

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

June 2003

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Research and Development  
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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.

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Director, Office of Infrastructure  
Research and Development

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# Technical Report Documentation Page

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| <b>16. Abstract</b><br>The SPS-1 experiment entitled <i>Strategic Study of Structural Factors for Flexible Pavements</i> 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.<br><br>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.<br><br>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                              |                               |                             |                              |                                     | APPROXIMATE CONVERSIONS FROM SI UNITS |                              |             |                               |                     |
| Symbol                                                           | When You Know                 | Multiply By                 | To Find                      | Symbol                              | Symbol                                | When You Know                | Multiply By | To Find                       | Symbol              |
| <b>LENGTH</b>                                                    |                               |                             |                              | <b>LENGTH</b>                       |                                       |                              |             |                               |                     |
| in                                                               | inches                        | 25.4                        | millimeters                  | mm                                  | mm                                    | millimeters                  | 0.039       | inches                        | in                  |
| ft                                                               | feet                          | 0.305                       | meters                       | m                                   | m                                     | meters                       | 3.28        | feet                          | ft                  |
| yd                                                               | yards                         | 0.914                       | meters                       | m                                   | m                                     | meters                       | 1.09        | yards                         | yd                  |
| mi                                                               | miles                         | 1.61                        | kilometers                   | km                                  | km                                    | kilometers                   | 0.621       | miles                         | mi                  |
| <b>AREA</b>                                                      |                               |                             |                              | <b>AREA</b>                         |                                       |                              |             |                               |                     |
| in <sup>2</sup>                                                  | square inches                 | 645.2                       | square millimeters           | mm <sup>2</sup>                     | mm <sup>2</sup>                       | square millimeters           | 0.0016      | square inches                 | in <sup>2</sup>     |
| ft <sup>2</sup>                                                  | square feet                   | 0.093                       | square meters                | m <sup>2</sup>                      | m <sup>2</sup>                        | square meters                | 10.764      | square feet                   | ft <sup>2</sup>     |
| yd <sup>2</sup>                                                  | square yard                   | 0.836                       | square meters                | m <sup>2</sup>                      | m <sup>2</sup>                        | square meters                | 1.195       | square yards                  | yd <sup>2</sup>     |
| ac                                                               | acres                         | 0.405                       | hectares                     | ha                                  | ha                                    | hectares                     | 2.47        | acres                         | ac                  |
| mi <sup>2</sup>                                                  | square miles                  | 2.59                        | square kilometers            | km <sup>2</sup>                     | km <sup>2</sup>                       | square kilometers            | 0.386       | square miles                  | mi <sup>2</sup>     |
| <b>VOLUME</b>                                                    |                               |                             |                              | <b>VOLUME</b>                       |                                       |                              |             |                               |                     |
| fl oz                                                            | fluid ounces                  | 29.57                       | milliliters                  | mL                                  | mL                                    | milliliters                  | 0.034       | fluid ounces                  | fl oz               |
| gal                                                              | gallons                       | 3.785                       | liters                       | L                                   | L                                     | liters                       | 0.264       | gallons                       | gal                 |
| ft <sup>3</sup>                                                  | cubic feet                    | 0.028                       | cubic meters                 | m <sup>3</sup>                      | m <sup>3</sup>                        | cubic meters                 | 35.71       | cubic feet                    | ft <sup>3</sup>     |
| yd <sup>3</sup>                                                  | cubic yards                   | 0.765                       | cubic meters                 | m <sup>3</sup>                      | m <sup>3</sup>                        | cubic meters                 | 1.307       | cubic yards                   | yd <sup>3</sup>     |
| NOTE: volumes greater than 1000 shall be shown in m <sup>3</sup> |                               |                             |                              |                                     |                                       |                              |             |                               |                     |
| <b>MASS</b>                                                      |                               |                             |                              | <b>MASS</b>                         |                                       |                              |             |                               |                     |
| oz                                                               | ounces                        | 28.35                       | grams                        | g                                   | g                                     | grams                        | 0.035       | ounces                        | oz                  |
| lb                                                               | pounds                        | 0.454                       | kilograms                    | kg                                  | kg                                    | kilograms                    | 2.202       | pounds                        | lb                  |
| T                                                                | short tons<br>(2000 lb)       | 0.907                       | megagrams<br>(or metric ton) | Mg<br>(or t)                        | Mg<br>(or t)                          | megagrams<br>(or metric ton) | 1.103       | short tons<br>(2000 lb)       | T                   |
| <b>TEMPERATURE (exact degrees)</b>                               |                               |                             |                              | <b>TEMPERATURE (exact degrees)</b>  |                                       |                              |             |                               |                     |
| °F                                                               | Fahrenheit                    | 5 (F-32)/9<br>or (F-32)/1.8 | Celsius                      | °C                                  | °C                                    | Celsius                      | 1.8C+32     | Fahrenheit                    | °F                  |
| <b>ILLUMINATION</b>                                              |                               |                             |                              | <b>ILLUMINATION</b>                 |                                       |                              |             |                               |                     |
| fc                                                               | foot-candles                  | 10.76                       | lux                          | lx                                  | lx                                    | lux                          | 0.0929      | foot-candles                  | fc                  |
| fl                                                               | foot-Lamberts                 | 3.426                       | candela/m <sup>2</sup>       | cd/m <sup>2</sup>                   | cd/m <sup>2</sup>                     | candela/m <sup>2</sup>       | 0.2919      | foot-Lamberts                 | fl                  |
| <b>FORCE and PRESSURE or STRESS</b>                              |                               |                             |                              | <b>FORCE and PRESSURE or STRESS</b> |                                       |                              |             |                               |                     |
| lbf                                                              | poundforce                    | 4.45                        | newtons                      | N                                   | N                                     | newtons                      | 0.225       | poundforce                    | lbf                 |
| lbf/in <sup>2</sup>                                              | poundforce per<br>square inch | 6.89                        | kilopascals                  | kPa                                 | kPa                                   | kilopascals                  | 0.145       | poundforce per<br>square inch | lbf/in <sup>2</sup> |

\*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

## 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—Weighing-In-Motion

### SPS-1 Project Name Abbreviations

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

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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.<sup>(1)</sup> 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.<sup>(2,3)</sup> 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 21<sup>st</sup> 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<br>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<br>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<br>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

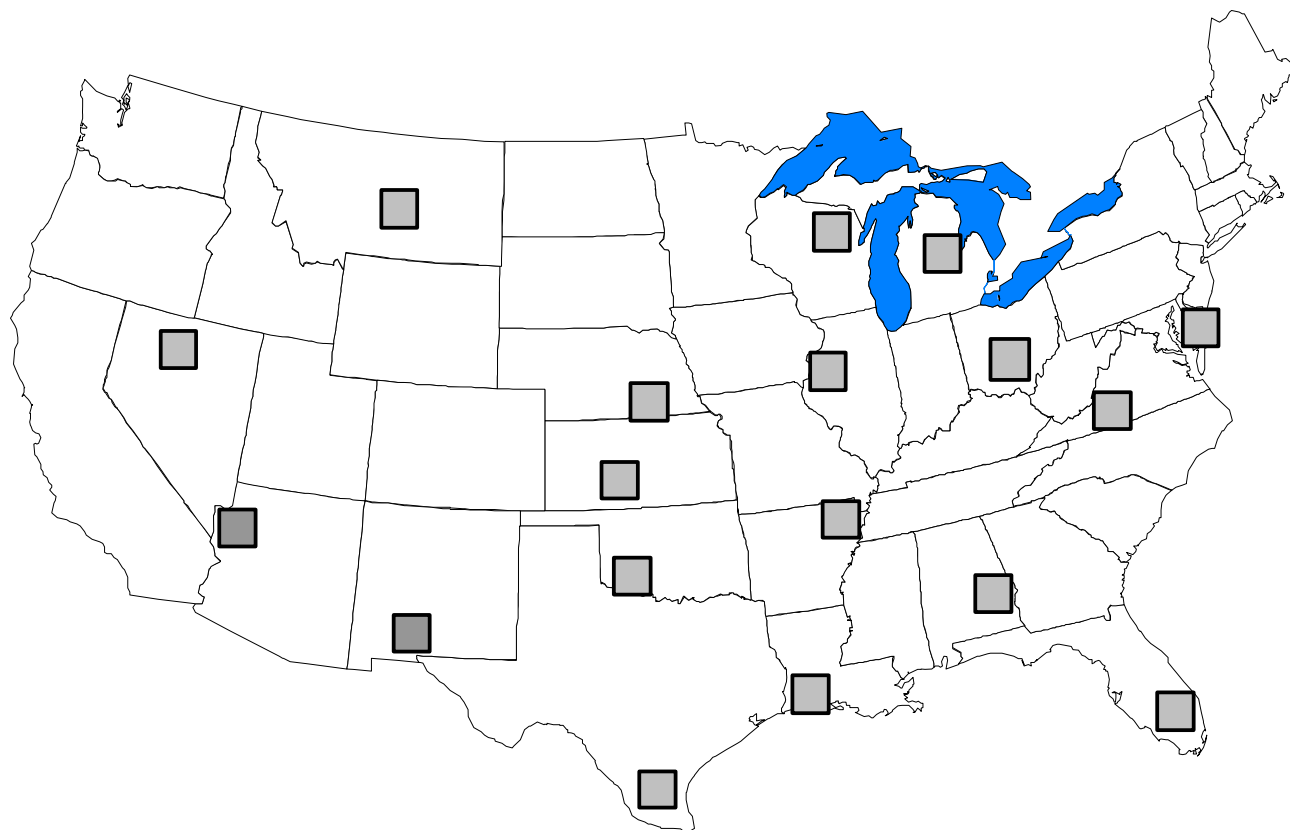


Figure 1. Location of the SPS-1 projects.

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<br>(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<br>IA(1)—7.0<br>OH(2)—4.6 | Site Cell 2.A              | Site Cell 3.A<br>KS(6)—5.8 | Site Cell 4.A<br>NM(0)—3.7              |
|                    | Cells 13–24                              | Site Cell 1.B<br>MI(1)—4.0<br>VA(1)—3.7 | Site Cell 2.B              | Site Cell 3.B<br>NB(1)—4.1 | Site Cell 4.B<br>OK(2)—2.1<br>TX(8)—2.3 |
| Coarse-Grained     | Cells 1–12                               | Site Cell 5.A<br>DE(2)—3.2              | Site Cell 6.A<br>FL(1)—3.7 | Site Cell 7.A<br>NV(0)—4.0 | Site Cell 8.A                           |
|                    | Cells 13–24                              | Site Cell 5.B<br>WI(0)—1.8              | Site Cell 6.B<br>AR(1)—5.7 | Site Cell 7.B<br>MT(0)—0.8 | Site Cell 8.B<br>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*.<sup>(4)</sup> 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.<sup>(4)</sup> 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.<sup>(5)</sup> 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.<sup>(6)</sup> 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 $\geq 1.2$ m)<br>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 $\geq 1.2$ 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:<br>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:<br>Specific Gravity:                                      |               |                                |
| Coarse Aggregate                                                               | P11           | 3                              |
| Fine Aggregate                                                                 | P12           | 3                              |
| Gradation of Aggregate                                                         | P14           | 3                              |
| National Aggregate Association (NAA) Test for<br>Fine Aggregate Particle Shape | P14A          | 3                              |
| Asphalt Cement:                                                                | P21           | 3                              |
| Absorption 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:                                                                |               |                                |
| Absorption 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.<sup>(5)</sup> 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.<sup>(7)</sup> 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.<sup>(8)</sup> 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.”<sup>(9)</sup> 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).<sup>(10)</sup> 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, PROF CAL 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.

