimum thicknesses recorded by the rod and level surveys deviated from the design requirements by more than 6 mm.

The HMA surface and binder mix did not meet the 40 percent maximum passing the No. 4 sieve. The samples of these mixes taken all contained approximately 60 percent passing the No. 4 sieve. No other deviations from the construction requirements were identified.

Data Completeness

Table 52 contains a summary of the materials data that are available for this project. Most of the required testing has been completed for this project. The permeability tests have not been completed on the subgrade and base samples. The resilient modulus has been completed on the subgrade, but not for the base layer. In addition, the fine aggregate particle shape tests are still required for the HMA base and surface layers.

On average, the longitudinal profile, distress surveys, and FWD testing have been collected in accordance with the long-term monitoring requirements. However, no transverse profile data were available. In addition, the data collection efforts did not meet the requirements for initial monitoring.

Table 51. Summary of key project monitoring data for the Florida SPS-1.

Florida SPS-1 Project Key Information Summary

Age as of Aug. 1999:	3.7 years	**Construction Date:**	11/1/95
Subgrade type:	Coarse Grained	**Climatic Zone:**	Wet - No Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	800 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	220 Days
Construction Problems:	Weather delays	**Weighing-In-Motion:**	342 Days

Site key information summary

ID	Surface Thickness, mm		Base Thickness, mm		Base Type	Drainage	Materials Testing Percent Complete		
	Design	Actual	Design	Actual			Surface	Base	Subgrade
0101	178	173	203	206	DGAB	No	86	45	86
0102	102	99	305	307	DGAB	No	86	45	86
0103	102	104	203	203	ATB	No	86	72	86
0104	178	173	305	305	ATB	No	86	72	86
0105	102	99	203	203	ATB/DGAB	No	86	72/45	86
0106	178	183	305	312	ATB/DGAB	No	86	72/45	86
0107	102	99	203	208	PATB/DGAB	Yes	86	33/45	86
0108	178	163	305	302	PATB/DGAB	Yes	86	33/45	86
0109	178	180	407	401	PATB/DGAB	Yes	86	33/45	86
0110	178	185	203	208	ATB/PATB	Yes	86	72/33	86
0111	102	99	305	312	ATB/PATB	Yes	86	72/33	86
0112	102	99	407	411	ATB/PATB	Yes	86	72/33	86
0161	102		254		Limerock	No	---	---	---

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

ID	IRI (Date at Initial.)	FWD	Distress Manual	Distress PASCO	Rut Depth	Friction	Traffic	Comments	Adequacy Code
0101	1 (1/27/97)	1	1	0	0	0	2		2
0102	4 (1/27/97)	1	1	0	0	0	2		2
0103	1 (1/27/97)	1	1	0	0	0	2		2
0104	4 (1/27/97)	1	1	0	0	0	2		2
0105	1 (1/27/97)	1	1	0	0	0	2		2
0106	1 (1/27/97)	1	1	0	0	0	2		2
0107	1 (1/27/97)	1	1	0	0	0	2		2
0108	4 (1/27/97)	1	1	0	0	0	2		2
0109	1 (1/27/97)	1	1	0	0	0	2		2
0110	4 (1/27/97)	1	1	0	0	0	2		2
0111	1 (1/27/97)	1	1	0	0	0	2		2
0112	1 (1/27/97)	1	1	0	0	0	2		2
0161	1 (1/27/97)	1	1	0	0	0	2		2

This project includes 2 years of almost continuous WIM data.

More than 800 days of data from an AWS have been collected. For continuous data collection, the project should have 1,307 days of data. In addition to the AWS data, this project has 17 years of available data from the NOAA database.

Table 52. Summary of available materials testing data on the Florida SPS-1.

Florida SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	6	83.3
Hydrometer Analysis	6	6	83.3
Atterberg Limits	6	6	83.3
Moisture-Density Relations	6	6	83.3
Resilient Modulus	5	6	83.3
Natural Moisture Content	6	22	100.0
Permeability	6	0	0.0
Unbound Base:			
Sieve Analysis	3	2	50.0
Atterberg Limits	3	2	50.0
Moisture-Density Relations	3	2	66.7
Resilient Modulus	3	0	0.0
Permeability	3	0	0.0
Natural Moisture Content	3	2	50.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	1	100.0
Aggregate Gradation	3	1	100.0
Asphalt Treated Base:			
Core Examination	34	34	100.0
Bulk Specific Gravity	34	16	100.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	1	3	100.0
Specific Gravity of Aggregate	6	6	100.0
Aggregate Gradation	3	3	100.0
NAA Test for Fine Aggregate Particle Shape	3	0	100.0
Penetration of Asphalt Cement	6	3	100.0
Specific Gravity of Asphalt Cement	6	3	100.0
Viscosity of Asphalt Cement	6	3	100.0
Asphalt Surface:			
Core Examination	64	62	93.0
Bulk Specific Gravity	64	29	100.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	1	3	100.0
Specific Gravity of Aggregate	6	6	100.0
Aggregate Gradation	3	3	100.0
NAA Test for Fine Aggregate Particle Shape	3	0	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

IOWA

The Iowa project was built on U.S. 61 near Fort Madison, IA, in 1992. U.S. 61 is a four-lane road with an estimated 17 percent trucks.[22] It was estimated that this project would annually receive 130,000 ESALs. The project was constructed with AC shoulders.

The project was planned for the wet-freeze environmental zone with a fine-grained subgrade and would fill column K of the experiment factorial (refer to table 1). However, the project associated with the J column was actually built. This means that this site factorial cell may not have a companion project. This project has an average annual freeze index of 235 °C-days. On average, 982 mm of rain falls each year on the project. The subgrade samples were classified as clay, clay with gravel, clay with sand, lean clay with sand, or silty clay. All samples of the subgrade were fine-grained materials.

This project includes sections 190101 through 190112 in the experiment design and one supplemental section. Table 53 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

Rainy weather caused many delays during the construction of the project. However, the construction report states than an effort was made to ensure that no permanent damage or distortion was caused to any of the layers. Each layer was scarified, allowed to dry, and recompacted prior to placing the next layer. The contractor experienced some difficulty in placing the PATB layer. In some areas, the material was placed and compacted at too high a temperature. The compaction equipment caused the material to "roll out" on the sides. In fact, an extra lift had to be laid at some of these locations to increase the thickness to the design value.

Project Deviations

Sections 190103, 190104, 190105, 190107, 190109, 190110, 190111, and 190112 included at least one layer whose average thickness deviated from design by more than 6 mm. The construction report notes that Sections 190107 and 190108 were constructed with 19 mm to 25 mm thicker PATB than design. No rod and level surveys were available for this project in the IMS.

The binder layer incorporated a greater percentage passing the No. 4 sieve than allowed. The requirements allow a maximum of 40 percent passing the No. 4 sieve. The samples of the HMA binder layer indicate that between 55 and 60 percent is passing the No. 4 sieve.

Data Completeness

Table 54 provides information of the materials testing data available for this project. The materials testing on this project is only partially completed. The subgrade only has resilient modulus data available. The DGAB only has a sieve analysis and the maximum dry density and optimum moisture content. The HMA surface layer only has the maximum specific gravity. The PATB layer testing has been completed, while the ATB layer is almost complete. The tests still required for the ATB layer include the bulk specific gravity, the maximum specific gravity, and the moisture susceptibility.

The distress and transverse profile surveys have met the requirements for both the initial and long-term monitoring. The longitudinal profile surveys have met the frequency requirements for the long-term monitoring; however, the initial survey was not performed within the required timeframe. FWD testing has not met the requirement for the long-term or the initial monitoring.

The project has 4 years of continuous WIM data available.

The project also has 815 days of data collected by an AWS. For continuous data collection, the project should have 2,190 days of data. The project was completed in 1992, which was 2 years before the directive concerning the installation of an AWS on SPS-1 projects. This project also includes 17 years of data from the NOAA database.

Table 53. Summary of key project monitoring data for the Iowa SPS-1.

Iowa SPS-1 Project Key Information Summary

Age as of Aug. 1999:	7	**Construction Date:**	1992
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	815 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	0 Days
Construction Problems:	Weather delays and PATB placement difficulties	**Weighing-In-Motion:**	108 Days

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0101	178	203	203	203	DGAB	No	6	11	14
0102	102	130	305	305	DGAB	No	6	11	14
0103	102	97	203	213	ATB	No	6	56	14
0104	178	178	305	315	ATB	No	6	56	14
0105	102	89	203	221	ATB/DGAB	No	6	56/11	14
0106	178	173	305	331	ATB/DGAB	No	6	56/11	14
0107	102	86	203	209	PATB/DGAB	Yes	6	100/11	14
0108	178	149	305	320	PATB/DGAB	Yes	6	100/11	14
0109	178	191	407	407	PATB/DGAB	Yes	6	100/11	14
0110	178	201	203	193	ATB/PATB	Yes	6	56/100	14
0111	102	112	305	299	ATB/PATB	Yes	6	56/100	14
0112	102	117	407	419	ATB/PATB	Yes	6	56/100	14
0159	102	102	229	229	ATB	No	---	---	---

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

ID	IRI (Data at Initial.)	FWD	Distress		Rut	Friction	Traffic	Comments	Adequacy
			Manual	PASCO	Depth				Code
0101	5 (10/15/93)	2	2	2	4	5	3		2
0102	6 (10/15/93)	2	1	2	4	5	4		2
0103	5 (10/15/93)	3	1	2	4	5	4		2
0104	5 (10/15/93)	3	1	2	5	5	4		2
0105	5 (10/15/93)	2	1	2	2	5	4		2
0106	6 (10/15/93)	3	1	2	3	5	4		2
0107	5 (2/15/93)	4	2	2	6	5	4		2
0108	6 (10/15/93)	2	1	2	4	5	4		2
0109	6 (10/15/93)	1	1	2	4	5	4		2
0110	5 (10/15/93)	1	1	2	3	5	4		2
0111	5 (10/15/93)	1	1	2	3	5	4		2
0112	5 (10/15/93)	1	1	2	3	5	4		2
0159	4 (10/15/93)	2	2	1	4	2	4		1

Table 54. Summary of available materials testing data on the Iowa SPS-1.

Iowa SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	0	0.0
Hydrometer Analysis	6	0	0.0
Atterberg Limits	6	0	0.0
Moisture-Density Relations	6	0	0.0
Resilient Modulus	6	6	100.0
Natural Moisture Content	6	0	0.0
Permeability	6	0	0.0
Unbound Base:			
Sieve Analysis	3	3	100.0
Atterberg Limits	3	2	100.0
Moisture-Density Relations	3	3	100.0
Resilient Modulus	3	0	0.0
Permeability	3	2	100.0
Natural Moisture Content	3	0	0.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	6	100.0
Aggregate Gradation	3	6	0.0
Asphalt Treated Base:			
Core Examination	34	15	100.0
Bulk Specific Gravity	34	0	0.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	6	100.0
Aggregate Gradation	3	3	100.0
NAA Test for Fine Aggregate Particle Shape	3	3	100.0
Penetration of Asphalt Cement	6	3	100.0
Specific Gravity of Asphalt Cement	6	3	100.0
Viscosity of Asphalt Cement	6	3	0.0
Asphalt Surface:			
Core Examination	60	62	100.0
Bulk Specific Gravity	60	0	0.0
Maximum Specific Gravity	3	7	100.0
Asphalt Content	3	6	100.0
Moisture Susceptibility	3	0	83.3
Specific Gravity of Aggregate	6	12	83.3
Aggregate Gradation	3	6	83.3
NAA Test for Fine Aggregate Particle Shape	3	6	66.7
Penetration of Asphalt Cement	6	6	100.0
Specific Gravity of Asphalt Cement	6	6	0.0
Viscosity of Asphalt Cement	6	6	0.0

KANSAS

The Kansas project was built on U.S. 54. The construction report was not available for this project.

The project was planned for the dry-freeze environmental zone with a fine-grained subgrade and would fill column R of the experiment factorial. This project has an average annual freeze index of 136 °C-days. On average, 627 mm of rain falls each year on the project. The subgrade samples were classified as lean clay, silty clay, sandy lean clay, or silty sand. Four of the 10 samples of the subgrade were fine-grained materials.

This project includes Section 200101 through 200112 in the experiment design. The project includes six supplemental sections. Table 55 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

Excessive moisture in the subbase caused extensive problems throughout the project. The contractor had difficulty in compacting the material to proper density. In some of the sections, fly ash was added to the material to stabilize it. Therefore, the sections do not have a uniform homogeneous platform on which they are resting.

Project Deviations

Sections 200104, 200105, and 200110 are the only sections on the project whose average thickness does not deviate from the design thickness by more than 6 mm. The elevation surveys indicate that the maximum deviations of the thicknesses for each layer are greater than 6 mm on every test section. No other deviations are noted from the available data.

Data Completeness

Table 56 provides information as to the materials testing data available for this project. The only testing that has been completed on this project is on the subgrade. For the subgrade, the only testing that remains is sieve analysis, moisture content, and permeability testing. All testing remains to be completed for all of the other materials.

The long-term monitoring meets the frequency requirements for the longitudinal profile, the distress, and the transverse profile data collection efforts. The deflection data collection meets the long-term monitoring frequency requirements for all but three sections (Sections 200109, 200110, and 200112). The initial monitoring requirements were met for the distress and transverse profile data collection. However, the deflection and longitudinal profile data collection did not meet the initial requirements. Six sets of friction data are available for all test sections, but all friction data are not at Level E in the IMS.

Table 55. Summary of key project monitoring data for the Kansas SPS-1.

Kansas SPS-1 Project Key Information Summary

Age as of Aug. 1999:	5.8 years	**Construction Date:**	10/1/93
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	1000 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	18 Days
Construction Problems:	Excessive moisture in subbase, rain delays.	**Weighing-In-Motion:**	232 Days

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0101	178	193	203	216	DGAB	No	0	0	48
0102	102	102	305	312	DGAB	No	0	0	48
0103	102	91	203	196	ATB	No	0	0	48
0104	178	173	305	307	ATB	No	0	0	48
0105	102	99	203	201	ATB/DGAB	No	0	0/0	48
0106	178	185	305	287	ATB/DGAB	No	0	0/0	48
0107	102	104	203	198	PATB/DGAB	Yes	0	0/0	48
0108	178	193	305	292	PATB/DGAB	Yes	0	0/0	48
0109	178	178	407	394	PATB/DGAB	Yes	0	0/0	48
0110	178	178	203	196	ATB/PATB	Yes	0	0/0	48
0111	102	102	305	307	ATB/PATB	Yes	0	0/0	48
0112	102	127	407	396	ATB/PATB	Yes	0	0/0	48
0159									
0160									
0161									
0162									
0163									
0164									

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

			Distress		Rut				Adequacy
ID	IRI (Date at Initial.)	FWD	Manual	PASCO	Depth	Friction	Traffic	Comments	Code
0101	4 (5/13/94)	5	4	2	9	6	2		2
0102	4 (5/13/94)	5	4	2	7	6	2		2
0103	6 (5/13/94)	6	4	2	7	0	2		2
0104	6 (5/13/94)	7	4	2	8	0	2		2
0105	6 (5/13/94)	7	4	2	6	0	2		2
0106	6 (5/13/94)	5	4	2	6	0	2		2
0107	4 (5/13/94)	5	4	2	8	0	2		2
0108	5 (5/13/94)	6	4	2	7	0	2		2
0109	6 (5/13/94)	5	4	2	8	0	2		2
0110	6 (5/13/94)	5	4	2	6	0	2		2
0111	6 (5/13/94)	6	4	2	7	0	2		2
0112	6 (5/13/94)	5	4	2	7	0	2		2
0159	3 (4/23/96)	4	3	2	4	6	2		2
0160	2 (2/13/97)	4	3	2	6	0	2		2
0161	3 (2/19/95)	4	3	2	5	0	2		2
0162	3 (2/19/95)	5	5	2	5	6	2		2
0163	2 (2/19/95)	5	4	1	3	6	2		2
0164	2 (2/19/95)	4	4	1	4	6	2		2

This project has 2 years of traffic data available.

An AWS was installed at this location. More than 1,000 days of AWS data have been collected and loaded into the IMS. This section should have 2,068 days of AWS data. This project also has 17 years of data from the NOAA database.

Table 56. Summary of available materials testing data on the Kansas SPS-1.