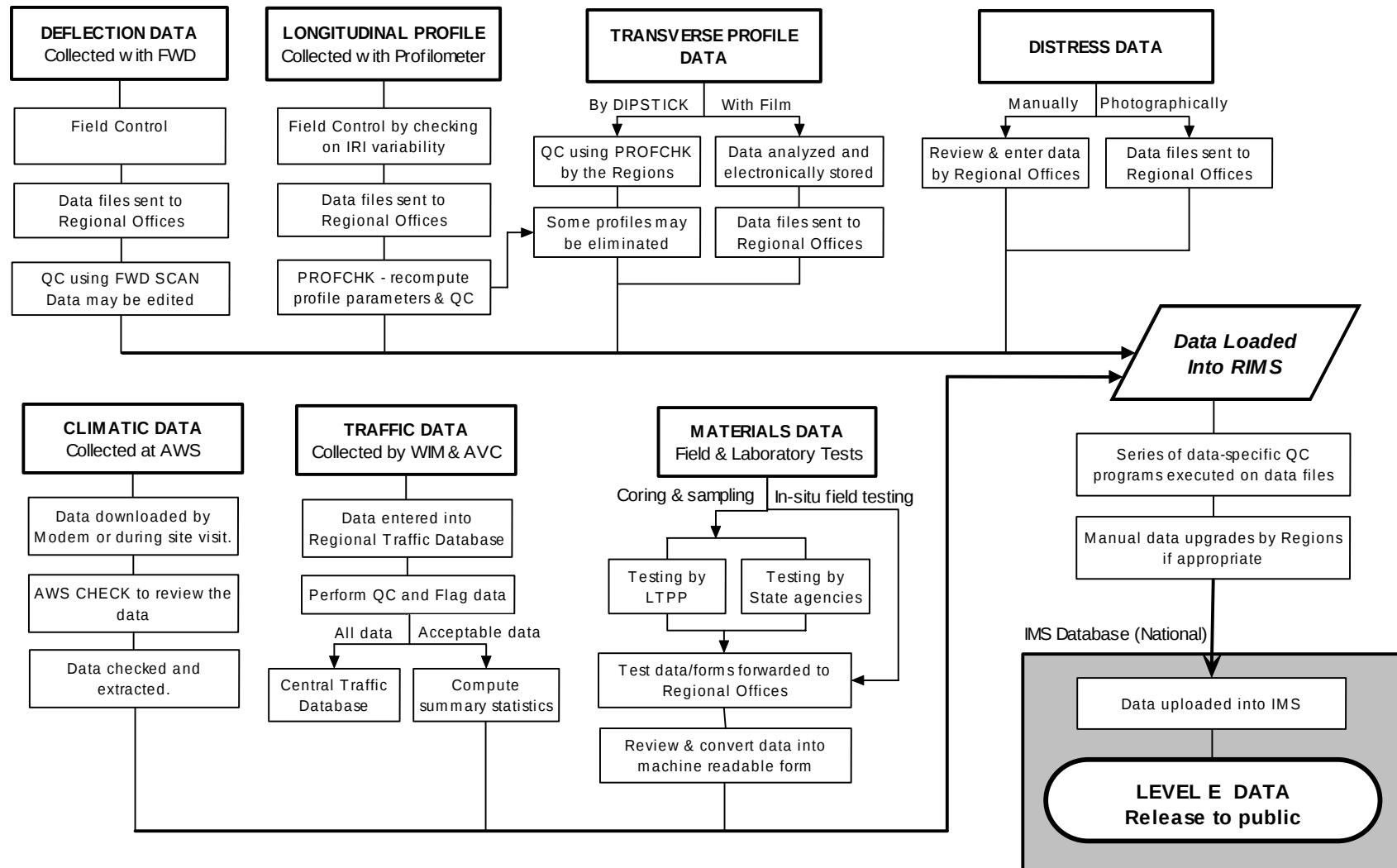


Figure 2. LTPP data collection and data movement flowchart.

- **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               |             | X             |
|                                 | Daily Min Temp                            |                 |                 |             | X             |
|                                 | Daily Mean Temp                           |                 |                 |             | X             |
|                                 | Maximum Avg Monthly Humidity              |                 |                 |             | X             |
|                                 | Minimum Avg Monthly Humidity              |                 |                 |             | X             |
|                                 | Monthly Precipitation                     |                 |                 |             |               |
|                                 | 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 Max Monthly Temp                      |                 |                 | X           |               |
|                                 | Days >32 °C                               |                 |                 | X           |               |
|                                 | Days <0 °C                                |                 |                 | 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               |             | X             |
|                                 | Minimum Avg Annual Humidity               |                 |                 |             | X             |
|                                 | Annual Precipitation                      |                 |                 |             |               |
|                                 | 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 °C                                |                 |                 | X           |               |
|                                 | Days <0 °C                                |                 |                 | 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               |             | X             |
|                                 | Temp at Testing                           | 94              | X               |             |               |
|                                 | Backcalculated Modulus                    | –               | X               |             |               |
|                                 | Manual Distress                           | 100             | X               |             |               |
|                                 | PASCO Distress                            | 50              | X               |             |               |
|                                 | Friction                                  | 38              |                 |             |               |
|                                 | Longitudinal Profile                      | 100             | X               |             |               |
|                                 | Transverse Profile                        | 89              | X               |             |               |
| Construction                    | Layer Thickness                           | 94              | X               | X           | X             |
|                                 | Rod and Level Thickness                   | 78              |                 |             |               |
|                                 | Asphalt Grade                             | 72              |                 |             |               |
|                                 | Aggregate Type                            | 67              |                 |             |               |
|                                 | Specific Gravity of Aggregate             | 56              |                 |             |               |
|                                 | Compaction of the Asphalt                 | 78              |                 |             |               |
|                                 | Laydown Temp                              | 72              |                 |             |               |
|                                 | In Situ Density of Bound Layers           | 33              |                 |             |               |
|                                 | Mix Design Air Voids                      | 67              |                 |             |               |
|                                 |                                           |                 |                 |             |               |

\*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 Cohesimeter                            | 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<sup>(11)</sup> and Construction Guidelines<sup>(12)</sup> 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<br>Soil Type | From TST L05B                           |              |           | From<br>SPS1 LAYER table |
|-------|------------------------|-----------------------------------------|--------------|-----------|--------------------------|
|       |                        | Soil Type                               | No. Sections | Class.OK? |                          |
| 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 <sup>(1)</sup> | ?                      |
|               |                | 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 <sup>(2)</sup> | 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 <sup>(3)</sup> | ?                      |
|               |                | NV         | Clayey Sand           | 223                         | 9.7                      | 156                 | 4.0        | 0 <sup>(4)</sup> | 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 °C-days would be classified as a freezing climate and those with less than 60 °C-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<sup>®</sup> for designating the site as wet or dry. A freezing index value of 60 °C-days was used to determine whether the site falls into a no-freeze or freeze cell while a different value is used in DATAPAVE.

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 °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.<sup>(4)</sup> 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.

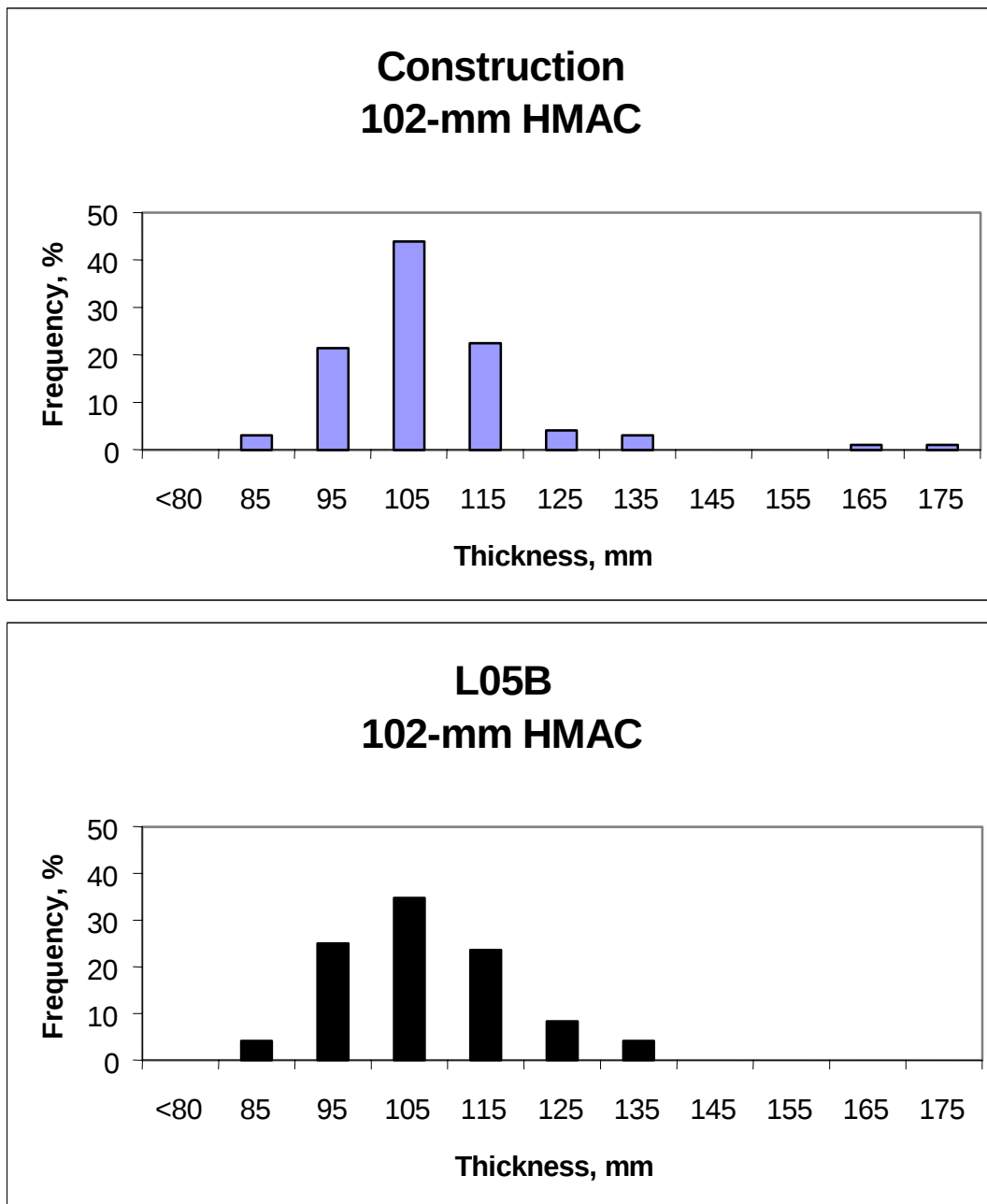


Figure 3. Thickness histograms for the thin HMA layer (102 mm) from tables SPS1\_LAYER (construction data) and TST\_L05B.

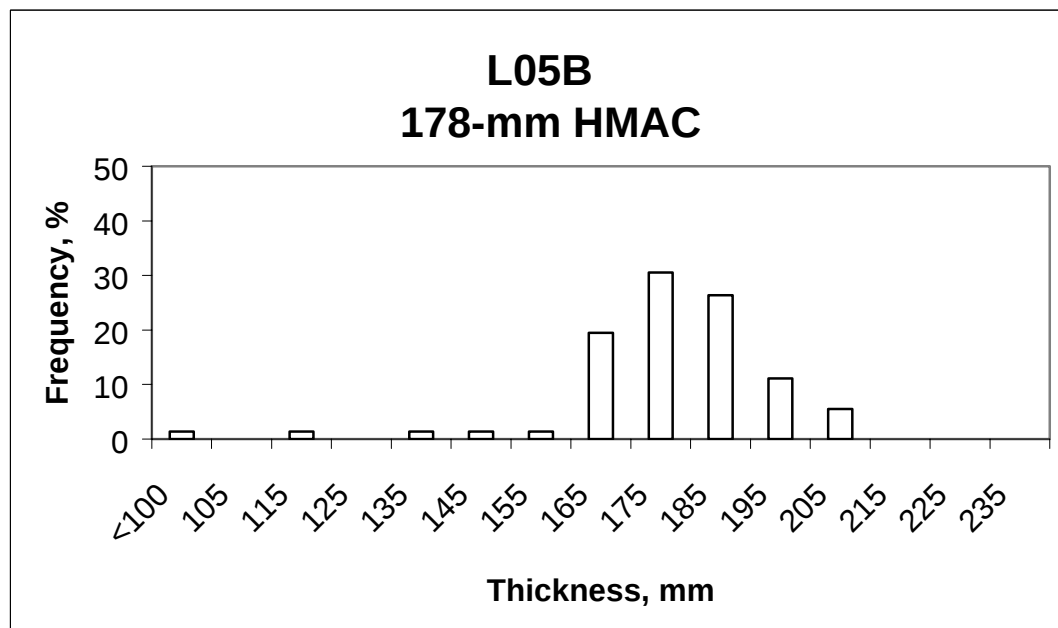
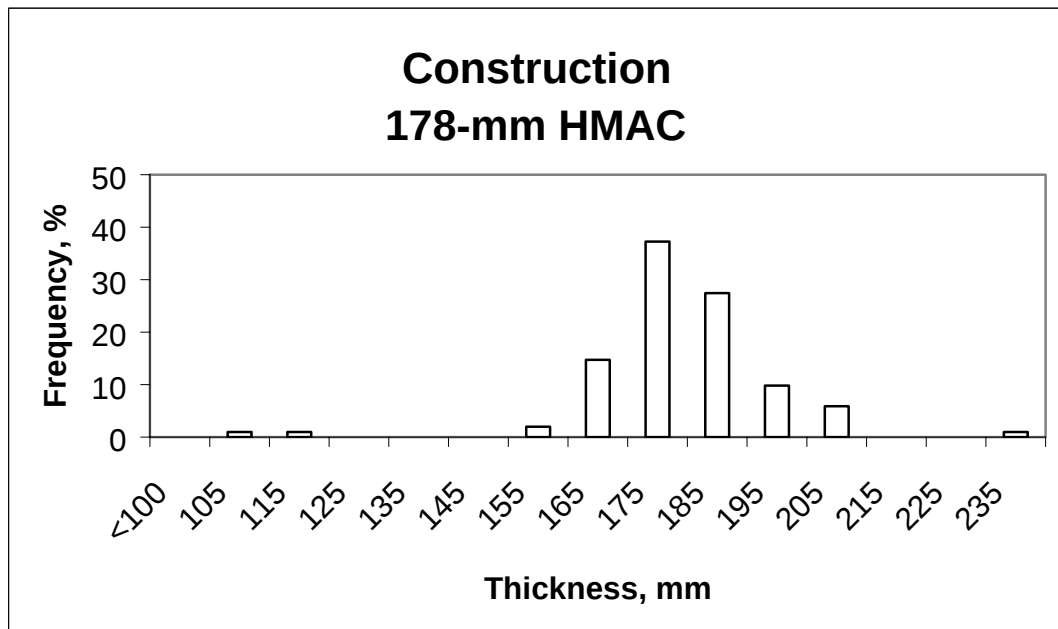


Figure 4. Thickness histograms for the thick HMA layer (178 mm) from tables SPS1\_LAYER (construction data) and TST\_L05B.

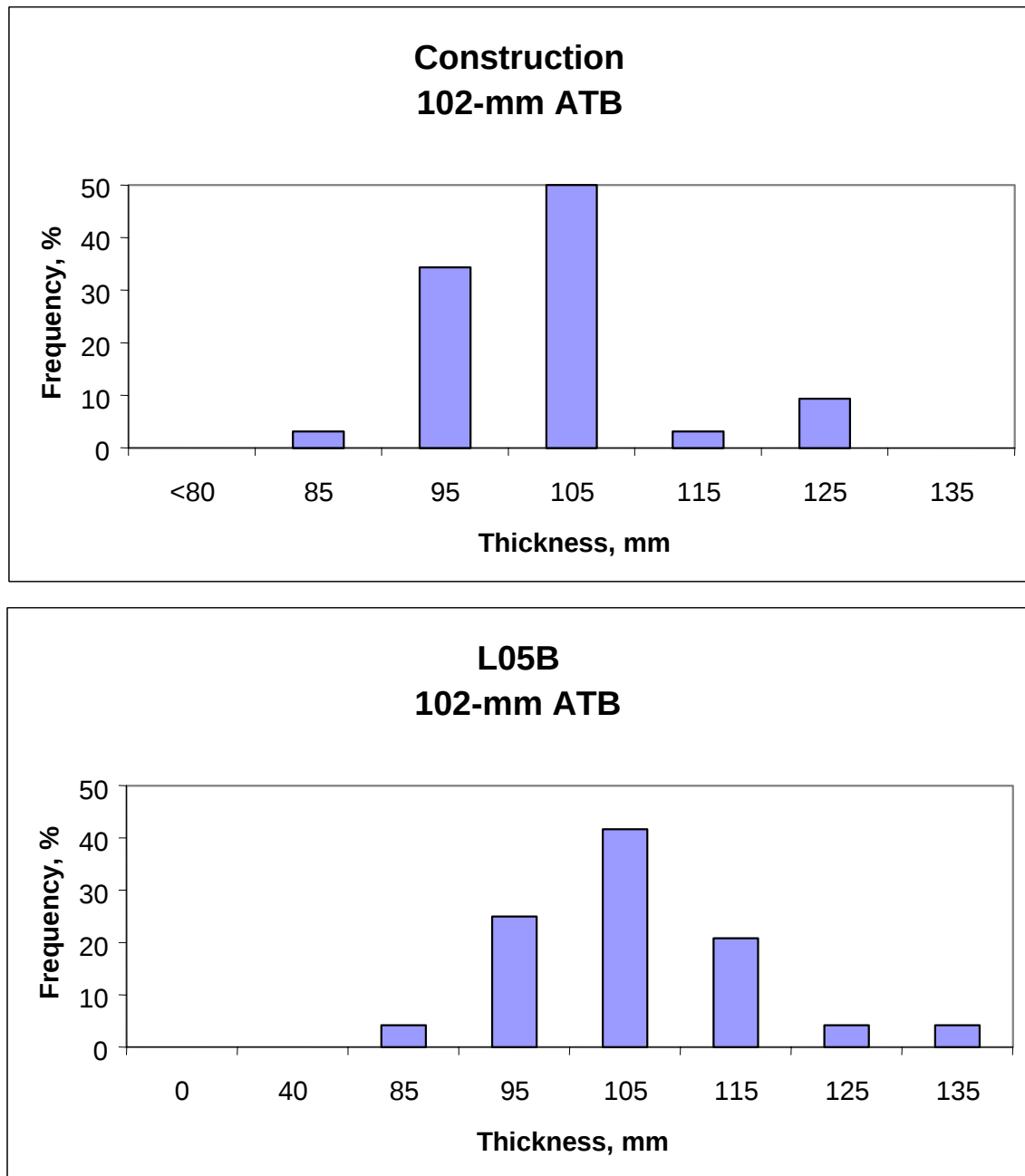


Figure 5. Thickness histograms for the thin ATB layer (102 mm) from tables SPS1\_LAYER (construction data) and TST\_L05B.

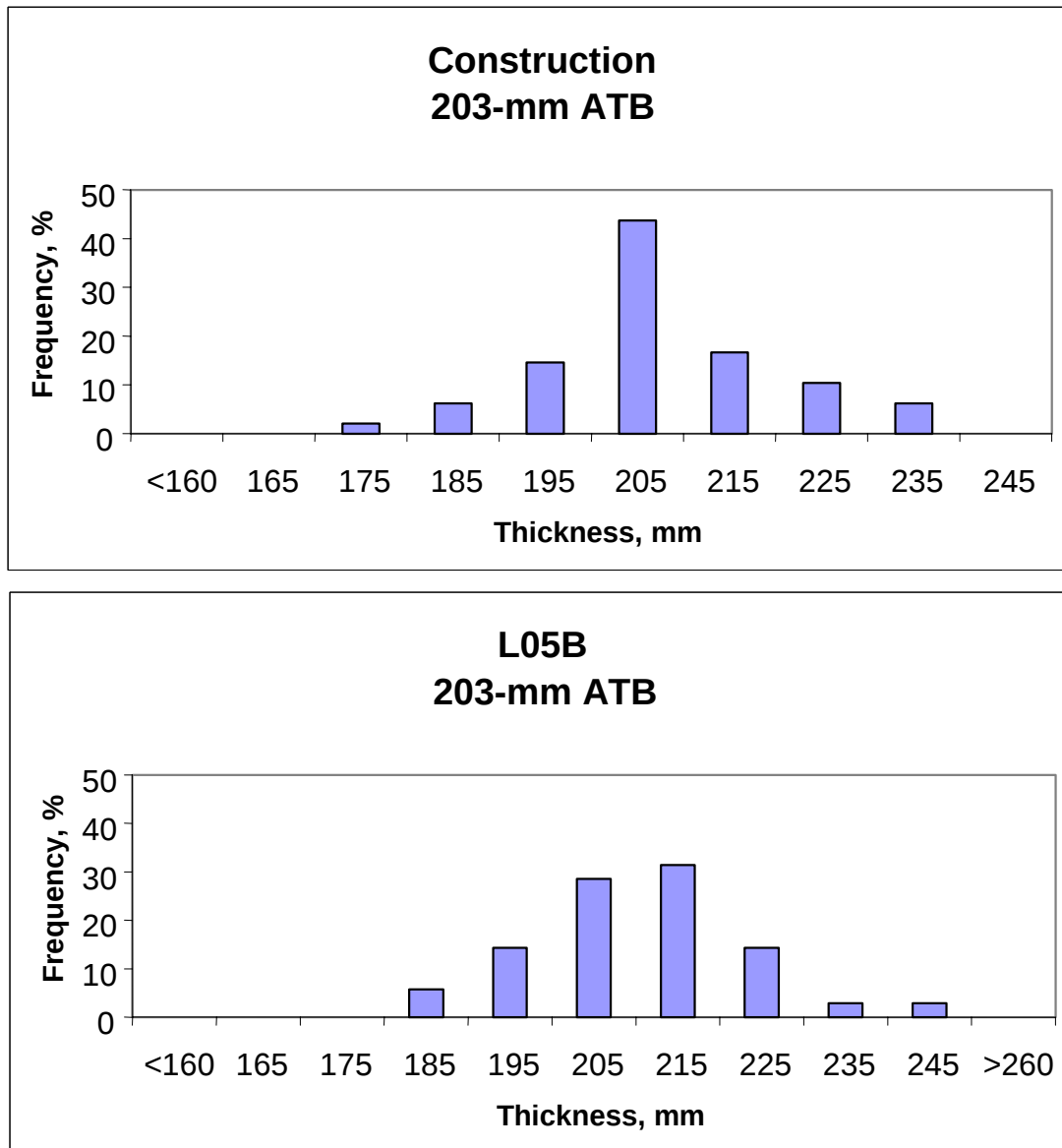


Figure 6. Thickness histograms for the thick ATB layer (203 mm) from tables SPS1\_LAYER (construction data) and TST\_L05B.