Kansas SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	0	0.0
Hydrometer Analysis	6	10	0.0
Atterberg Limits	6	11	9.1
Moisture-Density Relations	6	11	45.5
Resilient Modulus	6	2	100.0
Natural Moisture Content	6	0	0.0
Permeability	6	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
Permeable Asphalt Treated Base:			
Asphalt Content	3	0	0.0
Aggregate Gradation	3	0	0.0
Asphalt Treated Base:			
Core Examination	34	0	0.0
Bulk Specific Gravity	34	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0
Asphalt Surface:			
Core Examination	60	0	0.0
Bulk Specific Gravity	60	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0

LOUISIANA

The Louisiana project was built on U.S. 171 between Moss Bluff and Gillis, LA, in 1997. U.S. 171 is a four-lane divided highway with an estimated 23 percent trucks.[23] It was estimated that this project would annually receive 523,920 ESALs. The project was constructed with AC shoulders.

The project was planned for the wet-no freeze environmental zone with a fine-grained subgrade and would fill column O of the experiment factorial. This project has an average annual freeze index of 2 °C-days. On average, 1,538 mm of rain falls each year on the project. The subgrade samples were classified as lean clay. All samples of the subgrade were fine-grained materials.

This project includes Sections 220101 through 220112 in the experiment design. The State opted not to build any supplemental sections on this project. Table 57 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

Rain delays were encountered during the construction of the project. In addition, the contractor did not leave sufficient width of fabric to meet the overlap requirements for the trench. The aggregate used in the trenches had not been washed and contained some fines.

Project Deviations

Each of the sections had at least one layer whose average thickness deviated by more than 6 mm from the design thickness. An examination of the minimum and maximum thickness values for each of the sections indicated that some of these values deviated by a larger amount.

The only other construction deviation noted was the lift thicknesses of the DGAB. These were to be limited to 152 mm. However, the DGAB on this project was compacted in one lift on every section. Hence, some of the DGAB lifts were 305 mm thick.

Select material was also brought in to achieve the final elevation. This select material could not be compacted above 93 percent, because of the in-place subgrade material. Therefore, the subgrade was stabilized with 12 percent cement throughout the project. This enabled the contractor to eventually achieve 95 percent compaction of the select material.

Table 57. Summary of key project monitoring data for the Louisiana SPS-1.

Louisiana SPS-1 Project Key Information Summary

Age as of Aug. 1999:	2.1 years	**Construction Date:**	7/1/97
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - No Freeze
Subgrade Treatment:	Cement stabilization	**Automated Weather Station:**	300 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	None
Construction Problems:	Rain delays, DGAB compacted in one lift	**Weighing-In-Motion:**	None

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0113	102		203		DGAB	No	0	6	71
0114	178		305		DGAB	No	0	6	71
0115	178		203		ATB	No	0	0	71
0116	102		305		ATB	No	0	0	71
0117	178		203		ATB/DGAB	No	0	0/6	71
0118	102		305		ATB/DGAB	No	0	0/6	71
0119	178		203		PATB/DGAB	Yes	0	0/6	71
0120	102		305		PATB/DGAB	Yes	0	0/6	71
0121	102		407		PATB/DGAB	Yes	0	0/6	71
0122	102		203		ATB/PATB	Yes	0	0/0	71
0123	178		305		ATB/PATB	Yes	0	0/0	71
0124	178		407		ATB/PATB	Yes	0	0/0	71

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

			Distress		Rut				Adequacy
ID	IRI (Date at Initial.)	FWD	Manual	PASCO	Depth	Friction	Traffic	Comments	Code
0113	1 (11/17/97)	3	2	0	2	0	0		2
0114	1 (11/17/97)	3	2	0	2	0	0		2
0115	1 (11/17/97)	2	2	0	2	0	0		2
0116	1 (11/17/97)	2	2	0	2	0	0		2
0117	1 (11/17/97)	3	2	0	2	0	0		2
0118	1 (11/17/97)	3	2	0	2	0	0		2
0119	1 (11/17/97)	3	2	0	2	0	0		2
0120	1 (11/17/97)	3	2	0	2	0	0		2
0121	1 (11/17/97)	2	2	0	2	0	0		2
0122	1 (11/17/97)	2	2	0	2	0	0		2
0123	1 (11/17/97)	2	2	0	2	0	0		2
0124	1 (11/17/97)	2	2	0	2	0	0		2

Data Completeness

Table 58 provides information on the materials testing data available for this project. The only testing on the subgrade that has not been performed is the permeability testing. The only test on the DGAB that has been performed is the resilient modulus testing. Testing on the PATB, ATB, and HMAC mixes has not been completed.

The long-term monitoring requirements for frequency have been met for the longitudinal profile, distress, transverse profile, and FWD data collection. The initial monitoring requirements were not met for any of these tests.

No traffic data has been collected for this project.

The project has approximately 300 days of data collected by an AWS. The project should have 699 days of data. This project also includes 17 years of data from the NOAA database.

Table 58. Summary of available materials testing data on the Louisiana SPS-1.

Louisiana SPS-1 Materials Testing Summary			
Test	Minimum No. per Layer	Number Conducted	Percent at Level E
Subgrade:			
Sieve Analysis	6	6	100.0
Hydrometer Analysis	6	4	100.0
Atterberg Limits	6	4	100.0
Moisture-Density Relations	6	6	100.0
Resilient Modulus	6	6	100.0
Natural Moisture Content	6	4	100.0
Permeability	3	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 Modulous	3	1	100.0
Permeability	3	0	0.0
Natural Moisture Content	3	0	0.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	0	0.0
Aggregate Gradation	3	0	0.0
Asphalt Treated Base:			
Core Examination	34	34	100.0
Bulk Specific Gravity	34	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0
Asphalt Surface:			
Core Examination	60	60	100.0
Bulk Specific Gravity	60	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0

MICHIGAN

The Michigan project was built on U.S. 27 near St. Johns, MI, in 1995. The project was constructed with AC shoulders.

The project was planned for the wet-freeze environmental zone with a fine-grained subgrade and would fill column K of the experiment factorial. This project has an average annual freeze index of 283 °C-days. On average, 870 mm of rain falls each year on the project. The subgrade samples were classified as lean clay. All samples of the subgrade were fine-grained materials.

This project includes Sections 260113 through 260124 in the experiment design. The State built one supplemental section on this project. Table 59 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

No construction difficulties were noted in the IMS. This project does not have a final construction report available.

Project Deviations

All sections except three (260116, 260122, and 260123) have layers whose average thickness deviates more than 6 mm from the experiment design. Essentially no other data are available for comparison to the requirements.

Data Summary

Table 60 provides a summary of the available materials data. Only the subgrade and DGAB layers have any materials testing data available. The subgrade layer still requires the permeability testing and the DGAB still requires the permeability and resilient modulus testing. No testing has been conducted on the PATB, ATB, or the HMA layers.

Four of the sections failed 2 months after the project was completed (Sections 260113, 260114, 260119, and 260122). These four sections all have different structural features. No monitoring data was taken on these four sections. Monitoring of the other sections has met the frequency requirements for the long-term monitoring. Only the distress surveys have met the requirements for initial monitoring. A video distress survey has been completed, but the results for selected tests sections are not at Level E in the IMS. The first round of transverse profile, longitudinal profile, and FWD testing did not meet the time limits for initial monitoring.

This project has 3 years of available traffic data, but those data were not at Level E as of January 2000.

There are 670 days of AWS data available for this project. The project should have 1,399 days of data available. This project also has 17 years of data from the NOAA database.

The reason the initial monitoring requirement was not met is that some of the test sections were taken out of service 2 months after construction.

Table 59. Summary of key project monitoring data for the Michigan SPS-1.

Michigan SPS-1 Project Key Information Summary

Age as of Aug. 1999:	4.0 years	**Construction Date:**	8/1/95
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	670 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	884 Days
Construction Problems:	?	**Weighing-In-Motion:**	250 Days

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0113	102	112	203	203	DGAB	No	0	45	35
0114	178	165	305	305	DGAB	No	0	45	35
0115	178	84	203	244	ATB	No	0	0	35
0116	102	104	305	305	ATB	No	0	0	35
0117	178	163	203	234	ATB/DGAB	No	0	0/45	35
0118	102	84	305	312	ATB/DGAB	No	0	0/45	35
0119	178	163	203	203	PATB/DGAB	Yes	0	0/45	35
0120	102	94	305	305	PATB/DGAB	Yes	0	0/45	35
0121	102	94	407	406	PATB/DGAB	Yes	0	0/45	35
0122	102	97	203	208	ATB/PATB	Yes	0	0/0	35
0123	178	178	305	305	ATB/PATB	Yes	0	0/0	35
0124	178	152	407	406	ATB/PATB	Yes	0	0/0	35
0159									

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

			Distress		Rut				Adequacy
ID	IRI (Date at Initial.)	FWD	Manual	PASCO	Depth	Friction	Traffic	Comments	Code
0113	0	0	0	0	0	1	3	Out of Study 10/1/95	0
0114	0	0	0	0	0	1	3	Out of Study 10/1/95	0
0115	3 (12/30/96)	2	4	1	2	0	3		3
0116	3 (12/30/96)	3	4	1	2	0	3		3
0117	3 (12/30/96)	2	4	1	2	0	3		3
0118	3 (12/30/96)	2	2	1	1	0	3		3
0119	0	0	0	0	0	1	3	Out of Study 10/1/95	0
0120	3 (12/30/96)	2	2	1	1	1	3		3
0121	4 (3/28/96)	2	2	1	1	1	3		3
0122	0	0	2	0	0	1	3	Out of Study 10/1/95	0
0123	3 (12/30/96)	3	4	1	2	0	3		3
0124	3 (12/30/96)	3	4	1	2	0	3		3
0159	4 (12/28/96)	0	0	0	0	0	0		0

Table 60. Summary of available materials testing data on the Michigan SPS-1.

Michigan SPS-1 Materials Testing Summary			
Test	Minimum No. per Layer	Number Conducted	Percent at Level E
Subgrade:			
Sieve Analysis	6	2	100.0
Hydrometer Analysis	6	2	100.0
Atterberg Limits	6	2	100.0
Moisture-Density Relations	6	2	100.0
Resilient Modulus	6	5	60.0
Natural Moisture Content	6	2	100.0
Permeability	3	0	0.0
Unbound Base:			
Sieve Analysis	3	2	100.0
Atterberg Limits	3	2	100.0
Moisture-Density Relations	3	2	100.0
Resilient Modulous	3	2	0.0
Permeability	3	0	0.0
Natural Moisture Content	3	2	100.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	0	0.0
Aggregate Gradation	3	0	0.0
Asphalt Treated Base:			
Core Examination	34	0	0.0
Bulk Specific Gravity	34	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0
Asphalt Surface:			
Core Examination	60	0	0.0
Bulk Specific Gravity	60	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0

MONTANA

The Montana project was built on U.S. 15 in 1998. U.S. 15 is a four-lane divided highway. The project was constructed with AC shoulders.

The project was planned for the dry-freeze environmental zone with a coarse-grained subgrade and would fill column U of the experiment factorial. This project has an annual freeze index of 200 °C-days. The project receives 317 mm of rainfall each year. No information is available about the subgrade classification for this project.

This project includes Sections 300113 through 300124 in the experiment design. The State opted not to build any supplemental sections on this project. Table 61 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

No construction report was available to document difficulties in the construction process. The construction report is in draft form and waiting additional construction information prior to submittal to LTPP.

Project Deviation.

Every section had at least one layer whose average thickness deviated from the design thickness by more than 6 mm. According to the elevation surveys, all of the layers varied from the design thickness by more than 6 mm at one location at least. No other deviations could be noted from the construction data.

Data Completeness

Table 62 provides a summary of the materials testing data available for this project. No testing has been conducted for this project.

Even though some of the monitoring has not yet occurred on this project, all of the monitoring meets the long-term monitoring requirements. Both the distress and the FWD testing met the requirements for the initial monitoring.

Currently, no traffic data have been collected for this project.

More than 370 days of AWS data are available for this project. The project should have 242 days of AWS data. The weather station was installed prior to the completion of the project. This project does not have any data available from the NOAA database.

Table 61. Summary of key project monitoring data for the Montana SPS-1.

Montana SPS-1 Project Key Information Summary

Age as of Aug. 1999:	0.8 years	**Construction Date:**	10/1/98
Subgrade type:	Coarse-grained	**Climatic Zone:**	Dry - Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	370 Days
Climatic data availability:	0	**Automated Vehicle Class:**	None
Construction Problems:	?	**Weighing-In-Motion:**	None

Site key information summary

ID	Surface Thickness, mm		Base Thickness, mm		Base Type	Drainage	Materials Testing Percent Complete		
	Design	Actual	Design	Actual			Surface	Base	Subgrade
0113	102	122	203	213	DGAB	No	0	0	0
0114	178	183	305	315	DGAB	No	0	0	0
0115	178	188	203	231	ATB	No	0	0	0
0116	102	117	305	320	ATB	No	0	0	0
0117	178	183	203	234	ATB/DGAB	No	0	0/0	0
0118	102	117	305	328	ATB/DGAB	No	0	0/0	0
0119	178	185	203	226	PATB/DGAB	Yes	0	0/0	0
0120	102	107	305	318	PATB/DGAB	Yes	0	0/0	0
0121	102	109	407	419	PATB/DGAB	Yes	0	0/0	0
0122	102	114	203	211	ATB/PATB	Yes	0	0/0	0
0123	178	191	305	315	ATB/PATB	Yes	0	0/0	0
0124	178	183	407	455	ATB/PATB	Yes	0	0/0	0

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

ID	IRI (Date at Initial.)	FWD	Distress Manual	Distress PASCO	Rut Depth	Friction	Traffic	Comments	Adequacy Code
0113	2 (11/19/98)	3	2	0	2	0	0		0
0114	2 (11/19/98)	3	2	0	2	0	0		0
0115	2 (11/19/98)	3	2	0	2	0	0		0
0116	2 (11/19/98)	3	2	0	2	0	0		0
0117	2 (11/19/98)	3	2	0	2	0	0		0
0118	2 (11/19/98)	3	2	0	2	0	0		0
0119	2 (11/19/98)	3	2	0	2	0	0		0
0120	2 (11/19/98)	3	2	0	2	0	0		0
0121	2 (11/19/98)	3	2	0	2	0	0		0
0122	2 (11/19/98)	3	2	0	2	0	0		0
0123	2 (11/19/98)	3	2	0	2	0	0		0
0124	2 (11/19/98)	3	2	0	2	0	0		0

Table 62. Summary of available materials testing data on the Montana SPS-1.

Montana SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	10	100.0
Hydrometer Analysis	6	0	0.0
Atterberg Limits	6	0	0.0
Moisture-Density Relations	6	10	100.0
Resilient Modulus	6	0	0.0
Natural Moisture Content	6	0	0.0
Permeability	3	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
Permeable Asphalt Treated Base:			
Asphalt Content	3	0	0.0
Aggregate Gradation	3	0	0.0
Asphalt Treated Base:			
Core Examination	34	0	0.0
Bulk Specific Gravity	34	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0
Asphalt Surface:			
Core Examination	60	0	0.0
Bulk Specific Gravity	60	0	0.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	0	0.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	0	0.0
Aggregate Gradation	3	0	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	0	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	0	0.0

NEBRASKA

The Nebraska project was built on U.S. 81 southwest of Lincoln, NE, in 1995. U.S. 81 is a four-lane divided highway with an estimated 26 percent trucks.[24] It was estimated that this project would annually receive 119,000 ESALs. The project was constructed with AC shoulders.

The project was planned for the dry-freeze environmental zone with a fine-grained subgrade and would fill column S of the experiment factorial. This project has an average annual freeze index of 228 °C-days. On average, 785 mm of rain falls each year on the project. The subgrade samples were classified as lean clay. All samples of the subgrade were fine-grained materials.

This project includes sections 310113 through 310124 in the experiment design. The State opted not to build any supplemental sections on this project. Table 63 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

The deviations for the project include the following: two-way traffic used the new roadway until the original lanes were reconstructed, and three of the sections were constructed over culverts. However, the fill depths at these locations are greater than 3 m. Rain caused several delays during the construction of the project.

Project Deviations

All sections except two (Sections 310113 and 310121) had at least one layer whose average thickness deviated more than 6 mm from the design. No elevation data were recorded in the IMS.