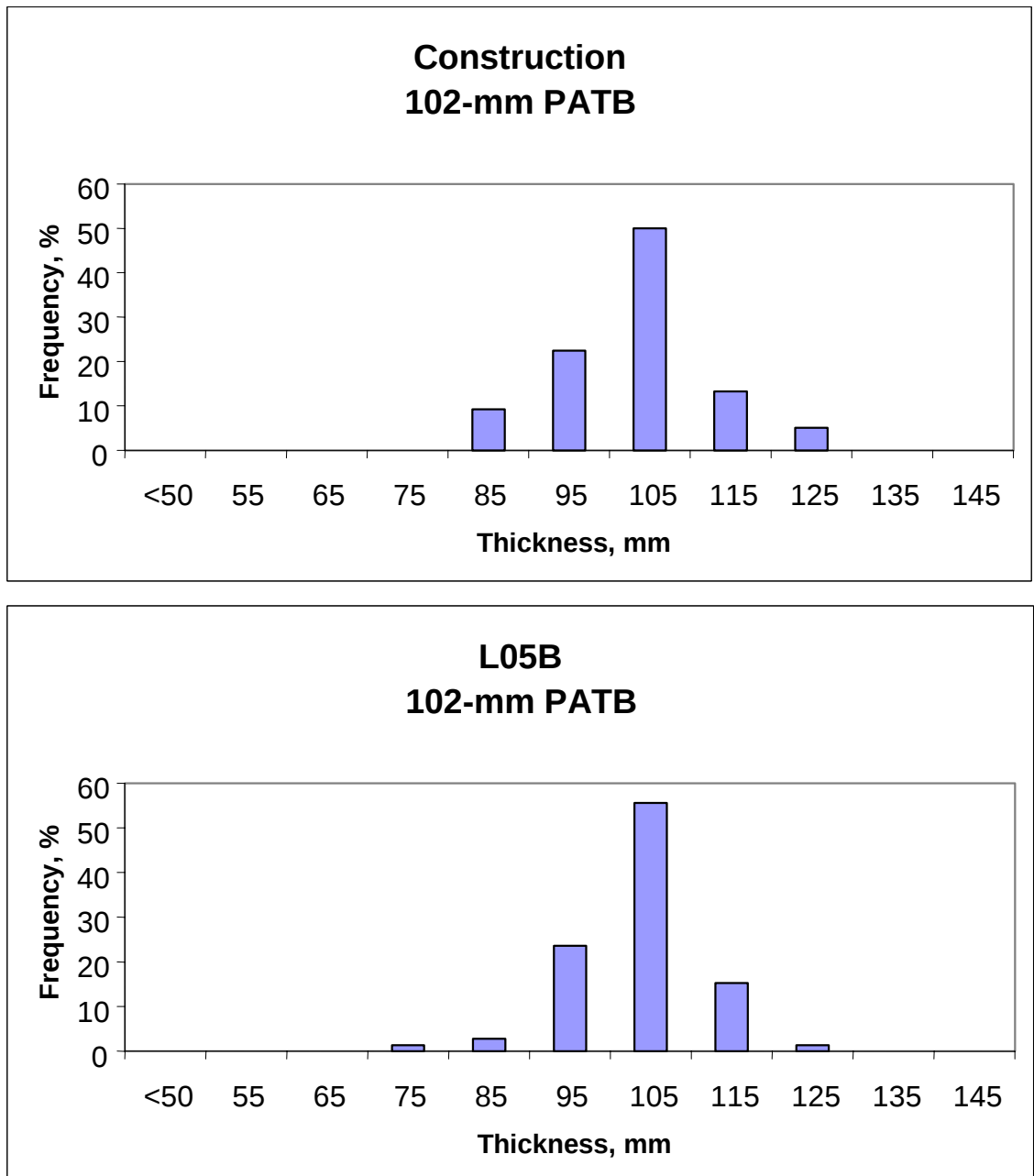


Figure 7. Thickness histograms for the PATB layer from tables SPS1\_LAYER (construction data) and TST\_L05B.

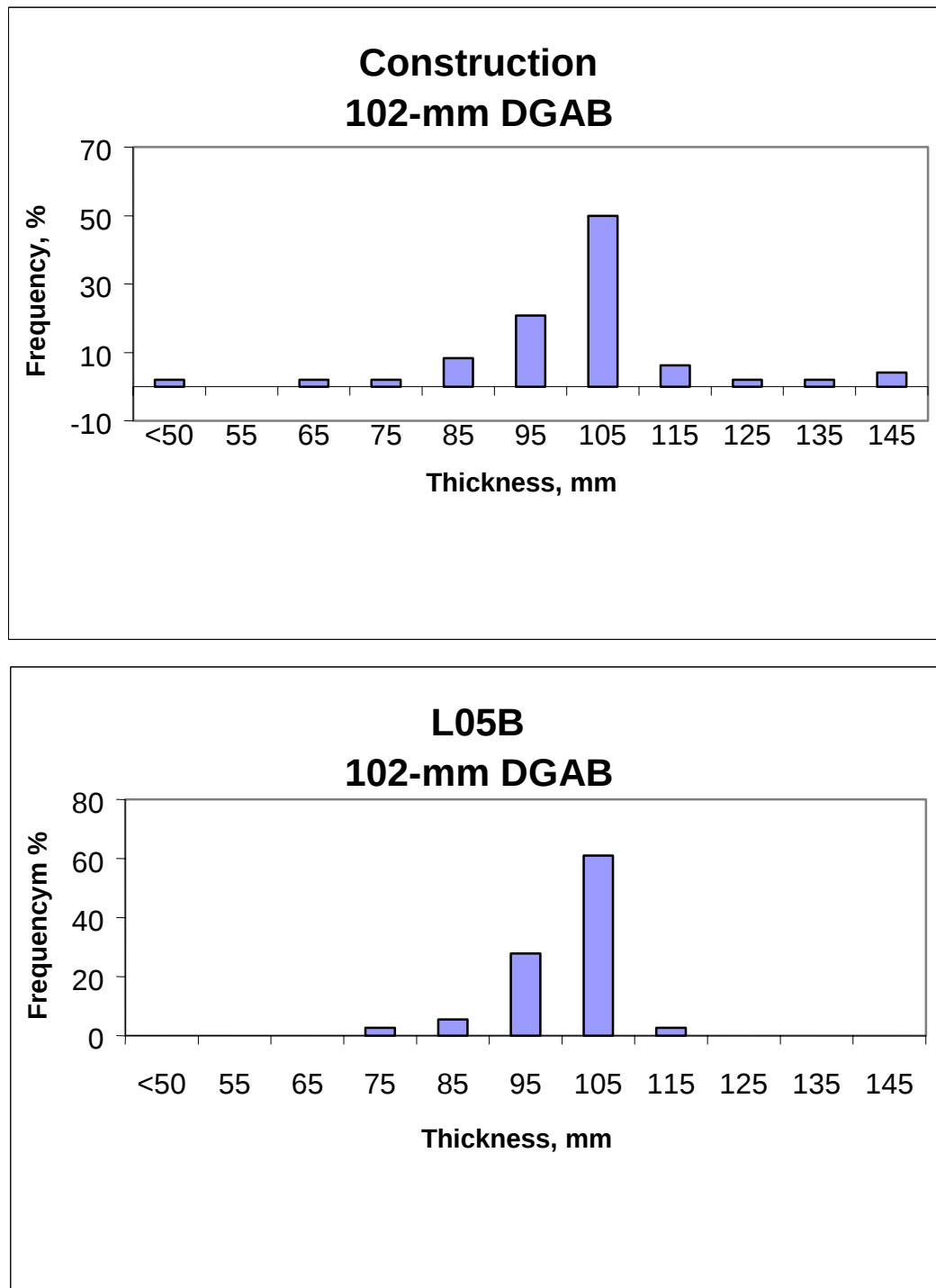


Figure 8. Thickness histograms for the 102-mm DGAB layer from tables SPS1\_LAYER (construction data) and TST\_L05B.

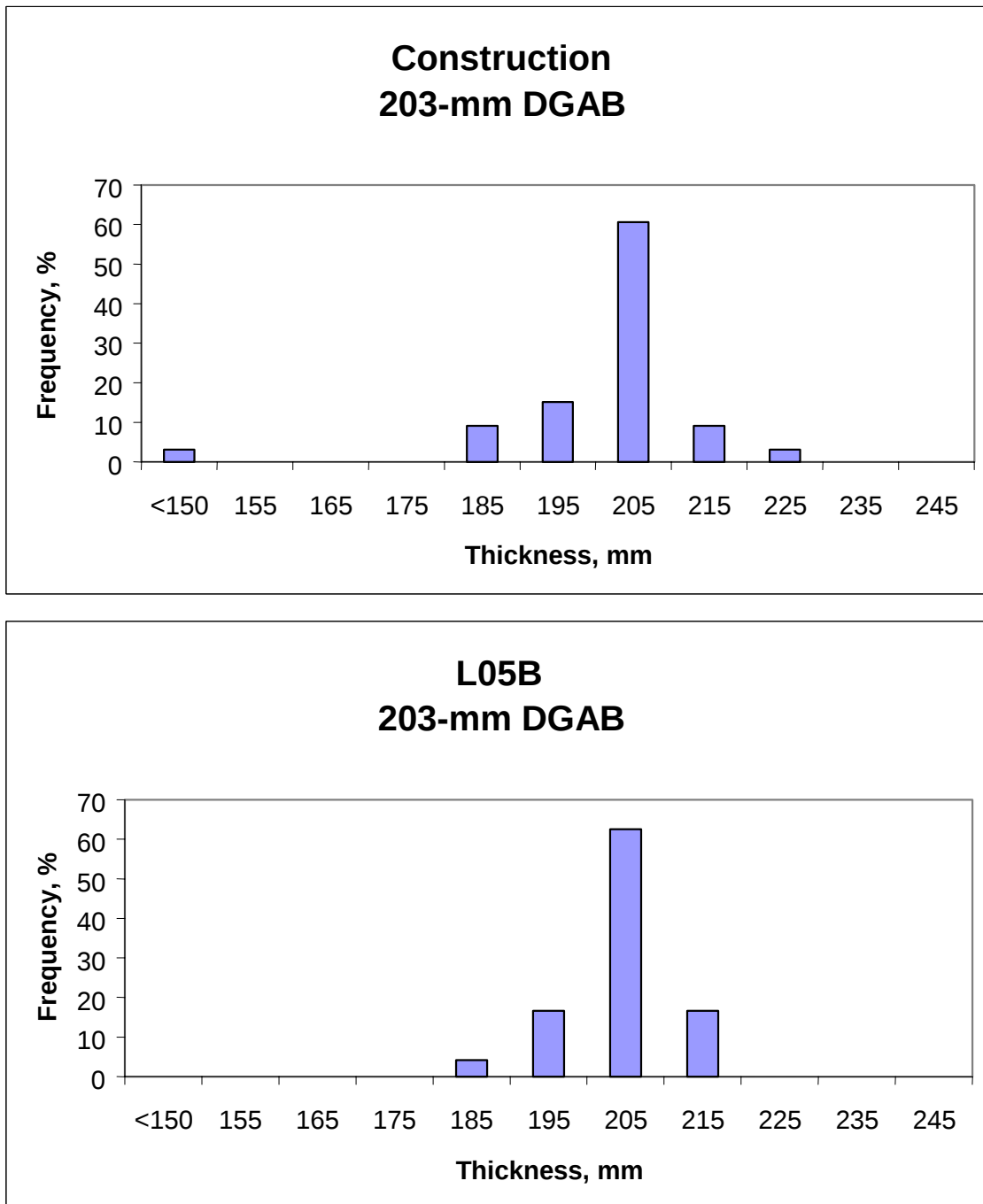


Figure 9. Thickness histograms for the 203-mm DGAB layer from tables SPS1\_LAYER (construction data) and TST\_L05B.

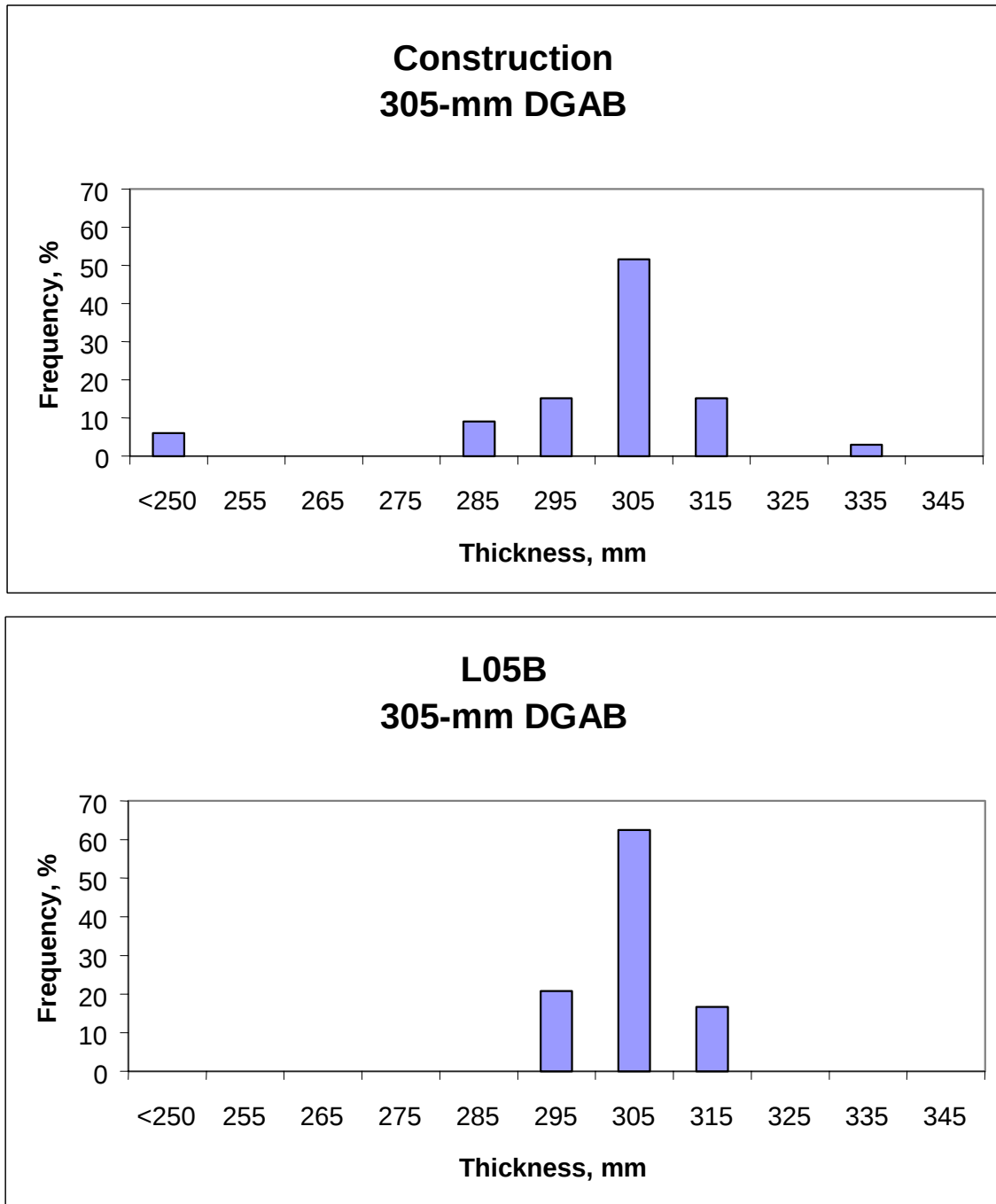


Figure 10. Thickness histograms for the 305-mm DGAB layer from tables SPS1\_LAYER (construction data) and TST\_L05B.

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—<br>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.<br>Bulk/Rice | Asphalt<br>Content | Moisture<br>Suscep. | Gradation | AC<br>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.<br>Bulk/Rice | Asphalt<br>Content | Moisture<br>Suscep. | Gradation | AC<br>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.

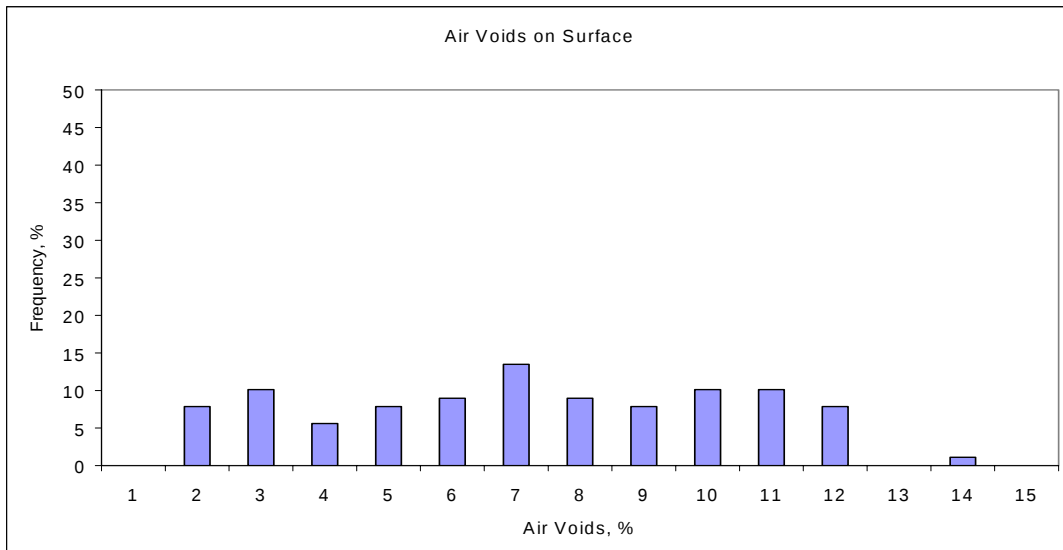


Figure 11. Histogram of air voids measured on the HMA surface layer.

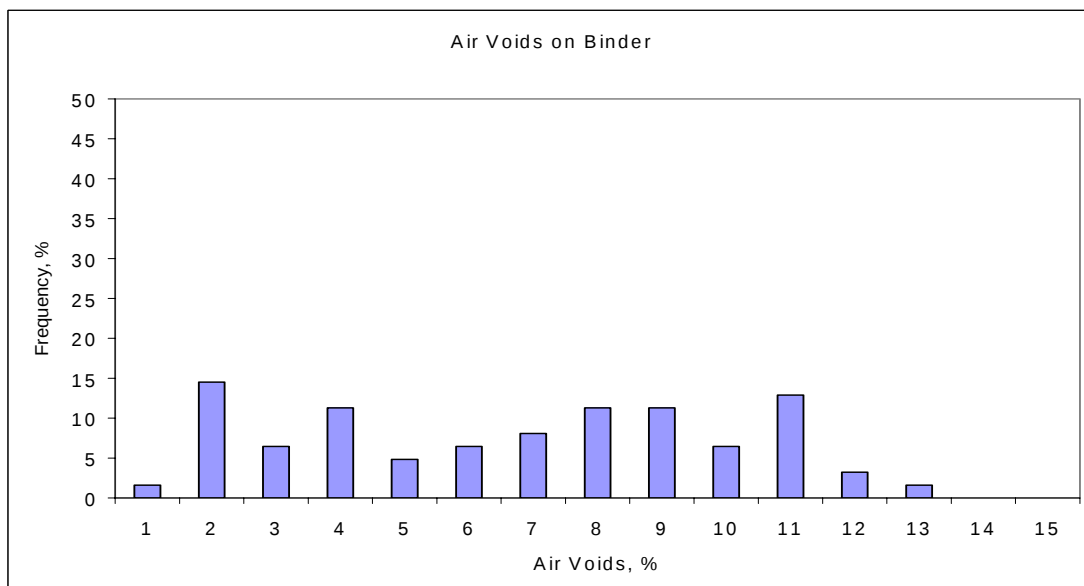


Figure 12. Histogram of air voids measured on the HMA binder layer.

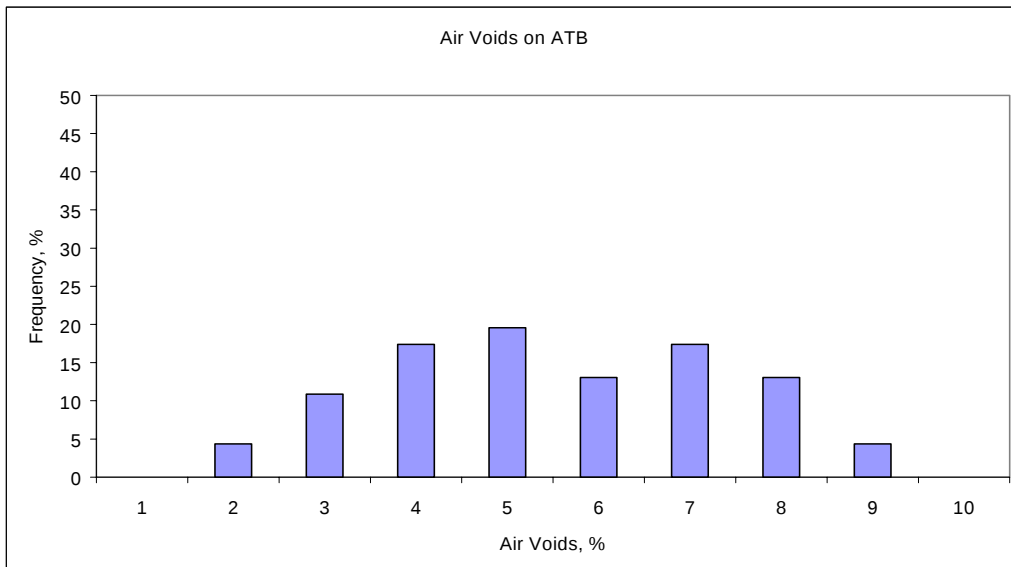


Figure 13. Histogram of air voids measured on the ATB layer.