A sample of the PATB reported the amount of aggregate passing the No. 200 sieve was greater than the standards allowed. In addition, a sample of the HMA reported that the amount of aggregate passing the No. 4 sieve was larger than the standards allowed. No other deviations were noted in the construction data.

Data Completeness

Table 64 provides a summary of the materials testing data available for this project. All of the layers have had most of the testing completed. The only tests that have not been conducted are the resilient modulus, permeability, and moisture content on the DGAB layer, and the moisture susceptibility on the ATB and HMA layer.

Table 63. Summary of key project monitoring data for the Nebraska SPS-1.

Nebraska SPS-1 Project Key Information Summary

Age as of Aug. 1999:	4.1 years	**Construction Date:**	7/1/95
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	1024 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	581 Days
Construction Problems:	3 test sections over culverts; rain delays	**Weighing-In-Motion:**	531 Days

Site key information summary

ID	Surface Thickness, mm		Base Thickness, mm		Base Type	Drainage	Materials Testing Percent Complete		
	Design	Actual	Design	Actual			Surface	Base	Subgrade
0113	102	130	203	203	DGAB	No	36	33	76
0114	178	170	305	305	DGAB	No	36	33	76
0115	178	112	203	323	ATB	No	36	57	76
0116	102	112	305	323	ATB	No	36	57	76
0117	178	201	203	198	ATB/DGAB	No	36	57/33	76
0118	102	109	305	315	ATB/DGAB	No	36	57/33	76
0119	178	201	203	203	PATB/DGAB	Yes	36	84/33	76
0120	102	119	305	305	PATB/DGAB	Yes	36	84/33	76
0121	102	135	407	406	PATB/DGAB	Yes	36	84/33	76
0122	102	97	203	213	ATB/PATB	Yes	36	57/84	76
0123	178	191	305	307	ATB/PATB	Yes	36	57/84	76
0124	178	191	407	414	ATB/PATB	Yes	36	57/84	76

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

ID	IRI (Date at Initial.)	FWD	Distress Manual	Distress PASCO	Rut Depth	Friction	Traffic	Comments	Adequacy Code
0113	4 (11/1/95)	2	2	1	1	0	2		3
0114	10 (11/1/95)	17	5	1	5	0	2		3
0115	4 (11/1/95)	2	2	1	3	0	2		3
0116	4 (11/1/95)	2	2	1	1	0	2		3
0117	4 (11/1/95)	2	2	1	3	0	2		3
0118	4 (11/1/95)	2	2	1	1	0	2		3
0119	4 (11/1/95)	2	2	1	3	0	2		3
0120	4 (11/1/95)	2	2	1	1	0	2		3
0121	4 (11/1/95)	2	2	1	3	0	2		3
0122	4 (11/1/95)	2	2	1	1	0	2		3
0123	4 (11/1/95)	2	2	1	3	0	2		3
0124	4 (11/1/95)	2	2	1	3	0	2		3

All long-term monitoring requirements have been met. However, initial monitoring requirements were not met for every type of data collection. The distress and FWD testing met the initial requirements. The longitudinal profile did not meet the requirements for initial monitoring. The initial monitoring for the transverse profile was not met for Sections 310113, 310116, 310118, 310120, and 310122.

Two years of WIM traffic data have been collected for this project.

This project has 1,024 days of AWS data available. Records show that the project should have 1,430 days of data available. This project also has 17 years of data from the NOAA database.

Table 64. Summary of available materials information on the Nebraska SPS-1.

Nebraska SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	5	100.0
Hydrometer Analysis	6	5	100.0
Atterberg Limits	6	5	100.0
Moisture-Density Relations	6	5	100.0
Resilient Modulus	6	5	80.0
Natural Moisture Content	6	5	100.0
Permeability	3	1	100.0
Unbound Base:			
Sieve Analysis	3	0	0.0
Atterberg Limits	3	0	0.0
Moisture-Density Relations	3	0	0.0
Resilient Modulous	3	0	0.0
Permeability	3	0	0.0
Natural Moisture Content	3	0	0.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	2	100.0
Aggregate Gradation	3	3	66.7
Asphalt Treated Base:			
Core Examination	34	33	66.7
Bulk Specific Gravity	34	8	62.5
Maximum Specific Gravity	3	7	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	4	75.0
Aggregate Gradation	3	2	100.0
NAA Test for Fine Aggregate Particle Shape	3	2	100.0
Penetration of Asphalt Cement	6	2	50.0
Specific Gravity of Asphalt Cement	6	2	100.0
Viscosity of Asphalt Cement	6	2	0.0
Asphalt Surface:			
Core Examination	60	28	100.0
Bulk Specific Gravity	60	18	88.9
Maximum Specific Gravity	3	18	100.0
Asphalt Content	3	4	100.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	8	87.5
Aggregate Gradation	3	4	100.0
NAA Test for Fine Aggregate Particle Shape	3	4	100.0
Penetration of Asphalt Cement	6	4	0.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	4	0.0

NEVADA

The Nevada project was built on U.S. 80 west of Battle Mountain, NV, in 1995. U.S. 80 is a four-lane divided highway with an estimated 52 percent trucks.[25] It was estimated that this project would annually receive 799,000 ESALs. The project was constructed with AC shoulders.

The project was planned for the dry-freeze environmental zone with a coarse-grained subgrade and would fill column T of the experiment factorial. This project has an average annual freeze index of 156 °C-days. On average, 223 mm of rain falls each year on the project. The subgrade samples were classified as sandy lean clay, silt with sand, silty sand, or clayey sand. Two of the five subgrade samples were fine-grained materials.

This project includes Sections 320101 through 320112 in the experiment design. The State opted not to build any supplemental sections on this project. Table 65 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

A plant breakdown occurred while laying the PATB. The breakdown slowed paving operations for approximately 1 hour. The breakdown occurred when the paver was in the middle of Section 320110. The paver hopper was continuously either too full or too empty during the paving of the ATB and HMA layers. A loader was used to add or remove material as necessary. Due to these problems, paving of these layers was intermittent.

Project Deviations

Section 320109 was the only section that did not have at least one layer whose average thickness deviated from the design thickness by more than 6 mm. For every section, all of the layers had variations in thickness that were larger than 6 mm from the design thickness.

Gradations of the DGAB material indicated that approximately 11 to 12 percent of the material was passing the No. 200 sieve. This was larger than the 10 percent allowed by the construction guidelines. The construction data did not show any other deviations from the guidelines.

Data Completeness

Table 66 provides a summary of the materials testing data available for this project. The subgrade testing for this project has been completed. However, very little of the other testing has been completed. The sieve analysis, moisture content, and permeability testing are the only tests that have been completed for the DGAB layer. The core examination and bulk specific gravities are only partially complete for the ATB and HMA layer. No other testing has been conducted.

The long-term monitoring requirements were met for the distress, transverse profile, longitudinal profile, and FWD data collection. However, the initial monitoring requirements were not met for any of these.

Table 65. Summary of key project monitoring data for the Nevada SPS-1.

Nevada SPS-1 Project Key Information Summary

Age as of Aug. 1999:	4.0 years	**Construction Date:**	8/1/95
Subgrade type:	Coarse Grained	**Climatic Zone:**	Dry - Freeze
Subgrade Treatment:	Lime-treated	**Automated Weather Station:**	None
Climatic data availability:	17 years	**Automated Vehicle Class:**	299 Days
Construction Problems:	Plant breakdown. Intermittent ATB and HMA paving.	**Weighing-In-Motion:**	338 Days

Site key information summary

ID	Surface Thickness, mm		Base Thickness, mm		Base Type	Drainage	Materials Testing Percent Complete		
	Design	Actual	Design	Actual			Surface	Base	Subgrade
0101	178	183	203	216	DGAB	No	14	50	91
0102	102	112	305	297	DGAB	No	14	50	91
0103	102	104	203	224	ATB	No	14	6	91
0104	178	185	305	315	ATB	No	14	6	91
0105	102	107	203	213	ATB/DGAB	No	14	6/50	91
0106	178	183	305	318	ATB/DGAB	No	14	6/50	91
0107	102	112	203	201	PATB/DGAB	Yes	14	0/50	91
0108	178	178	305	310	PATB/DGAB	Yes	14	0/50	91
0109	178	178	407	409	PATB/DGAB	Yes	14	0/50	91
0110	178	168	203	218	ATB/PATB	Yes	14	6/0	91
0111	102	104	305	325	ATB/PATB	Yes	14	6/0	91
0112	102	114	407	422	ATB/PATB	Yes	14	6/0	91

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

ID	IRI (Date at Initial.)	FWD	Distress Manual	Distress PASCO	Rut Depth	Friction	Traffic	Comments	Adequacy Code
0101	7 (12/3/96)	18	10	1	8	0	3		3
0102	3 (4/22/97)	6	3	1	3	0	1		3
0103	3 (4/22/97)	5	3	1	3	0	1		3
0104	3 (4/22/97)	5	3	1	3	0	1		3
0105	3 (4/22/97)	6	3	1	3	0	1		3
0106	3 (4/22/97)	6	3	1	3	0	1		3
0107	3 (4/22/97)	5	3	1	3	0	1		3
0108	3 (4/22/97)	5	3	1	3	0	1		3
0109	3 (4/22/97)	6	3	1	3	0	1		3
0110	3 (4/22/97)	4	3	1	3	0	1		3
0111	3 (4/22/97)	4	2	1	3	0	1		3
0112	3 (4/22/97)	5	3	1	3	0	1		3

This project has 1 year of traffic data available.

AWS equipment has been installed on this project, but there are no AWS data in the IMS. This project is linked to the SPS-2 project for which data do exist in the IMS. The project has 17 years of data from the NOAA database.

Table 66. Summary of available materials testing data on the Nevada SPS-1.

Nevada SPS-1 Materials Testing Summary			
Test	Minimum No. per Layer	Number Conducted	Percent at Level E
Subgrade:			
Sieve Analysis	6	6	100.0
Hydrometer Analysis	6	6	100.0
Atterberg Limits	6	6	100.0
Moisture-Density Relations	6	6	100.0
Resilient Modulus	6	5	100.0
Natural Moisture Content	6	6	100.0
Permeability	6	6	100.0
Unbound Base:			
Sieve Analysis	3	3	100.0
Atterberg Limits	3	3	100.0
Moisture-Density Relations	3	3	100.0
Resilient Modulous	3	0	0.0
Permeability	3	3	100.0
Natural Moisture Content	3	3	100.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	4	100.0
Aggregate Gradation	3	4	100.0
Asphalt Treated Base:			
Core Examination	34	19	100.0
Bulk Specific Gravity	34	1	100.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	4	100.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	3	6	100.0
Aggregate Gradation	3	3	100.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	3	100.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	3	100.0
Asphalt Surface:			
Core Examination	60	60	100.0
Bulk Specific Gravity	60	32	100.0
Maximum Specific Gravity	3	0	0.0
Asphalt Content	3	2	100.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	4	100.0
Aggregate Gradation	3	2	100.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	7	100.0
Specific Gravity of Asphalt Cement	6	0	0.0
Viscosity of Asphalt Cement	6	8	100.0

NEW MEXICO

The New Mexico project was built on U.S. 25 north of Las Cruces, NM, in 1995. U.S. 25 is a four-lane divided highway with an estimated 18 percent trucks.[26] It was estimated that this project would annually receive 393,000 ESALs. The project was constructed with AC shoulders.

The project was planned for the dry-no freeze environmental zone with a fine-grained subgrade and would fill column V of the experiment factorial. This project has an average annual freeze index of 5 °C-days. On average, 290 mm of rain falls each year on the project. The subgrade samples were classified as fat clay, fat clay with sand, sandy fat clay, or clayey sand. One of the six subgrade samples was coarse-grained material.

This project includes Sections 350101 through 350112 in the experiment design. The State opted not to build any supplemental sections on this project. Table 67 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

Some problems with paving occurred during the placement of the ATB. One truckload of mix was tender. In addition, the air voids were 2 to 3 percent higher than allowed for the ATB. The batch plant broke down and paving was delayed. Once the batch plant was brought back on-line, the air void difficulties in the ATB were corrected. No other difficulties were noted during construction.

Project Deviations

All sections except two (350102 and 350108) had at least one layer with the average thickness deviating from the design thickness by more than 6 mm. Based on the elevation surveys, all of the layers on all of the sections deviate somewhere within each section from the design thickness by more than 6 mm.

The design of the ATB mix did not meet the minimum requirements set by the construction guidelines. This material should have a flow between 3 and 7.6 mm and a stability of at least 10 kN. The design of the ATB mix for this project had a flow of 1.8 mm and a stability of 9.5 kN.

Samples of the HMA mix indicated that the aggregate in the surface mix had more material passing the No. 4 sieve than allowed. The testing data recorded over 50 percent of the aggregate from the surface passing the No. 4 sieve. The construction guidelines indicate that no more than 40 percent should pass the No. 4 sieve.

Table 67. Summary of key project monitoring data for the New Mexico SPS-1.

New Mexico SPS-1 Project Key Information Summary

Age as of Aug. 1999:	3.7	**Construction Date:**	11/1/95
Subgrade type:	Fine Grained	**Climatic Zone:**	Dry - No Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	1075 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	None
Construction Problems:	Plant breakdown	**Weighing-In-Motion:**	None

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0101	178	168	203	218	DGAB	No	86	33	100
0102	102	107	305	310	DGAB	No	86	33	100
0103	102	119	203	183	ATB	No	86	90	100
0104	178	191	305	282	ATB	No	86	90	100
0105	102	135	203	196	ATB/DGAB	No	86	90/33	100
0106	178	178	305	277	ATB/DGAB	No	86	90/33	100
0107	102	135	203	203	PATB/DGAB	Yes	86	33/33	100
0108	178	183	305	310	PATB/DGAB	Yes	86	33/33	100
0109	178	188	407	417	PATB/DGAB	Yes	86	33/33	100
0110	178	185	203	211	ATB/PATB	Yes	86	90/33	100
0111	102	109	305	287	ATB/PATB	Yes	86	90/33	100
0112	102	112	407	376	ATB/PATB	Yes	86	90/33	100

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

			Distress		Rut				Adequacy
ID	IRI (Date at Initial.)	FWD	Manual	PASCO	Depth	Friction	Traffic	Comments	Code
0101	1 (3/11/97)	1	2	0	2	0	0		3
0102	1 (3/11/97)	1	2	0	2	0	0		3
0103	1 (3/11/97)	1	2	0	2	0	0		3
0104	1 (3/11/97)	1	2	0	2	0	0		3
0105	1 (3/11/97)	1	2	0	2	0	0		3
0106	1 (3/11/97)	1	2	0	2	0	0		3
0107	1 (3/11/97)	1	2	0	2	0	0		3
0108	1 (3/11/97)	1	2	0	2	0	0		3
0109	1 (3/11/97)	1	2	0	2	0	0		3
0110	1 (3/11/97)	1	2	0	2	0	0		3
0111	1 (3/11/97)	1	2	0	2	0	0		3
0112	1 (3/11/97)	1	2	0	1	0	0		3

Data Completeness

Table 68 provides a summary of the materials testing data available for this project. The materials testing on this project is essentially complete. Testing is still required on the DGAB. This testing includes the sieve analysis, Atterberg limits, moisture-density relations, and resilient modulus.

The frequency requirements for the long-term monitoring have been met for all of the data collection types. The initial monitoring requirements were not met for any of the types of monitoring data that are collected.

This project does not have any available traffic data.

Approximately 1,075 days of AWS data are available for this project. It should have 1,307 days. This project also has 17 years of data from the NOAA database.

Table 68. Summary of available materials testing data on the New Mexico SPS-1.