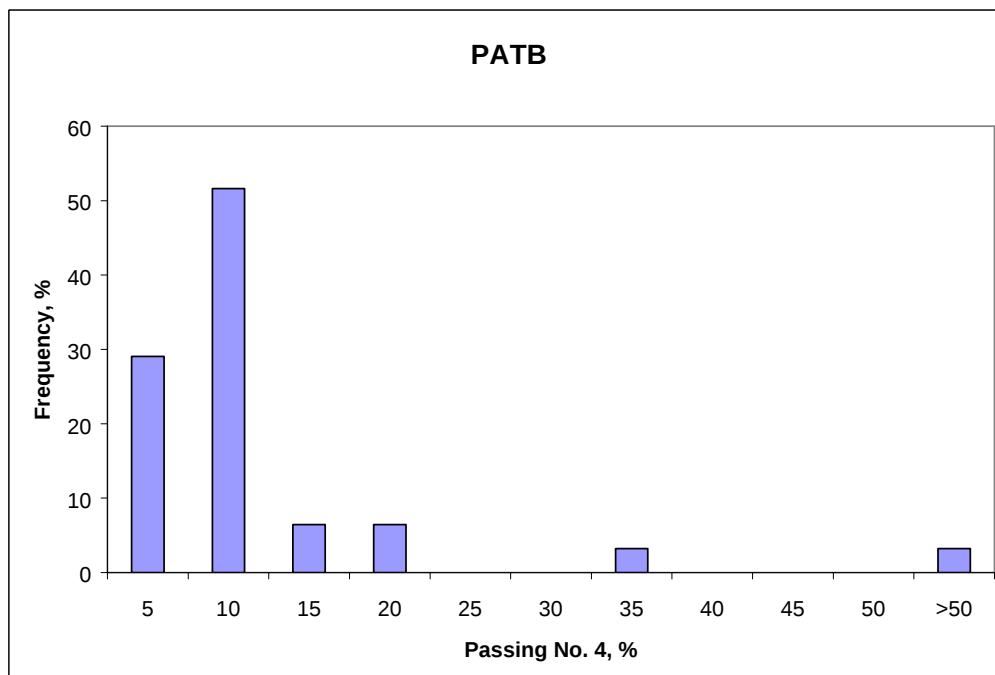


Figure 14. Histogram of the material passing the number 4 sieve, PATB layer.

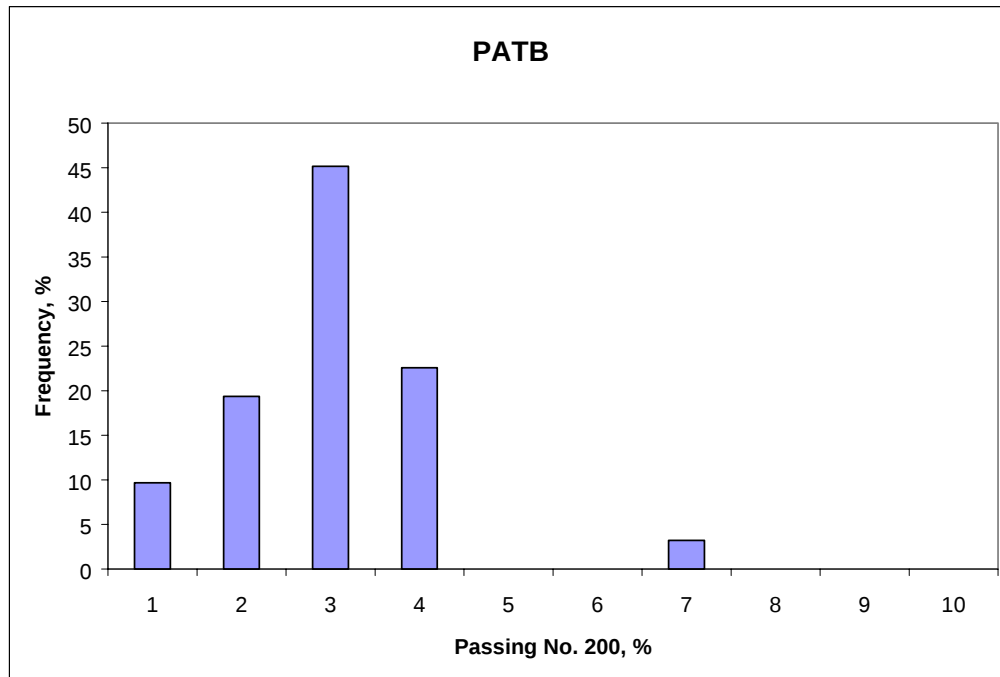


Figure 15. Histogram of material passing the number 200 sieve, PATB layer.

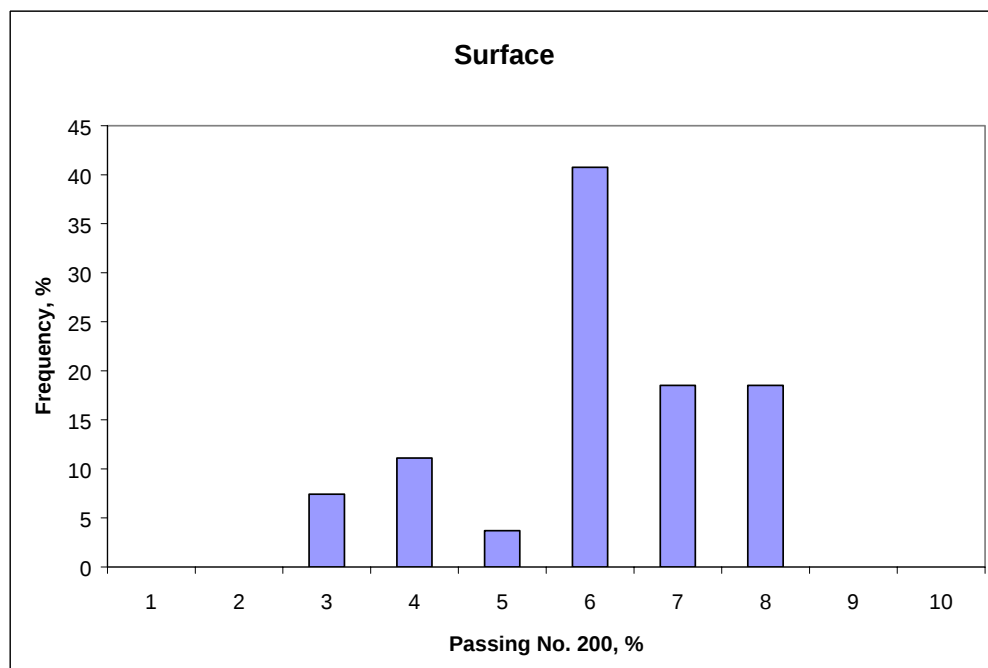


Figure 16. Histogram of material passing the number 200 sieve, HMA surface layer.

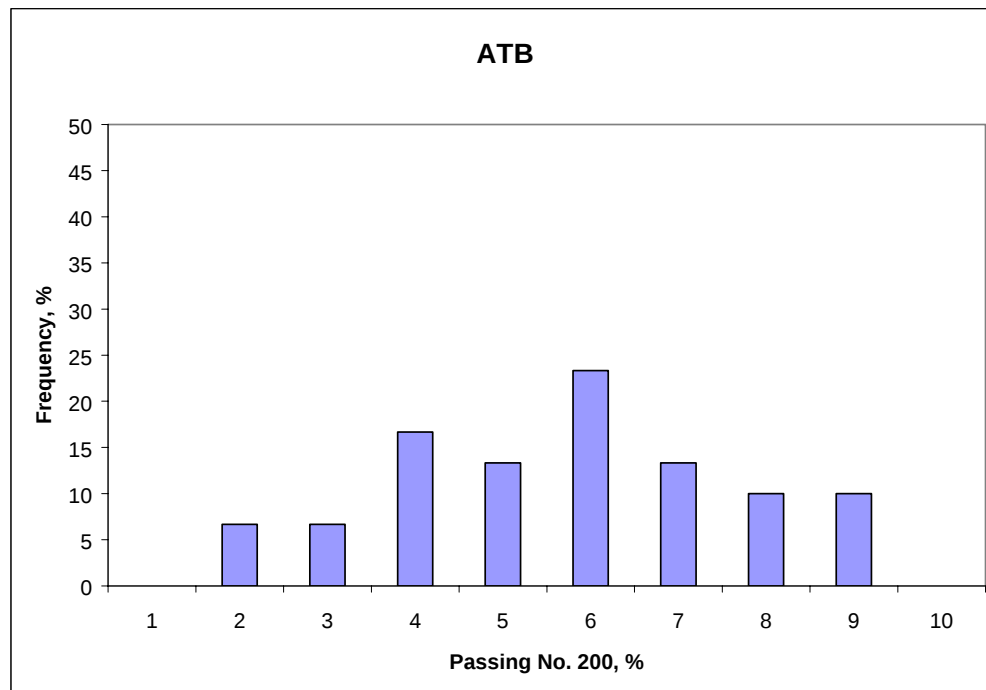


Figure 17. Histogram of material passing the number 200 sieve, ATB layer.