New Mexico SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	6	100.0
Hydrometer Analysis	6	6	100.0
Atterberg Limits	6	6	100.0
Moisture-Density Relations	6	6	100.0
Resilient Modulus	6	11	100.0
Natural Moisture Content	6	6	100.0
Permeability	3	3	33.3
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	3	100.0
Natural Moisture Content	3	3	100.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	1	100.0
Aggregate Gradation	3	1	100.0
Asphalt Treated Base:			
Core Examination	34	35	100.0
Bulk Specific Gravity	34	20	100.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	5	100.0
Moisture Susceptibility	3	2	100.0
Specific Gravity of Aggregate	6	6	100.0
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
Asphalt Surface:			
Core Examination	60	82	100.0
Bulk Specific Gravity	60	59	100.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	3	3	100.0
Specific Gravity of Aggregate	6	6	100.0
Aggregate Gradation	3	3	100.0
NAA Test for Fine Aggregate Particle Shape	3	4	100.0
Penetration of Asphalt Cement	6	3	100.0
Specific Gravity of Asphalt Cement	6	3	100.0
Viscosity of Asphalt Cement	6	3	100.0

OHIO

The Ohio project was built on U.S. 23 south of Waldo, OH, in 1995. U.S. 23 is a four-lane divided highway with an estimated 12 percent trucks.[26] The project was constructed with AC shoulders.

The project was planned for the wet-freeze environmental zone with a fine-grained subgrade and would fill column J of the experiment factorial. This project has an average annual freeze index of 208 °C-days. On average, 972 mm of rain falls each year on the project. No information is available as to the actual subgrade classification.

This project includes Sections 390101 through 390112 in the experiment design. The State opted to build two supplemental sections on this project. Table 69 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project. This project was opened for two to three weeks and then closed for approximately one year to repair some of the test sections that failed immediately after construction.

Construction Difficulties

A fill material was added on all of the sections. The typical lift thickness was 305 mm. Section 390105 was found to have 508 mm of embankment. The SHA determined that 508 mm was too thick and the embankment was cut down to 102 mm. The subgrade was resampled at this time.

Project Deviations

The average thickness recorded for the surface on Section 390110 and the ATB on Sections 390111 and 390112 deviate from the design thickness by more than 6 mm. Based on the elevation data, at least one thickness measurement of each layer on all of the sections indicates a deviation from the design thickness of more than 6 mm.

The lift thickness on the DGAB was much larger than the 152 mm allowed. These values ranged from 178 mm to 254 mm.

The gradation of the aggregate in the PATB layer is to have less than 2 percent passing the No. 200 sieve. One of the samples of this material contained 7 percent passing the No. 200 sieve.

The gradation of the aggregate included in the surface mix was to have less than 40 percent passing the No. 4 sieve. Four samples were obtained from this mix for the purpose of gradation testing. All four of these samples indicated that the amount of aggregate passing the No. 4 sieve was between 44 and 54 percent.

Table 69. Summary of key project monitoring data for the Ohio SPS-1.

Ohio SPS-1 Project Key Information Summary

Age as of Aug. 1999:	4.6 years	**Construction Date:**	1/1/95
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	1600 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	None
Construction Problems:	Fill material placed	**Weighing-In-Motion:**	None

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0101	178	175	203	203	DGAB	No	82	17	9
0102	102	99	305	300	DGAB	No	82	17	9
0103	102	99	203	203	ATB		82	19	9
0104	178	178	305	300	ATB	No	82	19	9
0105	102	102	203	102	ATB/DGAB	No	82	19/17	9
0106	178	173	305	99	ATB/DGAB	No	82	19/17	9
0107	102	97	203	104	PATB/DGAB	Yes	82	100/17	9
0108	178	168	305	203	PATB/DGAB	Yes	82	100/17	9
0109	178	178	407	305	PATB/DGAB	Yes	82	100/17	9
0110	178	185	203	99	ATB/PATB	Yes	82	19/100	9
0111	102	102	305	109	ATB/PATB	Yes	82	19/100	9
0112	102	102	407	102	ATB/PATB	Yes	82	19/100	9
0159									
0160									

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

			Distress		Rut				Adequacy
ID	IRI	FWD	Manual	PASCO	Depth	Friction	Traffic	Comments	Code
0101	3 (8/14/96)	4	1	1	2	0	0		3
0102	4 (8/14/96)	6	2	1	3	0	0		3
0103	3 (8/14/96)	4	3	0	2	0	0		3
0104	4 (8/14/96)	4	2	1	2	0	0		3
0105	3 (8/14/96)	6	3	1	4	0	0		3
0106	4 (8/14/96)	4	3	1	3	0	0		3
0107	4 (8/14/96)	3	2	1	3	0	0		3
0108	4 (8/14/96)	5	3	1	3	0	0		3
0109	4 (8/14/96)	5	3	1	3	0	0		3
0110	4 (8/14/96)	5	4	1	3	0	0		3
0111	4 (8/14/96)	3	2	1	2	0	0		3
0112	4 (8/14/96)	5	1	1	2	0	0		3
0159	1 (11/12/98)	4	0	0	0	0	0		3
0160	3 (12/27/96)	2	3	1	2	0	0		3

Data Completeness

Table 70 contains a summary of the available materials testing data. The testing is essentially complete for the HMA surface. The ATB still requires core examinations, bulk specific gravity tests, and moisture susceptibility tests. The only testing that has been completed on the DGAB is a sieve analysis and the permeability testing. The permeability testing is the only testing that has been completed on the subgrade.

All of the data collection efforts have met the requirements for long-term monitoring, but did not meet the requirements for initial monitoring.

This project has no traffic data available.

This project should have more than 1,600 days (more than 42 months) of AWS data available. None of these data were present in the database that was reviewed for this report. However, this project includes 17 years of data from the NOAA database.

Table 70. Summary of available materials testing data on the Ohio SPS-1.

Ohio SPS-1 Materials Testing Summary			
Test	Minimum No. per Layer	Number Conducted	Percent at Level E
Subgrade:			
Sieve Analysis	6	0	0.0
Hydrometer Analysis	6	0	0.0
Atterberg Limits	6	0	0.0
Moisture-Density Relations	6	0	0.0
Resilient Modulus	6	0	0.0
Natural Moisture Content	6	0	0.0
Permeability	3	2	0.0
Unbound Base:			
Sieve Analysis	3	1	0.0
Atterberg Limits	3	0	0.0
Moisture-Density Relations	3	0	0.0
Resilient Modulous	3	0	0.0
Permeability	3	2	0.0
Natural Moisture Content	3	0	0.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	4	100.0
Aggregate Gradation	3	4	25.0
Asphalt Treated Base:			
Core Examination	34	0	0.0
Bulk Specific Gravity	34	0	0.0
Maximum Specific Gravity	3	1	100.0
Asphalt Content	3	1	100.0
Moisture Susceptibility	3	0	0.0
Specific Gravity of Aggregate	6	2	100.0
Aggregate Gradation	3	1	0.0
NAA Test for Fine Aggregate Particle Shape	3	1	100.0
Penetration of Asphalt Cement	6	1	0.0
Specific Gravity of Asphalt Cement	6	1	100.0
Viscosity of Asphalt Cement	6	1	0.0
Asphalt Surface:			
Core Examination	60	42	85.7
Bulk Specific Gravity	60	18	94.4
Maximum Specific Gravity	3	4	100.0
Asphalt Content	3	4	100.0
Moisture Susceptibility	3	4	0.0
Specific Gravity of Aggregate	6	8	87.5
Aggregate Gradation	3	4	0.0
NAA Test for Fine Aggregate Particle Shape	3	4	100.0
Penetration of Asphalt Cement	6	4	75.0
Specific Gravity of Asphalt Cement	6	4	100.0
Viscosity of Asphalt Cement	6	4	0.0

OKLAHOMA

The Oklahoma project was built on U.S. 62 west of Lawton, OK, in 1997. U.S. 62 is a four-lane divided highway with an estimated 13 percent trucks.[27] This project receives over 280,000 ESALs per year. The project was constructed with AC shoulders.

The project was planned for the dry-no freeze environmental zone with a fine-grained subgrade and would fill column W of the experiment factorial. This project has an average annual freeze index of 90 °C-days. On average, 869 mm of rain falls each year on the project. Tube samples from the project all indicated that the subgrade was fine-grained.

This project includes Sections 400113 through 400124 in the experiment design. The State opted to build two supplemental sections on this project. Table 71 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

Some of the sections for this project are located on a cut and other sections are located on a fill. There are no transitions from cut to fill within any of the sections. The project was constructed on a site for which the earthwork had been performed 10 years earlier. Most of the settlement for this earthwork had probably occurred prior to construction.

The WIM equipment for this project was located 8 km (5 miles) from the project. Five potential traffic generators exist between the project and the WIM site. These include an intersection with a highway leading to a wildlife refuge, exit and entrance ramps for a subdivision, and three at-grade crossings. None of these was expected to have significant heavy truck volumes.

Project Deviations

All of the sections except Sections 400116 and 400123 had at least one layer whose average thickness deviated from the design thickness by more than 6 mm. Based on the elevation survey data, all of the layers had at least one thickness measurement that deviated from the design thickness by more than 6 mm.

The ATB was placed in two 152-mm lifts on the two sections that required 305 mm of ATB. The construction guidelines allowed the first lift to be 152 mm. The subsequent lifts were not allowed to be more than 102 mm thick.

Samples of the HMA surface mix indicate that the gradation used in that mix had too much aggregate passing the No. 4 sieve. The guidelines required that no more than 40 percent of the aggregate used pass the No. 4 sieve. The materials testing of this mix indicates that from 55 to 63 percent is passing the No. 4 sieve.

Table 71. Summary of key project monitoring data for the Oklahoma SPS-1.

Oklahoma SPS-1 Project Key Information Summary

Age as of Aug. 1999:	2.1 years	**Construction Date:**	7/1/97
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - No Freeze
Subgrade Treatment:	Lime-treated	**Automated Weather Station:**	400 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	None
Construction Problems:	Some sections on cut, some on fill	**Weighing-In-Motion:**	None

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	**Design**	**Actual**	**Design**	**Actual**			**Surface**	**Base**	**Subgrade**
0113	178		203		DGAB	No	78	0	48
0114	102		305		DGAB	No	78	0	48
0115	102		203		ATB	No	78	90	48
0116	178		305		ATB	No	78	90	48
0117	102		203		ATB/DGAB	No	78	90/0	48
0118	178		305		ATB/DGAB	No	78	90/0	48
0119	102		203		PATB/DGAB	Yes	78	100/0	48
0120	178		305		PATB/DGAB	Yes	78	100/0	48
0121	178		407		PATB/DGAB	Yes	78	100/0	48
0122	178		203		ATB/PATB	Yes	78	90/100	48
0123	102		305		ATB/PATB	Yes	78	90/100	48
0124	102		407		ATB/PATB	Yes	78	90/100	48
0160									

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

			Distress		Rut				Adequacy
ID	**IRI (Date at Initial.)**	**FWD**	**Manual**	**PASCO**	**Depth**	**Friction**	**Traffic**	**Comments**	**Code**
0113	1 (11/19/97)	2	3	0	0	1	0		2
0114	1 (11/19/97)	2	3	0	0	1	0		2
0115	1 (11/19/97)	2	3	0	0	1	0		2
0116	1 (11/19/97)	2	3	0	0	1	0		2
0117	1 (11/19/97)	2	3	0	0	1	0		2
0118	1 (11/19/97)	3	3	0	0	1	0		2
0119	1 (11/19/97)	2	3	0	0	1	0		2
0120	1 (11/19/97)	2	3	0	0	1	0		2
0121	1 (11/19/97)	2	3	0	0	1	0		2
0122	1 (11/19/97)	2	3	0	0	1	0		2
0123	1 (11/19/97)	2	3	0	0	1	0		2
0124	1 (11/19/97)	2	3	0	0	1	0		2
0160	1 (11/19/97)	2	3	0	0	1	0		2

Data Completeness

Table 72 provides a summary of the materials testing data available for this project. The testing on the asphalt surface, the ATB, and the PATB materials is essentially complete. No testing has been conducted on the DGAB material. The subgrade still requires testing to determine the moisture-density relations, the moisture content, and the permeability.

No transverse profile data are available for this project at Level E in the IMS. However, two sets of transverse profiles have been measured. The distress data collection has met the requirements for both initial and long-term monitoring frequencies. The deflection and longitudinal profile data collection have met the requirements for the frequency of long-term and initial monitoring requirements.

No traffic data are currently available for this project.

An AWS was installed at this location. The IMS contains more than 400 days of available data for this project. It should have 699 days of data. This project includes 17 years of data from the NOAA database.

Table 72. Summary of available materials testing data on the Oklahoma SPS-1.

Oklahoma SPS-1 Materials Testing Summary			
Test	Minimum No. per Layer	Number Conducted	Percent at Level E
Subgrade:			
Sieve Analysis	6	6	100.0
Hydrometer Analysis	6	6	100.0
Atterberg Limits	6	6	100.0
Moisture-Density Relations	6	6	0.0
Resilient Modulus	6	8	100.0
Natural Moisture Content	6	6	0.0
Permeability	3	0	0.0
Unbound Base:			
Sieve Analysis	3	3	100.0
Atterberg Limits	3	3	100.0
Moisture-Density Relations	3	6	100.0
Resilient Modulus	3	0	0.0
Permeability	3	0	0.0
Natural Moisture Content	3	3	100.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	3	100.0
Aggregate Gradation	3	3	100.0
Asphalt Treated Base:			
Core Examination	34	34	100.0
Bulk Specific Gravity	34	33	100.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	3	3	100.0
Specific Gravity of Aggregate	6	6	100.0
Aggregate Gradation	3	3	100.0
NAA Test for Fine Aggregate Particle Shape	3	4	100.0
Penetration of Asphalt Cement	6	4	100.0
Specific Gravity of Asphalt Cement	6	3	100.0
Viscosity of Asphalt Cement	6	4	100.0
Asphalt Surface:			
Core Examination	64	57	100.0
Bulk Specific Gravity	64	56	100.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	3	2	100.0
Specific Gravity of Aggregate	6	5	100.0
Aggregate Gradation	3	3	100.0
NAA Test for Fine Aggregate Particle Shape	3	3	100.0
Penetration of Asphalt Cement	6	3	100.0
Specific Gravity of Asphalt Cement	6	3	100.0
Viscosity of Asphalt Cement	6	2	100.0

TEXAS

The Texas project was built on U.S. 281 north of McAllen, TX, in 1997. U.S. 281 is a four-lane divided highway with an estimated 33 percent trucks.[28] This project only receives about 10,000 ESALs per year. The project was constructed with AC shoulders.

The project was planned for the dry-no freeze environmental zone with a fine-grained subgrade and would fill column X of the experiment factorial. However, the subgrade soil was classified as a fine-grained soil. This project has an average annual freeze index of 1 °C-days. On average, 561 mm of rain falls each year on the project. No information is available about the classification of the subgrade.

This project includes Sections 480113 through 480124 in the experiment design. The State opted to build eight supplemental sections on this project. Table 73 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

Transverse interceptor drains were not installed on this project. The project is located on level ground. The cross-slope of the lanes was considered sufficient to transfer water away from the section.

No deviations were found in the available construction data.

Data Completeness

Table 74 contains a summary of the materials testing data available for this project. The only testing completed for this project and which has reached Level E is for the subgrade. This material has had a sieve analysis, hydrometer analysis, and testing to determine the Atterberg limits and resilient modulus. Other material tests have been competed, but these data are not at Level E in the IMS.

The frequency requirements for both long-term and initial monitoring were met for the transverse profile, distress, and FWD testing. The long-term monitoring frequency requirements were met for the longitudinal profile. The initial monitoring requirements for the longitudinal profile were met, but the initial data are not at Level E.

This project does not have any available traffic data in the IMS even though substantial traffic data have been collected by the agency.

An AWS was installed on this site. The project currently has 187 days of available data. It should have 790 days of data. This project also includes 17 years of data from the NOAA database.

Table 73. Summary of key project monitoring data for the Texas SPS-1.

Texas SPS-1 Project Key Information Summary

Age as of Aug. 1999:	2.3 years	**Construction Date:**	4/1/97
Subgrade type:	Fine-grained	**Climatic Zone:**	Wet - No Freeze
Subgrade Treatment:	None	**Automated Weather Station:**	187 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	None
Construction Problems:	No transverse interceptor drains	**Weighing-In-Motion:**	None

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0113	178		203		DGAB	No	0	0	57
0114	102		305		DGAB	No	0	0	57
0115	102		203		ATB	No	0	0	57
0116	178		305		ATB	No	0	0	57
0117	102		203		ATB/DGAB	No	0	0/0	57
0118	178		305		ATB/DGAB	No	0	0/0	57
0119	102		203		PATB/DGAB	Yes	0	0/0	57
0120	178		305		PATB/DGAB	Yes	0	0/0	57
0121	178		407		PATB/DGAB	Yes	0	0/0	57
0122	178		203		ATB/PATB	Yes	0	0/0	57
0123	102		305		ATB/PATB	Yes	0	0/0	57
0124	102		407		ATB/PATB	Yes	0	0/0	57
0160	127		267		*LRA	No			
0161	127		216		LRA	No			
0162	127		216		Limestone	No			
0163	127		267		Limestone	No			
0164	127		267		**CCAB	No			
0165	127		216		CCAB	No			
0166	127		356		Caliche	No			
0167	127		356		Caliche	No			

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

ID	IRI (Date at Initial.)	FWD	Distress Manual	Distress PASCO	Rut Depth	Friction	Traffic	Comments	Adequacy Code
0113	2 (9/8/97)	1	3	0	2	0	0		2
0114	2 (9/8/97)	1	3	0	3	0	0		2
0115	2 (9/8/97)	1	3	0	1	0	0		2
0116	2 (9/8/97)	1	3	0	2	0	0		2
0117	2 (9/8/97)	1	3	0	1	0	0		2
0118	2 (9/8/97)	1	3	0	2	0	0		2
0119	2 (9/8/97)	1	3	0	2	0	0		2
0120	2 (9/8/97)	1	3	0	2	0	0		2
0121	2 (9/8/97)	1	3	0	2	0	0		2
0122	2 (9/8/97)	1	3	0	2	0	0		2
0123	2 (9/8/97)	1	3	0	2	0	0		2
0124	2 (9/8/97)	1	3	0	2	0	0		2
0160	2 (9/8/97)	1	3	0	2	0	0		2
0161	2 (9/8/97)	1	3	0	2	0	0		2
0162	2 (9/8/97)	1	3	0	2	0	0		2
0163	2 (9/8/97)	1	3	0	2	0	0		2
0164	2 (9/8/97)	1	3	0	2	0	0		2
0165	2 (9/8/97)	1	3	0	2	0	0		2
0166	2 (9/8/97)	1	3	0	2	0	0		2
0167	2 (9/8/97)	1	3	0	2	0	0		2

*LRA: Limerock Asphalt
**CCAB: Crushed Concrete Aggregate

Table 74. Summary of available materials testing data on the Texas SPS-1.

Texas SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	10	10	60.0
Hydrometer Analysis	10	10	60.0
Atterberg Limits	10	10	60.0
Moisture-Density Relations	10	19	60.0
Resilient Modulus	10	10	60.0
Natural Moisture Content	10	10	60.0
Permeability	7	10	60.0
Unbound Base:			
Sieve Analysis	7	7	42.9
Atterberg Limits	7	7	42.9
Moisture-Density Relations	7	7	42.9
Resilient Modulous	7	0	0.0
Permeability	7	7	42.9
Natural Moisture Content	7	2	50.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	3	100.0
Aggregate Gradation	3	3	100.0
Asphalt Treated Base:			
Core Examination	36	6	100.0
Bulk Specific Gravity	36	6	100.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	3	3	100.0
Specific Gravity of Aggregate	6	6	100.0
Aggregate Gradation	3	3	100.0
NAA Test for Fine Aggregate Particle Shape	3	3	100.0
Penetration of Asphalt Cement	6	3	100.0
Specific Gravity of Asphalt Cement	6	3	100.0
Viscosity of Asphalt Cement	6	3	100.0
Asphalt Surface:			
Core Examination	98	62	51.6
Bulk Specific Gravity	98	61	50.8
Maximum Specific Gravity	6	6	100.0
Asphalt Content	6	6	100.0
Moisture Susceptibility	6	6	100.0
Specific Gravity of Aggregate	12	12	100.0
Aggregate Gradation	6	6	100.0
NAA Test for Fine Aggregate Particle Shape	6	6	100.0
Penetration of Asphalt Cement	12	9	100.0
Specific Gravity of Asphalt Cement	12	9	100.0
Viscosity of Asphalt Cement	12	9	100.0

VIRGINIA

The Virginia project was built on State Route (S.R.) 265 in Danville, VA, in 1995. S.R. 265 is a four-lane divided highway. The project was constructed with AC shoulders.

The project was planned for the wet-freeze environmental zone with a fine-grained subgrade and would fill column K of the experiment factorial. This project has an average annual freeze index of 38 °C-days. On average, 1,142 mm of rain falls each year on the project. The subgrade was classified as a silty clay or silt, which is a fine-grained material.

This project includes Sections 510113 through 510124 in the experiment design. The State opted to build one supplemental section on this project. Table 75 contains a summary of the data available for this project. It also provides the pavement section design for each section of the project.

Construction Difficulties

All sections except three (Sections 510113, 510114, and 510122) have at least one layer thickness that deviates from the design by more than 6 mm. All of the layers on all of the sections have at least one thickness measurement that deviates from the design by more than 6 mm.

No more than 40 percent of the aggregate in the HMA surface is allowed to pass the No. 4 sieve. The materials testing information indicated that around 70 percent of the aggregate was passing the No. 4 sieve.

Data Completeness

Table 76 contains a summary of the testing data available for this project. Much of the testing has been completed for this project. The only testing required for the HMA surface and ATB layers is the fine aggregate particle shape testing. The unbound base has no results for the moisture-density, resilient modulus, and the permeability tests. The subgrade still requires results for the permeability and the hydrometer analysis.

Longitudinal profile and FWD did not meet initial monitoring requirements. Transverse profile and distress did meet initial monitoring requirements. All met the long-term monitoring requirements.

This project has 1,299 days of AWS data. It should have 1,307 days.

Table 75. Summary of key project monitoring data for the Virginia SPS-1.

Virginia SPS-1 Project Key Information Summary

Age as of Aug. 1999:	3.7 years	**Construction Date:**	11/1/95
Subgrade type:	Fine Grained	**Climatic Zone:**	Wet - No Freeze
Subgrade Treatment:	Cement-treated	**Automated Weather Station:**	1299 Days
Climatic data availability:	17 years	**Automated Vehicle Class:**	312 Days
Construction Problems:	None	**Weighing-In-Motion:**	313 Days

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0113	102	101.6	203	200.66	DGAB	No	43	50	71
0114	178	140	305	302.26	DGAB	No	43	50	71
0115	178	162.56	203	218.44	ATB	No	43	76	71
0116	102	114.3	305	314.96	ATB	No	43	76	71
0117	178	167.64	203	200.66	ATB/DGAB	No	43	76/50	71
0118	102	104.14	305	289.56	ATB/DGAB	No	43	76/50	71
0119	178	162.56	203	210.82	PATB/DGAB	Yes	43	100/50	71
0120	102	104.14	305	307.34	PATB/DGAB	Yes	43	100/50	71
0121	102	93.98	407	426.72	PATB/DGAB	Yes	43	100/50	71
0122	102	99.06	203	198.12	ATB/PATB	Yes	43	76/100	71
0123	178	165.1	305	309.88	ATB/PATB	Yes	43	76/100	71
0124	178	160.02	407	403.86	ATB/PATB	Yes	43	76/100	71
0159									

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

	IRI (Date at		Distress		Rut				Adequacy
ID	Initial.)	FWD	Manual	PASCO	Depth	Friction	Traffic	Comments	Code
0113	8 (4/24/96)	26	9	0	7	1	1		4
0114	8 (4/24/96)	26	8	0	6	1	1		4
0115	7 (4/24/96)	2	3	0	2	1	1		4
0116	7 (4/24/96)	2	3	0	2	1	1		4
0117	7 (4/24/96)	2	3	0	2	1	1		4
0118	7 (4/24/96)	2	3	0	2	1	1		4
0119	7 (4/24/96)	2	3	0	2	1	1		4
0120	7 (4/24/96)	2	3	0	2	1	1		4
0121	7 (4/24/96)	3	5	0	3	1	1		4
0122	7 (4/24/96)	2	3	0	2	1	1		4
0123	7 (4/24/96)	2	3	0	2	1	1		4
0124	7 (4/24/96)	2	3	0	2	1	1		4
0159	7 (4/24/96)	2	3	0	2	1	1		4

Table 76. Summary of available materials testing data on the Virginia SPS-1.

Virginia SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	6	83.3
Hydrometer Analysis	6	6	83.3
Atterberg Limits	6	6	50.0
Moisture-Density Relations	6	6	83.3
Resilient Modulus	6	0	0.0
Natural Moisture Content	6	6	83.3
Permeability	3	3	100.0
Unbound Base:			
Sieve Analysis	3	3	100.0
Atterberg Limits	3	3	0.0
Moisture-Density Relations	3	0	0.0
Resilient Modulus	3	0	0.0
Permeability	3	1	0.0
Natural Moisture Content	3	3	100.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	9	33.3
Aggregate Gradation	3	9	22.2
Asphalt Treated Base:			
Core Examination	34	49	63.3
Bulk Specific Gravity	34	28	64.3
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	3	3	0.0
Specific Gravity of Aggregate	6	6	66.7
Aggregate Gradation	3	3	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	3	100.0
Specific Gravity of Asphalt Cement	6	3	100.0
Viscosity of Asphalt Cement	6	3	0.0
Asphalt Surface:			
Core Examination	60	72	80.6
Bulk Specific Gravity	60	44	70.5
Maximum Specific Gravity	3	1	0.0
Asphalt Content	3	1	0.0
Moisture Susceptibility	3	1	0.0
Specific Gravity of Aggregate	6	1	0.0
Aggregate Gradation	3	1	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	1	0.0
Specific Gravity of Asphalt Cement	6	1	0.0
Viscosity of Asphalt Cement	6	1	0.0

WISCONSIN

The Wisconsin project was built on S.R. 29 in 1997. S.R. 29 is a four-lane divided highway. The project was constructed with AC shoulders.

The project was planned to fill column M of the experiment factorial. This column is in the wet-freeze environmental zone with a coarse subgrade. No data were available to assess whether the environment and subgrade did meet these requirements.

This project includes Sections 550113 through 550124 in the experiment design. The State opted not to build any supplemental sections on this project. Table 77 contains a summary of the data available for this project. It also provides the pavement section design for each section of this project.

Construction Difficulties

The construction report was submitted to LTPP after the detailed review. However, review of that report indicates that no construction difficulties were noted.

Data Completeness

Table 78 provides a summary of the testing data available on this project. No testing has been completed on any of the materials on any of the layers. This is a new project and the testing is in process.

The monitoring conducted on the project does not meet the requirements for the initial time limits. The distress and FWD data collected meet the requirements for the long-term monitoring.

No traffic data, AWS, or climatic data were available for this project at the time of the detailed review. However, these data are being collected at the site.

Table 77. Summary of key project monitoring data for the Wisconsin SPS-1.

Wisconsin SPS-1 Project Key Information Summary

Age as of Aug. 1999:	1.8 years	**Construction Date:**	10/1/97
Subgrade type:	?	**Climatic Zone:**	?
Subgrade Treatment:	?	**Automated Weather Station:**	None
Climatic data availability:	0 years	**Automated Vehicle Class:**	None
Construction Problems:	None	**Weighing-In-Motion:**	None

Site key information summary

	Surface		Base				Materials Testing		
	Thickness, mm		Thickness, mm		Type	Drainage	Percent Complete		
ID	Design	Actual	Design	Actual			Surface	Base	Subgrade
0113	178		203		DGAB	No	0	0	0
0114	102		305		DGAB	No	0	0	0
0115	102		203		ATB	No	0	0	0
0116	178		305		ATB	No	0	0	0
0117	102		203		ATB/DGAB	No	0	0/0	0
0118	178		305		ATB/DGAB	No	0	0/0	0
0119	102		203		PATB/DGAB	Yes	0	0/0	0
0120	178		305		PATB/DGAB	Yes	0	0/0	0
0121	178		407		PATB/DGAB	Yes	0	0/0	0
0122	178		203		ATB/PATB	Yes	0	0/0	0
0123	102		305		ATB/PATB	Yes	0	0/0	0
0124	102		407		ATB/PATB	Yes	0	0/0	0

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

			Distress		Rut				Adequacy
ID	IRI (Date at Initial.)	FWD	Manual	PASCO	Depth	Friction	Traffic	Comments	Code
0113	3 (12/1/97)	1	1	0	1	0	0		0
0114	3 (12/1/97)	1	1	0	1	0	0		0
0115	2 (12/1/97)	1	1	0	1	0	0		0
0116	3 (12/1/97)	1	1	0	1	0	0		0
0117	3 (12/1/97)	1	1	0	1	0	0		0
0118	3 (12/1/97)	1	1	0	1	0	0		0
0119	3 (12/1/97)	1	1	0	1	0	0		0
0120	3 (12/1/97)	1	1	0	1	0	0		0
0121	3 (12/1/97)	1	1	0	1	0	0		0
0122	3 (12/1/97)	1	1	0	1	0	0		0
0123	3 (12/1/97)	1	1	0	1	0	0		0
0124	3 (12/1/97)	1	1	0	1	0	0		0

Table 78. Summary of available materials testing data on the Wisconsin SPS-1.

Wisconsin SPS-1 Materials Testing Summary			
Test	**Minimum No. per Layer**	**Number Conducted**	**Percent at Level E**
Subgrade:			
Sieve Analysis	6	0	0.0
Hydrometer Analysis	6	0	0.0
Atterberg Limits	6	0	0.0
Moisture-Density Relations	6	0	0.0
Resilient Modulus	6	0	0.0
Natural Moisture Content	6	0	0.0
Permeability	3	9	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	5	0.0
Natural Moisture Content	3	0	0.0
Permeable Asphalt Treated Base:			
Asphalt Content	3	3	100.0
Aggregate Gradation	3	3	0.0
Asphalt Treated Base:			
Core Examination	34	34	100.0
Bulk Specific Gravity	34	34	100.0
Maximum Specific Gravity	3	3	100.0
Asphalt Content	3	3	100.0
Moisture Susceptibility	3	3	0.0
Specific Gravity of Aggregate	6	6	50.0
Aggregate Gradation	3	3	83.3
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	3	0.0
Specific Gravity of Asphalt Cement	6	3	33.3
Viscosity of Asphalt Cement	6	3	0.0
Asphalt Surface:			
Core Examination	60	60	0.0
Bulk Specific Gravity	60	60	0.0
Maximum Specific Gravity	3	3	0.0
Asphalt Content	3	3	0.0
Moisture Susceptibility	3	3	0.0
Specific Gravity of Aggregate	6	6	0.0
Aggregate Gradation	3	3	0.0
NAA Test for Fine Aggregate Particle Shape	3	0	0.0
Penetration of Asphalt Cement	6	6	0.0
Specific Gravity of Asphalt Cement	6	6	0.0
Viscosity of Asphalt Cement	6	6	0.0

APPENDIX B. SUMMARY OF CONSTRUCTION DATA

Appendix B contains a summary of the construction data available for each project. The thickness data provided from these measurements come from three different sources. The first source is the **TST_L05B** table and contains the values that are considered most representative of the material that was actually placed on the section. The second source is the **SPS1_LAYER** table, which includes thicknesses that should be the same as those provided in the **TST_L05B** table. However, in the majority of the data shown, these thicknesses are not the same. The third source for thickness data is the **SPS1_LAYER_THICKNESS** table. These data were obtained from elevation measurements taken on the projects after the placement of each layer.