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 <sup>(1)</sup> |
| 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 <sup>(2)</sup>    | 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 <sup>(3)</sup>    | 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<br>(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    | <ul style="list-style-type: none"> <li>Mechanical problem with paver; construction joint placed in Section 010111.</li> <li>Deformations occurred on top of the PATB.</li> <li>DGAB contained excess minus 200 material.</li> </ul>                                                                                                                                                                                             | 2             |
| Arizona    | <ul style="list-style-type: none"> <li>Rain delays during subgrade preparation.</li> <li>Fill material pumped, but was replaced prior to paving.</li> <li>Section 0122 included a layer of DGAB below the PATB.</li> <li>DGAB for sections 0119 and 0122 did not meet the gradation requirements.</li> </ul>                                                                                                                    | 5             |
| Arkansas   | <ul style="list-style-type: none"> <li>Rain caused construction delays, but surfaces were allowed to dry prior to resuming construction.</li> <li>DGAB thickness on section 0114 was less than half of the required value. Many other sections were also less than the design value.</li> <li>The stability of the HMA mixture was less than the specified value.</li> </ul>                                                    | 3             |
| Delaware   | <ul style="list-style-type: none"> <li>High water table along the project.</li> <li>Ditches were shallow, so outlets of edge drains were not placed at the 76-m spacing.</li> <li>The number 4 sieve from the gradation tests for the HMA surface did not meet the project specifications.</li> </ul>                                                                                                                           | 3             |
| Florida    | <ul style="list-style-type: none"> <li>Rain delays caused the DGAB to be reworked multiple times.</li> <li>The number 4 sieve from the gradation tests for the HMA surface and binder layers did not meet the project specification.</li> </ul>                                                                                                                                                                                 | 3             |
| Iowa       | <ul style="list-style-type: none"> <li>Multiple rain delays, but surfaces were allowed to dry and were reworked.</li> <li>PATB “rolled out” on the sides, which resulted in the placement of an extra lift to meet the thickness requirement.</li> <li>The number 4 sieve from the gradation tests for the HMA binder layer exceeded the project requirements.</li> </ul>                                                       | 4             |
| Kansas     | <ul style="list-style-type: none"> <li>Excessive moisture in the subbase, which caused difficulty in compacting the material.</li> <li>Fly ash was added to the subbase layer for stabilization purposes.</li> </ul>                                                                                                                                                                                                            | 4             |
| Louisiana  | <ul style="list-style-type: none"> <li>Test sections for thickness cells 1 to 12 rather than 13 to 24 were built.</li> <li>Rain delays.</li> <li>Subgrade was stabilized with cement.</li> <li>Fabric did not meet overlay requirements.</li> <li>Aggregate in drainage trenches contained fines.</li> <li>DGAB was compacted in one lift.</li> <li>Select material was used at site to achieve the final elevation.</li> </ul> | 2             |
| Michigan   | <ul style="list-style-type: none"> <li>No construction report was available for review.</li> </ul>                                                                                                                                                                                                                                                                                                                              | 3             |
| Montana    | <ul style="list-style-type: none"> <li>Recently constructed.</li> </ul>                                                                                                                                                                                                                                                                                                                                                         | 0             |
| Nebraska   | <ul style="list-style-type: none"> <li>Three test sections were constructed over culverts.</li> <li>Rain delays.</li> <li>The minus 200 material for the PATB exceeded the project requirements.</li> </ul>                                                                                                                                                                                                                     | 4             |
| Nevada     | <ul style="list-style-type: none"> <li>Plant breakdown occurred while placing the PATB for test section 320110.</li> <li>The DGAB contained excess minus 200 materials.</li> </ul>                                                                                                                                                                                                                                              | 4             |
| New Mexico | <ul style="list-style-type: none"> <li>HMA facility breakdown.</li> <li>High air voids reported in the ATB prior to plant breakdown.</li> <li>Localized tenderness problem noted.</li> </ul>                                                                                                                                                                                                                                    | 3             |
| Ohio       | <ul style="list-style-type: none"> <li>Fill material placed on all sections.</li> <li>DGAB thickness was much larger than the planned thickness.</li> <li>The number 4 sieve for the HMA surface did not meet the project requirements.</li> </ul>                                                                                                                                                                              | 4             |
| Oklahoma   | <ul style="list-style-type: none"> <li>The number 4 sieve for the HMA surface did not meet the project requirements.</li> <li>One of the two ATB lifts exceeded the project thickness requirements.</li> </ul>                                                                                                                                                                                                                  | 2             |
| Texas      | <ul style="list-style-type: none"> <li>Transverse interceptor drains not installed along the project.</li> </ul>                                                                                                                                                                                                                                                                                                                | 3             |
| Virginia   | <ul style="list-style-type: none"> <li>Subgrade treated with cement.</li> <li>The number 4 sieve for the HMA surface did not meet the project requirements.</li> </ul>                                                                                                                                                                                                                                                          | 4             |
| Wisconsin  | <ul style="list-style-type: none"> <li>Recently constructed.</li> </ul>                                                                                                                                                                                                                                                                                                                                                         | 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.

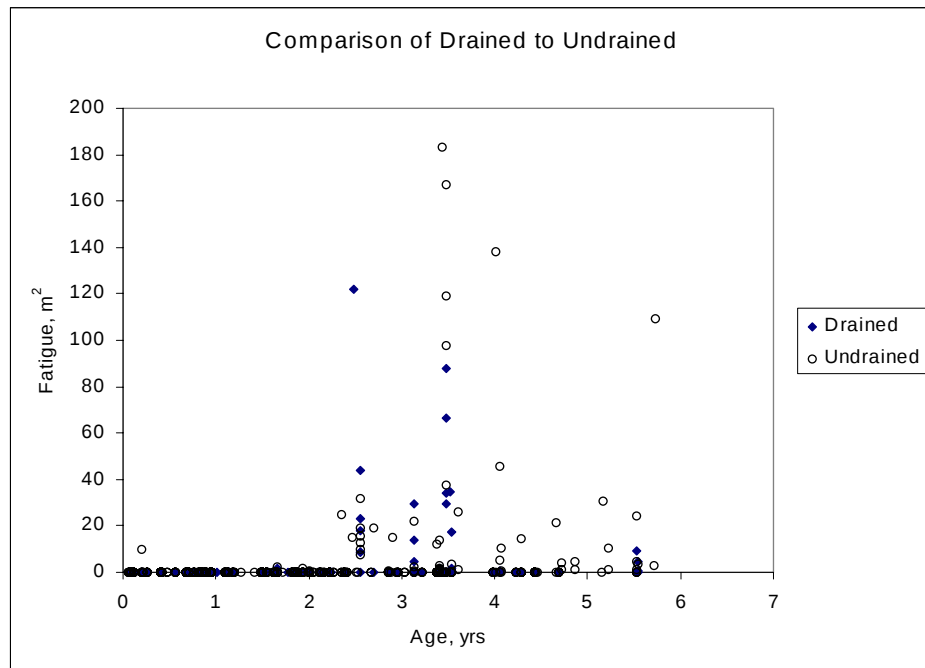


Figure 18. Area of fatigue cracking measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined.

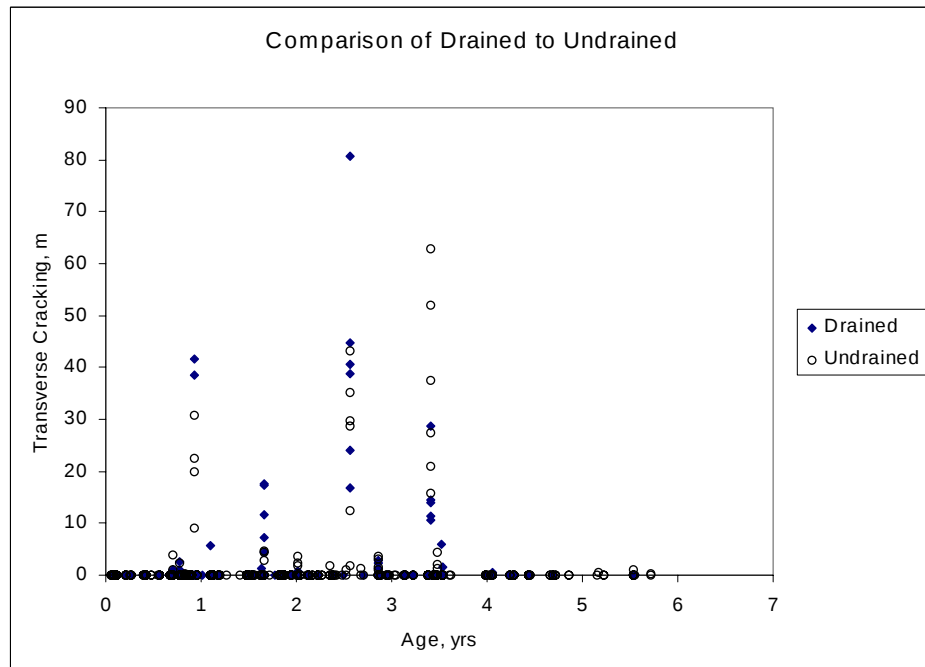


Figure 19. Total length of transverse cracks measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined.

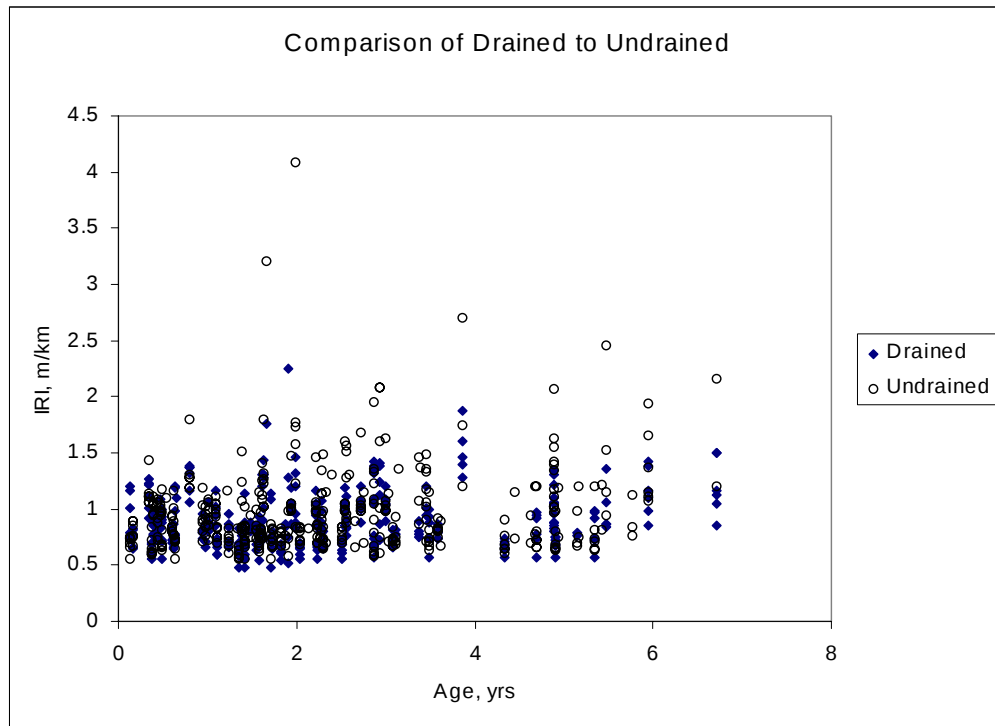


Figure 20. IRI values measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined.

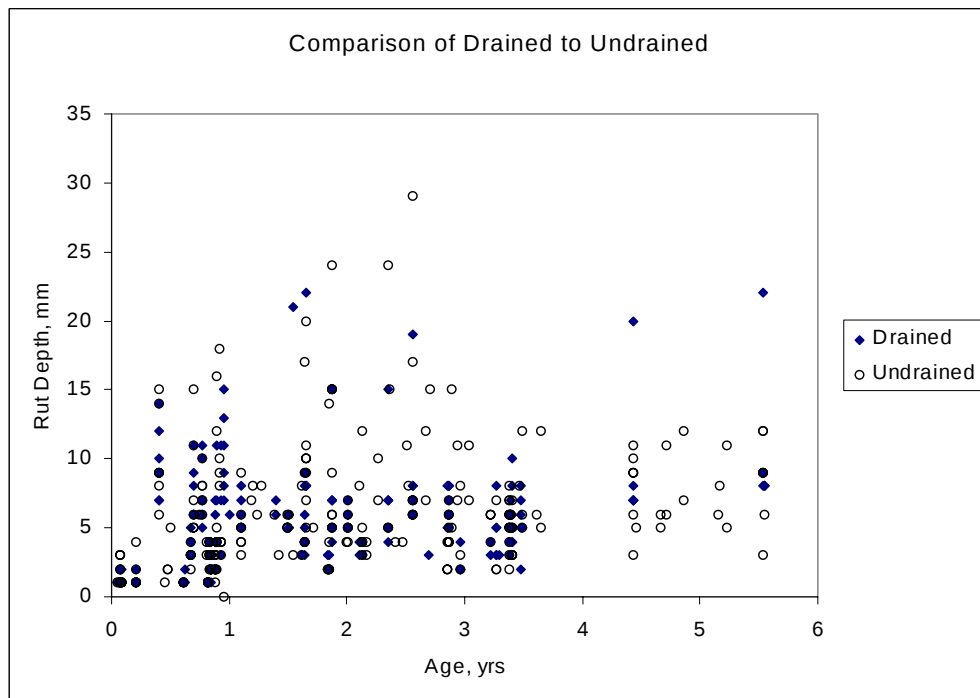


Figure 21. Rut depths measured over time comparing test sections with and without permeable base layers for all SPS-1 projects combined.