Alabama (1)	101	102	103	104	105	106	107	108	109	110	111	112	161	162	163
Required Thickness															
AC Surface	178	102	102	178	102	178	102	178	178	178	102	102			
ATB	0	0	203	305	102	203	0	0	0	102	203	305			
PATB	0	0	0	0	0	0	102	102	102	102	102	102			
DGAB	203	305	0	0	102	102	102	203	305	0	0	0			
L05B Thickness															
AC Surface															
ATB															
PATB															
DGAB															
SPS Construction Thickness															
AC Surface	168	99	109	170	104	188	104	185	188	170	112	99			
ATB	0	0	185	300	102	206	0	0	0	107	201	320			
PATB	0	0	0	0	0	0	91	107	107	97	94	84			
DGAB	201	302	0	0	102	91	104	201	302	0	0	0			
Rod & Level															
AC Surface	174	99	108	168	105	188	103		188	174	113	99			
ATB	0	0	187	299		206	0		0	107	200	320			
PATB	0	0	0	0		0	93		107	97	93	84			
DGAB	201	302	0	0		95	104	200	303	0	0	0			
Rod & Level Std Dev															
AC Surface	6	8	8	11	13	7	7		9	6	7	10			
ATB			9	9		9				10	10	6			
PATB							10		10	12	12	10			
DGAB	9	8				8	8	13	9						
Rod & Level Min															
AC Surface	163	81	89	147	86	173	89	0	170	165	102	74			
ATB	0	0	163	284	0	188	0	0	0	91	178	305			
PATB	0	0	0	0	0	0	71	0	81	76	71	64			
DGAB	188	287	0	0	0	79	86	170	277	0	0	0			
Rod & Level Max															
AC Surface	183	112	122	193	127	208	124	0	213	188	132	119			
ATB	0	0	203	320	0	224	0	0	0	127	224	335			
PATB	0	0	0	0	0	0	117	0	127	122	112	102			
DGAB	218	323	0	0	0	112	122	226	320	0	0	0			
DGAB Material Requirements															
< 50% Passing #4 Sieve		47				48		33							
< 10 % Passing #200		12				12		8							
LL < 25															
PI < 4															
Max Lift Thickness < 6	6	6			6	6	6	6	6						
ATB Material Requirements															
Hveem															
Swell < 0.7 mm															
Stability > 35															
Marshall 50-blow															
Flow 2 - 5 mm															
Stability 4.4 kN															
Marshall 75-blow															
Flow 3 - 7.6 mm			3	3	3					3	3	3			
Stability 10 kN			18	18	18	18				18	18	18			
First lift thickness < 6 inches			2	3	3	2				1	2	3			
Sub lift thickness < 4			3	3	1	3				2	2	3			
PATB Material Requirements															
< 2% Passing #200															
2 - 2.5% Asphalt Content															
Roller type (Steel Wheel)							STEEL WHL TANDEM								
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1			
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6			
HMAC Binder Material Requirements															
Marshall															
75 blows	75	75	75	75	75	75	75		75	75	75	75			
Min Stability 8 kN	14	14	14	14	14	14	14		14	14	14	14			
Flow 2 mm - 4 mm	3	3	3	3	3	3	3		3	3	3	3			

Arizona (4)	113	114	115	116	117	118	119	120	121	122	123	124	160	161	162	163
Required Thickness																
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178				
ATB	0	0	203	305	102	203	0	0	0	102	203	305				
PATB	0	0	0	0	0	0	102	102	102	102	102	102				
DGAB	203	305	0	0	102	102	102	203	305	0	0	0				
L05B Thickness																
AC Surface	114	173	168	104	193	102	160	102	104	107	173	170				
ATB	0	0	216	307	107	196	0	0	0	102	201	297				
PATB	0	0	0	0	0	0	114	109	107	117	97	104				
DGAB	191	305	0	0	107	104	107	193	300	140	0	0				
SPS Construction Thickness																
AC Surface	107	180	163	94	180	94	157	107	107	102	170	173				
ATB	0	0	216	300	99	196	0	0	0	109	198	292				
PATB	0	0	0	0	0	0	114	109	107	117	97	104				
DGAB	191	305	0	0	107	109	112	185	310	0	0	0				
Rod & Level																
AC Surface	107	181	163	95	180	95	157	103	106	100	170	174				
ATB	0	0	216	299	100	196	0	0	0	108	199	293				
PATB	0	0	0	0	0	0	114	109	106	116	96	105				
DGAB	191	304	0	0	108	109	113	186	311	0	0	0				
Rod & Level Std Dev																
AC Surface	11	21	5	6	8	7	8	9	7	8	5	7				
ATB			9	11	9	5				7	7	7				
PATB							13	12	9	9	11	6				
DGAB	12	24			10	8	19	16	11							
Rod & Level Min																
AC Surface	89	163	152	86	170	81	135	81	94	76	163	163				
ATB	0	0	196	284	71	183	0	0	0	97	180	274				
PATB	0	0	0	0	0	0	66	76	86	109	76	91				
DGAB	165	241	0	0	89	91	79	155	290	0	0	0				
Rod & Level Max																
AC Surface	137	249	178	122	198	122	180	132	119	119	183	188				
ATB	0	0	241	338	112	208	0	0	0	117	213	310				
PATB	0	0	0	0	0	0	140	124	122	137	117	119				
DGAB	216	378	0	0	135	127	152	224	335	0	0	0				
DGAB Material Requirements																
< 50% Passing #4 Sieve						49	67	49		80						
< 10 % Passing #200						8	12	7		17						
LL < 25																
PI < 4						NP	NP	NP		NP						
Max Lift Thickness < 6	5	7			5	5	5	5	7							
ATB Material Requirements																
Hveem																
Swell < 0.7 mm																
Stability > 35																
Marshall 50-blow																
Flow 2 - 5 mm			3	3	3	3					3	3				
Stability 4.4 kN			19	19	19	19					19	19				
Marshall 75-blow																
Flow 3 - 7.6 mm																
Stability 10 kN																
First lift thickness < 6 inches			4	4	4	4				4	4	4				
Sub lift thickness < 4			4	4		4					4	4				
PATB Material Requirements																
< 2% Passing #200							3			2		3				
2 - 2.5% Asphalt Content							3			3		3				
Roller type (Steel Wheel)							STEEL WHL TANDEM									
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1				
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6				
HMAC Binder Material Requirements																
Marshall																
75 blows																
Min Stability 8 kN																
Flow 2 mm - 4 mm																

Arkansas (5)	113	114	115	116	117	118	119	120	121	122	123	124
Required Thickness												
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178
ATB	0	0	203	305	102	203	0	0	0	102	203	305
PATB	0	0	0	0	0	0	102	102	102	102	102	102
DGAB	203	305	0	0	102	102	102	203	305	0	0	0
L05B Thickness												
AC Surface												
ATB												
PATB												
DGAB												
SPS Construction Thickness												
AC Surface	102	165	180	102	173	102	163	97	107	112	180	175
ATB	0	0	188	290	99	198	0	0	0	99	203	287
PATB	0	0	0	0	0	0	97	86	89	102	91	91
DGAB	208	132	0	0	104	89	107	206	312	0	0	0
Rod & Level												
AC Surface	64	133	123	74	129	74	135	68	62	72	147	151
ATB	0	0	184	290	98	197	0	0	0	97	202	284
PATB	0	0	0	0	0	0	97	88	89	100	91	91
DGAB	208	132	0	0	103	88	108	208	313	0	0	0
Rod & Level Std Dev												
AC Surface	6	9	2	5	6	6	10	8	5	5	9	6
ATB			10	8	6	7				12	10	10
PATB							8	9	10	8	5	5
DGAB	8	16			7	9	13	11	15			
Rod & Level Min												
AC Surface	48	102	117	64	117	64	119	48	48	61	127	135
ATB	0	0	152	269	86	180	0	0	0	25	178	262
PATB	0	0	0	0	0	0	79	51	71	86	79	76
DGAB	188	104	0	0	89	74	79	188	284	0	0	0
Rod & Level Max												
AC Surface	74	152	127	89	147	86	155	89	71	81	165	165
ATB	0	0	203	302	107	208	0	0	0	112	218	300
PATB	0	0	0	0	0	0	112	109	109	119	104	102
DGAB	226	173	0	0	112	107	135	229	351	0	0	0
DGAB Material Requirements												
< 50% Passing #4 Sieve												
< 10 % Passing #200												
LL < 25												
PI < 4												
Max Lift Thickness < 6	4	4			4	4	4	4	4			
ATB Material Requirements												
Hveem												
Swell < 0.7 mm												
Stability > 35												
Marshall 50-blow												
Flow 2 - 5 mm			2	2	2	2				2	2	2
Stability 4.4 kN			11	11	11	11				11	11	11
Marshall 75-blow												
Flow 3 - 7.6 mm												
Stability 10 kN												
First lift thickness < 6 inches			4	4	4	4				4	4	4
Sub lift thickness < 4			4	4		4					4	4
PATB Material Requirements												
< 2% Passing #200												
2 - 2.5% Asphalt Content												
Roller type (Steel Wheel)							DOUBLE-DRUM VIBR.					
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6
HMAC Binder Material Requirements												
Marshall												
75 blows	75	75	75	75	75	75	75	75	75	75	75	75
Min Stability 8 kN	8	8	8	8	8	8	8	8	8	8	8	8
Flow 2 mm - 4 mm	2	2	2	2	2	2	2	2	2	2	2	2

Delaware (10)	101	102	103	104	105	106	107	108	109	110	111	112	159	160
Required Thickness														
AC Surface	178	102	102	178	102	178	102	178	178	178	102	102		
ATB	0	0	203	305	102	203	0	0	0	102	203	305		
PATB	0	0	0	0	0	0	102	102	102	102	102	102		
DGAB	203	305	0	0	102	102	102	203	305	0	0	0		
L05B Thickness														
AC Surface	180	104	122	170	112	170	122	178	185	183	94	114		
ATB	0	0	203	305	112	216	0	0	0	104	221	312		
PATB	0	0	0	0	0	0	97	94	107	91	99	86		
DGAB	206	300	0	0	86	99	99	185	307	0	0	0		
SPS Construction Thickness														
AC Surface	173	114	122	170	112	173	160	183	188	185	91	112		
ATB	0	0	203	305	112	216	0	0	0	104	218	312		
PATB	0	0	0	0	0	0	97	94	107	91	102	86		
DGAB	206	300	0	0	86	99	99	185	307	0	0	0		
Rod & Level														
AC Surface	176	104	121	171	113	175	122	178	186	183	95	114		
ATB	0	0	203	306	111	216	0	0	0	105	222	313		
PATB	0	0	0	0	0	0	96	94	107	92	99	86		
DGAB	206	299	0	0	86	99	100	185	308	0	0	0		
Rod & Level Std Dev														
AC Surface	10	19	12	6	16	8	11	7	6	11	9	10		
ATB			10	9	9	13				8	10	11		
PATB							11	10	8	9	10	11		
DGAB	14	15			11	17	20	20	19					
Rod & Level Min														
AC Surface	152	58	46	157	79	152	102	152	173	147	79	102		
ATB	0	0	178	287	81	193	0	0	0	89	198	290		
PATB	0	0	0	0	0	0	74	71	86	74	79	61		
DGAB	168	262	0	0	64	61	56	135	277	0	0	0		
Rod & Level Max														
AC Surface	196	127	137	183	137	196	147	185	201	213	112	137		
ATB	0	0	226	323	132	244	0	0	0	127	246	338		
PATB	0	0	0	0	0	0	127	119	124	109	127	124		
DGAB	229	333	0	0	117	132	140	218	356	0	0	0		
DGAB Material Requirements														
< 50% Passing #4 Sieve														
< 10 % Passing #200														
LL < 25														
PI < 4														
Max Lift Thickness < 6	4	4			4	4	4	5	4					
ATB Material Requirements														
Hveem														
Swell < 0.7 mm														
Stability > 35														
Marshall 50-blow														
Flow 2 - 5 mm			3		4	3				4	4	4		
Stability 4.4 kN			10		11	9				8	8	8		
Marshall 75-blow														
Flow 3 - 7.6 mm				3										
Stability 10 kN				11										
First lift thickness < 6 inches			4	6	5	5				4	5	6		
Sub lift thickness < 4			4	6		5				2	6	5		
PATB Material Requirements														
< 2% Passing #200														
2 - 2.5% Asphalt Content							2		2					
Roller type (Steel Wheel)							STEEL WHL TANDEM							
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1		
Drainage Type	1	1	1	1	1	1	2	2	2	6	6	6		
HMAC Binder Material Requirements														
Marshall														
75 blows	75	75	75	75	75	75	75	75	50	75	75	75		
Min Stability 8 kN	11	11	10	13	11	10	9	9	8	10	10	10		
Flow 2 mm - 4 mm	3	3	3	3	3	3	3	3	4	3	3	3		

Florida (12)	101	102	103	104	105	106	107	108	109	110	111	112	161
Required Thickness													
AC Surface	178	102	102	178	102	178	102	178	178	178	102	102	
ATB	0	0	203	305	102	203	0	0	0	102	203	305	
PATB	0	0	0	0	0	0	102	102	102	102	102	102	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
L05B Thickness													
AC Surface	173	99	104	173	99	183	99	163	180	185	99	99	
ATB	0	0	203	305	102	211	0	0	0	104	211	312	
PATB	0	0	0	0	0	0	104	102	104	104	102	99	
DGAB	206	307	0	0	102	102	104	201	297	0	0	0	
SPS Construction Thickness													
AC Surface	173	102	104	173	104	185	91	163	183	188	99	97	
ATB	0	0	206	305	104	203	0	0	0	99	211	310	
PATB	0	0	0	0	0	0	104	102	104	104	102	99	
DGAB	206	307	0	0	102	102	104	201	297	0	0	0	
Rod & Level													
AC Surface	168	93	101	175	97	178	93	162	181	177	99	101	
ATB	0	0	203	309	103	204	0	0	0	98	199	301	
PATB	0	0	0	0	0	0	104	102	103	104	103	97	
DGAB	206	307	0	0	102	102	103	201	297	0	0	0	
Rod & Level Std Dev													
AC Surface	4	4	5	4	5	6	7	6	4	6	6	7	
ATB			5	6	5	6				7	5	6	
PATB							4	6	4	5	5	4	
DGAB	5	15			11	6	8	5	7				
Rod & Level Min													
AC Surface	157	86	89	168	89	165	79	152	173	163	86	89	
ATB	0	0	196	295	94	193	0	0	0	86	185	287	
PATB	0	0	0	0	0	0	91	86	94	91	89	86	
DGAB	196	208	0	0	79	86	86	193	287	0	0	0	
Rod & Level Max													
AC Surface	178	109	107	183	107	193	109	173	188	185	112	119	
ATB	0	0	218	323	117	218	0	0	0	112	216	315	
PATB	0	0	0	0	0	0	112	117	109	112	112	109	
DGAB	218	333	0	0	124	117	124	213	310	0	0	0	
DGAB Material Requirements													
< 50% Passing #4 Sieve	53												
< 10 % Passing #200	10												
LL < 25	0												
PI < 4	NP												
Max Lift Thickness < 6	6	7			6	6	6	6	9				
ATB Material Requirements													
Hveem													
Swell < 0.7 mm													
Stability > 35													
Marshall 50-blow													
Flow 2 - 5 mm													
Stability 4.4 kN													
Marshall 75-blow													
Flow 3 - 7.6 mm													
Stability 10 kN													
First lift thickness < 6 inches			3	3	2	3				2	3	4	
Sub lift thickness < 4			3	3	2	3				2	3	4	
PATB Material Requirements													
< 2% Passing #200							3						
2 - 2.5% Asphalt Content							3						
Roller type (Steel Wheel)							PNEUMATIC TIRED						
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1	
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6	
HMAC Binder Material Requirements													
Marshall													
75 blows	75	75	75	75	75	75	75	75	75	75	75	75	
Min Stability 8 kN													
Flow 2 mm - 4 mm													

Iowa (19)	101	102	103	104	105	106	107	108	109	110	111	112	159
Required Thickness													
AC Surface	178	102	102	178	102	178	102	178	178	178	102	102	
ATB	0	0	203	305	102	203	0	0	0	102	203	305	
PATB	0	0	0	0	0	0	102	102	102	102	102	102	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
L05B Thickness													
AC Surface	203		97	178	89	173	86		191	201	112	117	
ATB	0	0	213	315			0	0	0				
PATB	0	0	0	0	0	0				112	109	104	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
SPS Construction Thickness													
AC Surface	203	130	97	178	89	173	86	152	191	201	112	114	
ATB	0	0	224	318	122	234	0	0	0	81	191	315	
PATB	0	0	0	0	0	0	114	117	124	112	109	102	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
Rod & Level													
AC Surface													
ATB													
PATB													
DGAB													
Rod & Level Std Dev													
AC Surface													
ATB													
PATB													
DGAB													
Rod & Level Min													
AC Surface													
ATB													
PATB													
DGAB													
Rod & Level Max													
AC Surface													
ATB													
PATB													
DGAB													
DGAB Material Requirements													
< 50% Passing #4 Sieve	48							50	46				
< 10 % Passing #200	7							8	8				
LL < 25													
PI < 4								NP	NP				
Max Lift Thickness < 6	6	6			6	6	6	6	6				
ATB Material Requirements													
Hveem													
Swell < 0.7 mm													
Stability > 35													
Marshall 50-blow													
Flow 2 - 5 mm													
Stability 4.4 kN													
Marshall 75-blow													
Flow 3 - 7.6 mm													
Stability 10 kN													
First lift thickness < 6 inches													
Sub lift thickness < 4													
PATB Material Requirements													
< 2% Passing #200													
2 - 2.5% Asphalt Content							2	2	2	2	2	2	
Roller type (Steel Wheel)													
Drainage Location													
Drainage Type													
HMAC Binder Material Requirements													
Marshall													
75 blows													
Min Stability 8 kN													
Flow 2 mm - 4 mm													

Kansas (20)	101	102	103	104	105	106	107	108	109	110	111	112	159	160	161	162	163	164
Required Thickness																		
AC Surface	178	102	102	178	102	178	102	178	178	178	102	102						
ATB	0	0	203	305	102	203	0	0	0	102	203	305						
PATB	0	0	0	0	0	0	102	102	102	102	102	102						
DGAB	203	305	0	0	102	102	102	203	305	0	0	0						
L05B Thickness																		
AC Surface	193	102	91	173	99	185	104	193	178	178	102	127						
ATB	0	0	196	307	97	185	0	0	0	97	216	305						
PATB	0	0	0	0	0	0	104	91	91	99	91	91						
DGAB	216	312	0	0	104	102	94	201	302	0	0	0						
SPS Construction Thickness																		
AC Surface	178	102	102	178	102	178	102	178	178	102	178	102						
ATB	0	0	203	305	102	203	0	0	0	102	203	305						
PATB	0	0	0	0	0	0	102	102	102	102	102	102						
DGAB	203	305	0	0	102	102	102	203	305	0	0	0						
Rod & Level																		
AC Surface	171	96	108	188	102	173	109	183	189	191	97	105						
ATB	0	0	194	308	107	195	0	0	0	97	217	317						
PATB	0	0	0	0	0	0	97	95	91	100	94	95						
DGAB	213	310	0	0	98	100	101	197	304	0	0	0						
Rod & Level Std Dev																		
AC Surface	10	9	10	7	11	7	5	8	9	7	7	6						
ATB			7	8	5	10				8	11	8						
PATB							5	6	7	8	8	8						
DGAB	11	8			7	6	10	8	8									
Rod & Level Min																		
AC Surface	152	81	86	173	71	152	94	165	165	173	81	91						
ATB	0	0	180	290	97	183	0	0	0	79	201	305						
PATB	0	0	0	0	0	0	86	81	76	79	76	76						
DGAB	178	290	0	0	86	89	79	185	279	0	0	0						
Rod & Level Max																		
AC Surface	193	122	132	198	119	188	119	196	203	201	112	119						
ATB	0	0	216	320	122	224	0	0	0	112	249	338						
PATB	0	0	0	0	0	0	107	107	109	122	112	112						
DGAB	231	325	0	0	119	112	122	216	318	0	0	0						
DGAB Material Requirements																		
< 50% Passing #4 Sieve																		
< 10 % Passing #200																		
LL < 25																		
PI < 4																		
Max Lift Thickness < 6	4	4			4	4	4	4	4									
ATB Material Requirements																		
Hveem																		
Swell < 0.7 mm																		
Stability > 35																		
Marshall 50-blow																		
Flow 2 - 5 mm																		
Stability 4.4 kN																		
Marshall 75-blow																		
Flow 3 - 7.6 mm																		
Stability 10 kN																		
First lift thickness < 6 inches																		
Sub lift thickness < 4																		
PATB Material Requirements																		
< 2% Passing #200																		
2 - 2.5% Asphalt Content																		
Roller type (Steel Wheel)																		
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1						
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6						
HMAC Binder Material Requirements																		
Marshall																		
75 blows																		
Min Stability 8 kN																		
Flow 2 mm - 4 mm																		

Louisiana (22)	113	114	115	116	117	118	119	120	121	122	123	124
Required Thickness												
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178
ATB	0	0	203	305	102	203	0	0	0	102	203	305
PATB	0	0	0	0	0	0	102	102	102	102	102	102
DGAB	203	305	0	0	102	102	102	203	305	0	0	0
L05B Thickness												
AC Surface												
ATB												
PATB												
DGAB												
SPS Construction Thickness												
AC Surface	132	239	191	124	170	112	168	97	89	99	173	170
ATB	0	0	208	272	91	183	0	0	0	94	191	282
PATB	0	0	0	0	0	0	91	86	104	102	97	89
DGAB	206	290	0	0	135	104	112	206	335	0	0	0
Rod & Level												
AC Surface	133	237	191	123	169	112	169	96	89	98	172	172
ATB	0	0	208	269	90	181	0	0	0	93	190	281
PATB	0	0	0	0	0	0	90	86	104	101	95	88
DGAB	204	289	0	0	135	102	111	207	333	0	0	0
Rod & Level Std Dev												
AC Surface	9	10	9	7	16	11	7	7	6	6	6	9
ATB			12	12	13	14				10	10	19
PATB							10	13	9	11	11	6
DGAB	11	8			20	15	8	8	16			
Rod & Level Min												
AC Surface	117	216	168	97	142	76	155	84	76	86	155	155
ATB	0	0	180	231	61	147	0	0	0	76	168	234
PATB	0	0	0	0	0	0	71	56	74	76	71	74
DGAB	183	274	0	0	104	76	89	188	305	0	0	0
Rod & Level Max												
AC Surface	152	259	211	137	201	132	183	112	102	112	183	196
ATB	0	0	241	295	112	211	0	0	0	122	203	310
PATB	0	0	0	0	0	0	112	112	119	124	117	107
DGAB	231	307	0	0	178	140	127	226	371	0	0	0
DGAB Material Requirements												
< 50% Passing #4 Sieve												
< 10 % Passing #200												
LL < 25												
PI < 4												
Max Lift Thickness < 6	8	12			4	4	4	8	12			
ATB Material Requirements												
Hveem												
Swell < 0.7 mm												
Stability > 35												
Marshall 50-blow												
Flow 2 - 5 mm			3	3	3	3				3	3	3
Stability 4.4 kN			9	9	9	9				9	9	9
Marshall 75-blow												
Flow 3 - 7.6 mm												
Stability 10 kN												
First lift thickness < 6 inches			3	4	4	4				2	3	3
Sub lift thickness < 4			3	4		4				2	3	3
PATB Material Requirements												
< 2% Passing #200												
2 - 2.5% Asphalt Content												
Roller type (Steel Wheel)							DOUBLE-DRUM VIBR.					
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1
Drainage Type	1	1	1	1	1	1	2	2	2	6	6	6
HMAC Binder Material Requirements												
Marshall												
75 blows	50	50	50	50	50	50		50	50	50	50	50
Min Stability 8 kN	10	10	10	10	10	10		10	10	10	10	10
Flow 2 mm - 4 mm	3	3	3	3	3	3		3	3	3	3	3

Michigan (26)	113	114	115	116	117	118	119	120	121	122	123	124	159
Required Thickness													
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178	
ATB	0	0	203	305	102	203	0	0	0	102	203	305	
PATB	0	0	0	0	0	0	102	102	102	102	102	102	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
L05B Thickness													
AC Surface	112	165		104	163	84	163	94	94	97	178	152	
ATB	0	0	244	305	132	211	0	0	0	107	203	305	
PATB	0	0	0	0	0	0	102	102	102	102	102	102	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
SPS Construction Thickness													
AC Surface													
ATB													
PATB													
DGAB													
Rod & Level													
AC Surface													
ATB													
PATB													
DGAB													
Rod & Level Std Dev													
AC Surface													
ATB													
PATB													
DGAB													
Rod & Level Min													
AC Surface													
ATB													
PATB													
DGAB													
Rod & Level Max													
AC Surface													
ATB													
PATB													
DGAB													
DGAB Material Requirements													
< 50% Passing #4 Sieve	53	34											
< 10 % Passing #200	11	8											
LL < 25													
PI < 4	NP	NP											
Max Lift Thickness < 6													
ATB Material Requirements													
Hveem													
Swell < 0.7 mm													
Stability > 35													
Marshall 50-blow													
Flow 2 - 5 mm													
Stability 4.4 kN													
Marshall 75-blow													
Flow 3 - 7.6 mm													
Stability 10 kN													
First lift thickness < 6 inches													
Sub lift thickness < 4													
PATB Material Requirements													
< 2% Passing #200													
2 - 2.5% Asphalt Content													
Roller type (Steel Wheel)													
Drainage Location													
Drainage Type													
HMAC Binder Material Requirements													
Marshall													
75 blows													
Min Stability 8 kN													
Flow 2 mm - 4 mm													

Montana (30)	113	114	115	116	117	118	119	120	121	122	123	124
Required Thickness												
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178
ATB	0	0	203	305	102	203	0	0	0	102	203	305
PATB	0	0	0	0	0	0	102	102	102	102	102	102
DGAB	203	305	0	0	102	102	102	203	305	0	0	0
L05B Thickness												
AC Surface												
ATB												
PATB												
DGAB												
SPS Construction Thickness												
AC Surface												
ATB												
PATB												
DGAB												
Rod & Level												
AC Surface	109		189	113	183	118	183	108	114	116	191	183
ATB	0		232	317	110	223	0	0	0	102	214	326
PATB	0		0	0	0	0	118	116	109	110	99	109
DGAB	210		0	0	120	108	112	206	312	0	0	0
Rod & Level Std Dev												
AC Surface	11		7	5	7	6	10	6	8	16	6	9
ATB			9	7	7	10				7	9	5
PATB							6	7	8	10	10	8
DGAB	24				18	22	17	17	11			
Rod & Level Min												
AC Surface	81		168	104	165	104	157	91	86	18	180	170
ATB	0		216	305	89	203	0	0	0	91	201	318
PATB	0		0	0	0	0	107	102	91	91	76	97
DGAB	102		0	0	91	74	76	170	287	0	0	0
Rod & Level Max												
AC Surface	142		201	124	203	137	201	124	127	135	203	198
ATB	0		249	330	122	244	0	0	0	122	231	330
PATB	0		0	0	0	0	127	127	122	127	119	122
DGAB	244		0	0	173	157	142	244	330	0	0	0
DGAB Material Requirements												
< 50% Passing #4 Sieve												
< 10 % Passing #200												
LL < 25												
PI < 4												
Max Lift Thickness < 6					5	5	5	8	8			
ATB Material Requirements												
Hveem												
Swell < 0.7 mm												
Stability > 35												
Marshall 50-blow												
Flow 2 - 5 mm												
Stability 4.4 kN												
Marshall 75-blow												
Flow 3 - 7.6 mm												
Stability 10 kN												
First lift thickness < 6 inches			2	2	2	2				2	2	2
Sub lift thickness < 4			3	2	2	2				2	2	2
PATB Material Requirements												
< 2% Passing #200												
2 - 2.5% Asphalt Content												
Roller type (Steel Wheel)							DOUBLE-DRUM VIBR.					
Drainage Location								1	1			
Drainage Type								6	6			
HMAC Binder Material Requirements												
Marshall												
75 blows												
Min Stability 8 kN												
Flow 2 mm - 4 mm												

Nebraska (31)	113	114	115	116	117	118	119	120	121	122	123	124
Required Thickness												
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178
ATB	0	0	203	305	102	203	0	0	0	102	203	305
PATB	0	0	0	0	0	0	102	102	102	102	102	102
DGAB	203	305	0	0	102	102	102	203	305	0	0	0
L05B Thickness												
AC Surface		170		112	201	109	201	119		97	191	190.5
ATB	0	0	323	323	97	213	0	0	0	112	206	312.4
PATB	0	0	0	0	0	0	102	102	102	102	102	101.6
DGAB	203	305	0	0	102	102	102	203	305	0	0	0
SPS Construction Thickness												
AC Surface								102	102			
ATB								203	305			
PATB								102	102			
DGAB								0	0			
Rod & Level												
AC Surface												
ATB												
PATB												
DGAB												
Rod & Level Std Dev												
AC Surface												
ATB												
PATB												
DGAB												
Rod & Level Min												
AC Surface												
ATB												
PATB												
DGAB												
Rod & Level Max												
AC Surface												
ATB												
PATB												
DGAB												
DGAB Material Requirements												
< 50% Passing #4 Sieve												
< 10 % Passing #200												
LL < 25												
PI < 4												
Max Lift Thickness < 6								6				
ATB Material Requirements												
Hveem												
Swell < 0.7 mm												
Stability > 35												
Marshall 50-blow												
Flow 2 - 5 mm												
Stability 4.4 kN												
Marshall 75-blow												
Flow 3 - 7.6 mm												
Stability 10 kN												
First lift thickness < 6 inches												
Sub lift thickness < 4												
PATB Material Requirements												
< 2% Passing #200									7			
2 - 2.5% Asphalt Content									5			2.5
Roller type (Steel Wheel)								DOUBLE-DRUM VIBR.				
Drainage Location												
Drainage Type												
HMAC Binder Material Requirements												
Marshall												
75 blows												
Min Stability 8 kN												
Flow 2 mm - 4 mm												

Nevada (32)	101	102	103	104	105	106	107	108	109	110	111	112
Required Thickness												
AC Surface	178	102	102	178	102	178	102	178	178	178	102	102
ATB	0	0	203	305	102	203	0	0	0	102	203	305
PATB	0	0	0	0	0	0	102	102	102	102	102	102
DGAB	203	305	0	0	102	102	102	203	305	0	0	0
L05B Thickness												
AC Surface	183	112	104	185	107	183	112	178	178	168	104	114
ATB	0	0	224	315	122	224	0	0	0	107	213	315
PATB	0	0	0	0	0	0	104	114	102	112	112	107
DGAB	216	297	0	0	91	94	97	196	307	0	0	0
SPS Construction Thickness												
AC Surface	180	112	104	185	107	183	112	178	178	168	104	114
ATB	0	0	224	315	122	224	0	0	0	107	213	315
PATB	0	0	0	0	0	0	104	114	102	112	112	107
DGAB	216	297	0	0	91	94	84	196	307	0	0	0
Rod & Level												
AC Surface	183	104	106	186	106	182	106	177	178	179	105	108
ATB	0	0	219	316	123	223	0	0	0	101	213	314
PATB	0	0	0	0	0	0	105	115	103	112	112	107
DGAB	215	296	0	0	91	95	97	197	308	0	0	0
Rod & Level Std Dev												
AC Surface	11	6	3	7	6	4	7	7	8	6	3	5
ATB			7	9	5	10				7	15	9
PATB							16	9	11	7	13	9
DGAB	9	11			5	10	8	8	7			
Rod & Level Min												
AC Surface	155	91	97	160	91	173	94	168	163	165	97	94
ATB	0	0	208	300	112	203	0	0	0	86	180	290
PATB	0	0	0	0	0	0	66	91	81	97	89	91
DGAB	196	269	0	0	79	76	79	183	295	0	0	0
Rod & Level Max												
AC Surface	208	117	112	198	119	193	124	198	193	193	112	117
ATB	0	0	234	338	150	241	0	0	0	119	234	335
PATB	0	0	0	0	0	0	140	132	124	124	142	127
DGAB	234	320	0	0	107	117	112	213	323	0	0	0
DGAB Material Requirements												
< 50% Passing #4 Sieve	46	41							33			
< 10 % Passing #200	12	11							9			
LL < 25		25										
PI < 4	NP	11							NP			
Max Lift Thickness < 6	6	8			6	6	6	6	8			
ATB Material Requirements												
Hveem												
Swell < 0.7 mm												
Stability > 35			39	39	39	39				39	39	39
Marshall 50-blow												
Flow 2 - 5 mm												
Stability 4.4 kN												
Marshall 75-blow												
Flow 3 - 7.6 mm												
Stability 10 kN												
First lift thickness < 6 inches			4	4	2	4				2	4	4
Sub lift thickness < 4			2	4	2	2				2	2	4
PATB Material Requirements												
< 2% Passing #200												
2 - 2.5% Asphalt Content												
Roller type (Steel Wheel)							DOUBLE-DRUM VIBR.					
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6
HMAC Binder Material Requirements												
Marshall												
75 blows												
Min Stability 8 kN												
Flow 2 mm - 4 mm												

New Mexico (35)	101	102	103	104	105	106	107	108	109	110	111	112
Required Thickness												
AC Surface	178	102	102	178	102	178	102	178	178	178	102	102
ATB	0	0	203	305	102	203	0	0	0	102	203	305
PATB	0	0	0	0	0	0	102	102	102	102	102	102
DGAB	203	305	0	0	102	102	102	203	305	0	0	0
L05B Thickness												
AC Surface	168	107	119	191		178		183	188	185	109	112
ATB	0	0	183	282	102	203	0	0	0	117	193	297
PATB	0	0	0	0	0	0	102	107	114	94	94	79
DGAB	218	310	0	0	94	74	102	203	302	0	0	0
SPS Construction Thickness												
AC Surface	163	104	132	198	119	193	109	175	183	180	109	112
ATB	0	0	170	300	99	201	0	0	0	122	206	295
PATB	0	0	0	0	0	0	109	112	102	94	97	86
DGAB	218	310	0	0	94	74	102	203	302	0	0	0
Rod & Level												
AC Surface	162	105	132	197	119	193	110	174	182	179	108	112
ATB	0	0	169	297	97	200	0	0	0	122	204	292
PATB	0	0	0	0	0	0	108	111	100	93	95	86
DGAB	201	308	0	0	95	73	101	202	299	0	0	0
Rod & Level Std Dev												
AC Surface	21	16	6	5	12	8	15	7	9	6	5	7
ATB			13	25	9	14				6	7	12
PATB							7	7	10	8	12	10
DGAB	24	28			21	25	20	18	17			
Rod & Level Min												
AC Surface	81	81	124	185	102	170	94	157	163	165	89	97
ATB	0	0	140	193	79	157	0	0	0	109	193	269
PATB	0	0	0	0	0	0	91	89	79	76	76	64
DGAB	157	239	0	0	61	18	51	157	272	0	0	0
Rod & Level Max												
AC Surface	201	150	155	208	170	211	152	185	203	196	119	124
ATB	0	0	203	338	119	234	0	0	0	135	218	318
PATB	0	0	0	0	0	0	122	122	119	112	124	109
DGAB	274	356	0	0	178	117	150	241	333	0	0	0
DGAB Material Requirements												
< 50% Passing #4 Sieve												
< 10 % Passing #200												
LL < 25												
PI < 4												
Max Lift Thickness < 6	4	6			4	4	4	4	6			
ATB Material Requirements												
Hveem												
Swell < 0.7 mm												
Stability > 35												
Marshall 50-blow												
Flow 2 - 5 mm												
Stability 4.4 kN												
Marshall 75-blow												
Flow 3 - 7.6 mm			2	2	2	2				2	2	2
Stability 10 kN			9	9	9	9				9	9	9
First lift thickness < 6 inches			3	3	2	3				2	3	3
Sub lift thickness < 4			3	3	2	3				2	3	3
PATB Material Requirements												
< 2% Passing #200									2			
2 - 2.5% Asphalt Content									2			
Roller type (Steel Wheel)							STEEL WHL TANDEM					
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6
HMAC Binder Material Requirements												
Marshall												
75 blows												
Min Stability 8 kN												
Flow 2 mm - 4 mm												

Ohio (39)	101	102	103	104	105	106	107	108	109	110	111	112	160
Required Thickness													
AC Surface	178	102	102	178	102	178	102	178	178	178	102	102	
ATB	0	0	203	305	102	203	0	0	0	102	203	305	
PATB	0	0	0	0	0	0	102	102	102	102	102	102	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
L05B Thickness													
AC Surface	175	99	99	178	102	173	97	168	178	185	102	102	
ATB	0	0	203	300	0		0	0	0	99	109	102	
PATB	0	0	0	0		0							
DGAB	203	300	0	0	102	99	104	203	305	0	0	0	
SPS Construction Thickness													
AC Surface	175	99	99	178	102	173	97	168	178	185	102	102	
ATB	0	0	203	300	94	201	0	0	0	94	198	300	
PATB	0	0	0	0	0	0	99	102	99	99	109	102	
DGAB	203	300	0	0	102	99	104	203	305	0	0	0	
Rod & Level													
AC Surface	173	99	97	177	101	172	97	166	177	185	103	99	
ATB	0	0	205	298	95	200	0	0	0	93	198	299	
PATB	0	0	0	0	0	0	100	103	99	100	109	102	
DGAB	203	301	0	0	102	97	103	204	304	0	0	0	
Rod & Level Std Dev													
AC Surface	7	5	5	4	11	5	6	6	5	7	3	4	
ATB			9	5	11	8				7	5	7	
PATB							7	7	6	9	5	5	
DGAB	6	8			8	8	7	8	6				
Rod & Level Min													
AC Surface	157	89	91	168	41	163	86	155	168	173	97	94	
ATB	0	0	193	290	79	180	0	0	0	79	185	282	
PATB	0	0	0	0	0	0	79	81	89	86	97	94	
DGAB	188	287	0	0	89	71	91	180	287	0	0	0	
Rod & Level Max													
AC Surface	188	107	112	183	112	183	109	180	188	201	109	107	
ATB	0	0	226	307	122	218	0	0	0	112	211	315	
PATB	0	0	0	0	0	0	117	119	109	127	122	109	
DGAB	216	315	0	0	119	112	119	216	318	0	0	0	
DGAB Material Requirements													
< 50% Passing #4 Sieve													
< 10 % Passing #200													
LL < 25													
PI < 4													
Max Lift Thickness < 6	10	8			7	7	7	10	8				
ATB Material Requirements													
Hveem													
Swell < 0.7 mm													
Stability > 35													
Marshall 50-blow													
Flow 2 - 5 mm													
Stability 4.4 kN													
Marshall 75-blow													
Flow 3 - 7.6 mm													
Stability 10 kN													
First lift thickness < 6 inches			3	3	2	3				4	3	3	
Sub lift thickness < 4			3	3	2	3					3	3	
PATB Material Requirements													
< 2% Passing #200					7								
2 - 2.5% Asphalt Content					6		2	2			5		
Roller type (Steel Wheel)							STEEL WHL TANDEM						
Drainage Location	3	3		3	3	3	1	1	1	1	1	1	
Drainage Type	1	1		1	1	1	6	6	6	6	6	6	
HMAC Binder Material Requirements													
Marshall													
75 blows													
Min Stability 8 kN													
Flow 2 mm - 4 mm													

Oklahoma (40)	113	114	115	116	117	118	119	120	121	122	123	124	160
Required Thickness													
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178	
ATB	0	0	203	305	102	203	0	0	0	102	203	305	
PATB	0	0	0	0	0	0	102	102	102	102	102	102	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
L05B Thickness													
AC Surface													
ATB													
PATB													
DGAB													
SPS Construction Thickness													
AC Surface	117	175	198	99	206	114	196	130	99	109	180	183	
ATB	0	0	221	305	107	213	0	0	0	109	206	277	
PATB	0	0	0	0	0	0	102	127	124	122	97	109	
DGAB	201	287	0	0	102	91	109	196	282	0	0	0	
Rod & Level													
AC Surface	117	194	196	100	205	112	196	129	98	108	180	183	
ATB	0	0	222	304	108	213	0	0	0	110	205	278	
PATB	0	0	0	0	0	0	102	126	124	121	98	110	
DGAB	201	287	0	0	101	92	108	196	282	0	0	0	
Rod & Level Std Dev													
AC Surface	8	9	8	11	8	6	14	9	8	11	7	18	
ATB			7	35	6	17				14	12	9	
PATB							9	8	5	20	9	10	
DGAB	9	14			18	10	9	17	12				
Rod & Level Min													
AC Surface	97	170	180	76	188	94	163	112	76	81	170	150	
ATB	0	0	208	71	94	173	0	0	0	81	180	264	
PATB	0	0	0	0	0	0	86	109	109	84	76	84	
DGAB	183	262	0	0	74	71	89	165	246	0	0	0	
Rod & Level Max													
AC Surface	135	211	211	117	224	124	218	150	114	124	196	224	
ATB	0	0	241	335	117	239	0	0	0	142	229	302	
PATB	0	0	0	0	0	0	124	147	135	178	119	130	
DGAB	218	318	0	0	145	112	124	241	300	0	0	0	
DGAB Material Requirements													
< 50% Passing #4 Sieve													
< 10 % Passing #200													
LL < 25													
PI < 4													
Max Lift Thickness < 6	4	6			4	4	4	4	6				
ATB Material Requirements													
Hveem													
Swell < 0.7 mm													
Stability > 35													
Marshall 50-blow													
Flow 2 - 5 mm													
Stability 4.4 kN													
Marshall 75-blow													
Flow 3 - 7.6 mm													
Stability 10 kN													
First lift thickness < 6 inches			3	6	4	3				4	4	6	
Sub lift thickness < 4			3	6		3					4	6	
PATB Material Requirements													
< 2% Passing #200							3			1	2		
2 - 2.5% Asphalt Content							3			2	2		
Roller type (Steel Wheel)							STEEL WHL TANDEM						
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1	
Drainage Type	1	1	1	1	1	1	2	2	2	6	6	6	
HMAC Binder Material Requirements													
Marshall													
75 blows													
Min Stability 8 kN													
Flow 2 mm - 4 mm													

Texas (48)	113	114	115	116	117	118	119	120	121	122	123	124	160	161	162	163	164	165	166	167
Required Thickness																				
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178								
ATB	0	0	203	305	102	203	0	0	0	102	203	305								
PATB	0	0	0	0	0	0	102	102	102	102	102	102								
DGAB	203	305	0	0	102	102	102	203	305	0	0	0								
L05B Thickness																				
AC Surface																				
ATB																				
PATB																				
DGAB																				
SPS Construction Thickness																				
AC Surface	97	165	180	137	206	117	183	112	91	107	170	183								
ATB	0	0	201	274	107	234	0	0	0	94	198	274								
PATB	0	0	0	0	0	0	89	102	94	122	112	107								
DGAB	198	312	0	0	66	43	104	188	300	0	0	0								
Rod & Level																				
AC Surface																				
ATB																				
PATB																				
DGAB																				
Rod & Level Std Dev																				
AC Surface																				
ATB																				
PATB																				
DGAB																				
Rod & Level Min																				
AC Surface																				
ATB																				
PATB																				
DGAB																				
Rod & Level Max																				
AC Surface																				
ATB																				
PATB																				
DGAB																				
DGAB Material Requirements																				
< 50% Passing #4 Sieve																				
< 10 % Passing #200																				
LL < 25																				
PI < 4																				
Max Lift Thickness < 6	5	5			4	4	5	5	5											
ATB Material Requirements																				
Hveem																				
Swell < 0.7 mm																				
Stability > 35																				
Marshall 50-blow																				
Flow 2 - 5 mm																				
Stability 4.4 kN																				
Marshall 75-blow																				
Flow 3 - 7.6 mm																				
Stability 10 kN																				
First lift thickness < 6 inches			3	3	2	3				2	3	3								
Sub lift thickness < 4			3	3	2	3				2	3	3								
PATB Material Requirements																				
< 2% Passing #200																				
2 - 2.5% Asphalt Content																				
Roller type (Steel Wheel)							PNEUMATIC TIRED													
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1								
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6								
HMAC Binder Material Requirements																				
Marshall																				
75 blows																				
Min Stability 8 kN																				
Flow 2 mm - 4 mm																				

Virginia (51)	113	114	115	116	117	118	119	120	121	122	123	124	159
Required Thickness													
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178	
ATB	0	0	203	305	102	203	0	0	0	102	203	305	
PATB	0	0	0	0	0	0	102	102	102	102	102	102	
DGAB	203	305	0	0	102	102	102	203	305	0	0	0	
L05B Thickness													
AC Surface	102		163	114	168	104	163	104	94	99	165	160	
ATB	0	0	218	315	102	203	0	0	0	99	206	318	
PATB	0	0	0	0	0	0	112	109	109	99	104	86	
DGAB	201	302	0	0	99	86	99	198	318	0	0	0	
SPS Construction Thickness													
AC Surface	102	173	163	114	168	104	163	104	94	99	165	160	
ATB	0	0	218	315	102	203	0	0	0	99	206	318	
PATB	0	0	0	0	0	0	112	109	109	99	104	86	
DGAB	201	302	0	0	99	86	99	198	318	0	0	0	
Rod & Level													
AC Surface	58	105	114	73	125	61	126	72	54	55	122	119	
ATB	0	0	218	315	102	204	0	0	0	98	205	317	
PATB	0	0	0	0	0	0	113	110	109	100	105	86	
DGAB	201	303	0	0	98	87	100	199	317	0	0	0	
Rod & Level Std Dev													
AC Surface	12	10	12	9	12	8	11	5	12	9	12	10	
ATB			9	11	8	11				10	8	15	
PATB							8	11	7	8	11	22	
DGAB	9	13			10	12	13	17	13				
Rod & Level Min													
AC Surface	28	79	81	33	97	41	104	56	33	36	89	94	
ATB	0	0	201	290	86	178	0	0	0	79	185	277	
PATB	0	0	0	0	0	0	102	91	89	81	81	5	
DGAB	185	269	0	0	66	61	61	157	287	0	0	0	
Rod & Level Max													
AC Surface	94	124	137	91	147	74	152	86	74	74	142	142	
ATB	0	0	241	335	122	226	0	0	0	124	224	340	
PATB	0	0	0	0	0	0	137	147	127	119	122	117	
DGAB	218	333	0	0	119	117	119	257	368	0	0	0	
DGAB Material Requirements													
< 50% Passing #4 Sieve					51			50	47				
< 10 % Passing #200					11			12	10				
LL < 25													
PI < 4													
Max Lift Thickness < 6	5	5			5	5	5	5	5				
ATB Material Requirements													
Hveem													
Swell < 0.7 mm													
Stability > 35													
Marshall 50-blow													
Flow 2 - 5 mm													
Stability 4.4 kN													
Marshall 75-blow													
Flow 3 - 7.6 mm													
Stability 10 kN													
First lift thickness < 6 inches			4	4	4	4				4	4	4	
Sub lift thickness < 4			5	4		4					4	5	
PATB Material Requirements													
< 2% Passing #200									4				
2 - 2.5% Asphalt Content													
Roller type (Steel Wheel)							STEEL WHL TANDEM						
Drainage Location	3	3	3	3	3	3	1	1	1	1	1	1	
Drainage Type	1	1	1	1	1	1	6	6	6	6	6	6	
HMAC Binder Material Requirements													
Marshall													
75 blows	75		75	75	75	75	75	75	75	75	75	75	
Min Stability 8 kN													
Flow 2 mm - 4 mm													

Wisconsin (55)	113	114	115	116	117	118	119	120	121	122	123	124
Required Thickness												
AC Surface	102	178	178	102	178	102	178	102	102	102	178	178
ATB	0	0	203	305	102	203	0	0	0	102	203	305
PATB	0	0	0	0	0	0	102	102	102	102	102	102
DGAB	203	305	0	0	102	102	102	203	305	0	0	0
L05B Thickness												
AC Surface												
ATB												
PATB												
DGAB												
SPS Construction Thickness												
AC Surface	104	178	178	104					104		178	178
ATB	0	0	203	305					0		203	305
PATB	0	0	0	0					102		102	102
DGAB	203	305	46	20					305		0	0
Rod & Level												
AC Surface												
ATB												
PATB												
DGAB												
Rod & Level Std Dev												
AC Surface												
ATB												
PATB												
DGAB												
Rod & Level Min												
AC Surface												
ATB												
PATB												
DGAB												
Rod & Level Max												
AC Surface												
ATB												
PATB												
DGAB												
DGAB Material Requirements												
< 50% Passing #4 Sieve												
< 10 % Passing #200												
LL < 25												
PI < 4												
Max Lift Thickness < 6												
ATB Material Requirements												
Hveem												
Swell < 0.7 mm												
Stability > 35												
Marshall 50-blow												
Flow 2 - 5 mm												
Stability 4.4 kN												
Marshall 75-blow												
Flow 3 - 7.6 mm												
Stability 10 kN												
First lift thickness < 6 inches												
Sub lift thickness < 4												
PATB Material Requirements												
< 2% Passing #200							6					
2 - 2.5% Asphalt Content							5					
Roller type (Steel Wheel)												
Drainage Location	3	3	3	3	3	3	1	1	1			
Drainage Type	1	1	1	1	1	1	2	2	2			
HMAC Binder Material Requirements												
Marshall												
75 blows												
Min Stability 8 kN												
Flow 2 mm - 4 mm												

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