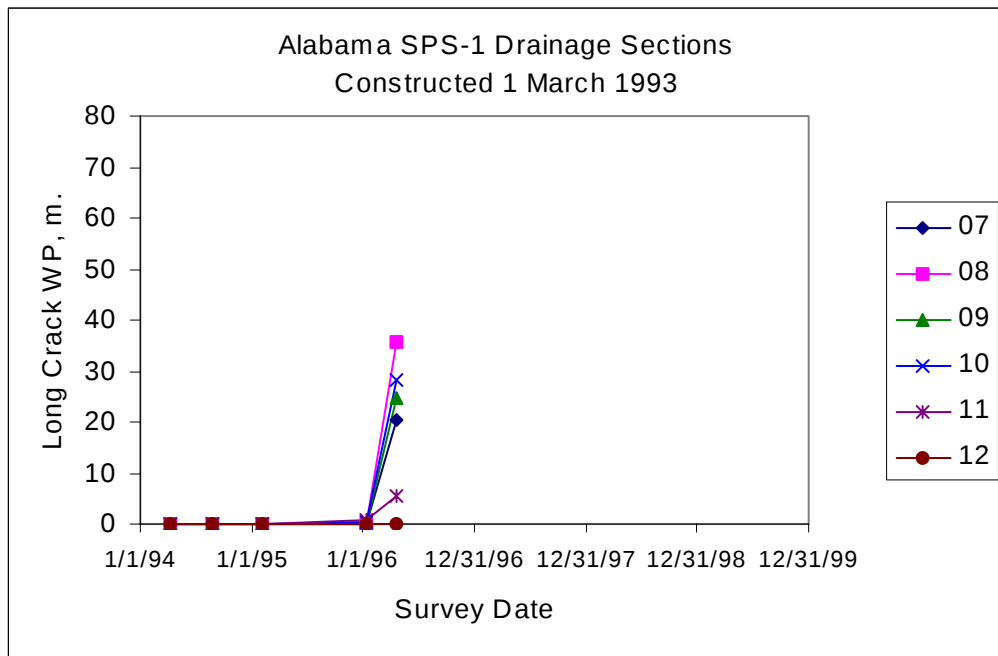
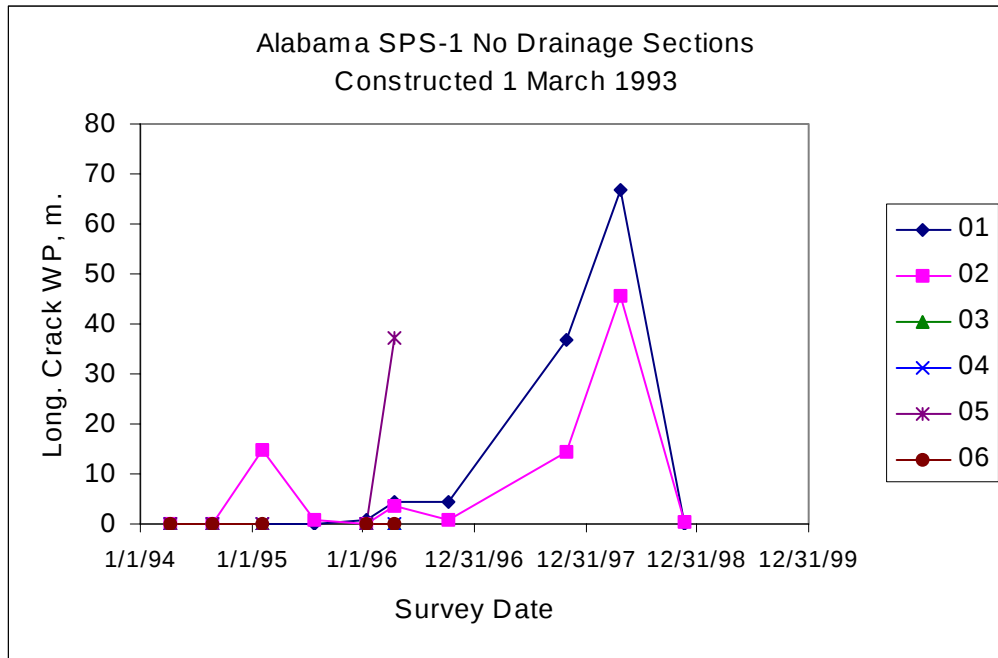


Figure 22. Longitudinal cracking in the wheel paths measured on different dates for the core test sections of the Alabama project.

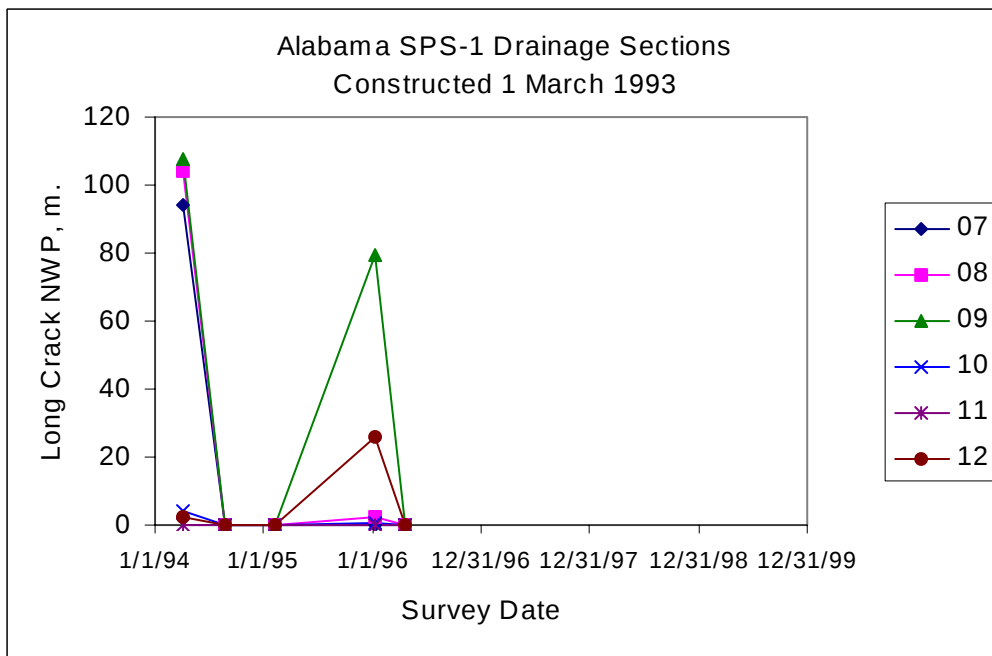
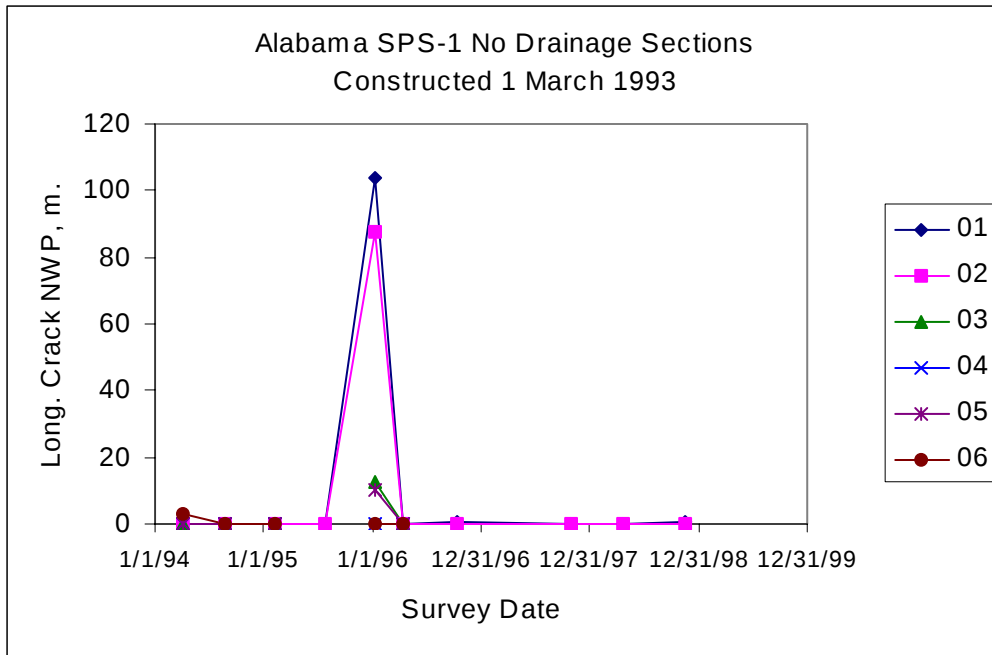


Figure 23. Longitudinal cracking outside the wheel paths measured on different dates for the core test sections of the Alabama project.

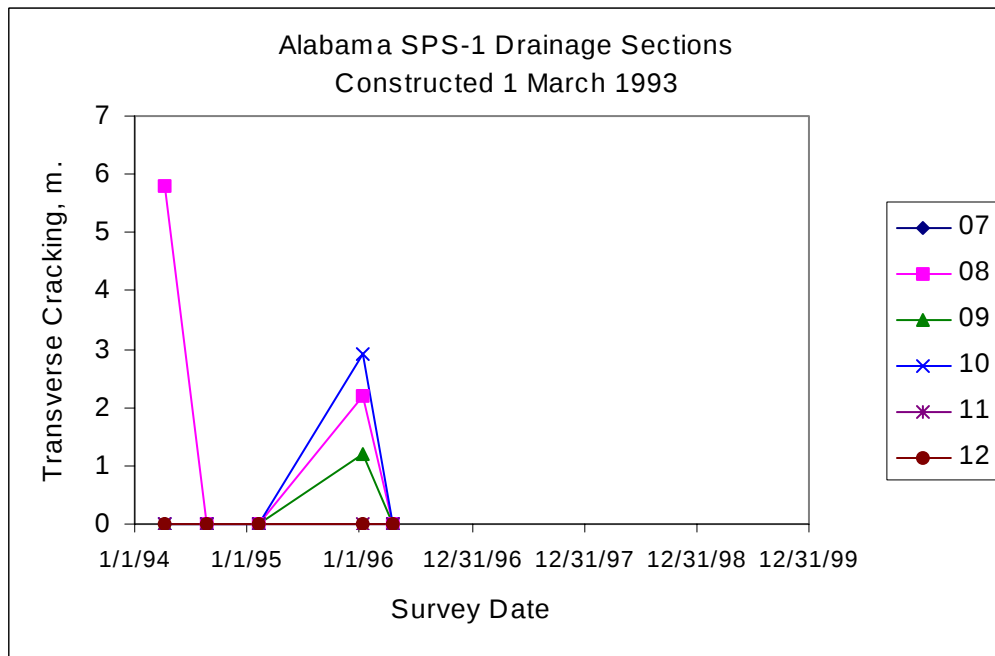
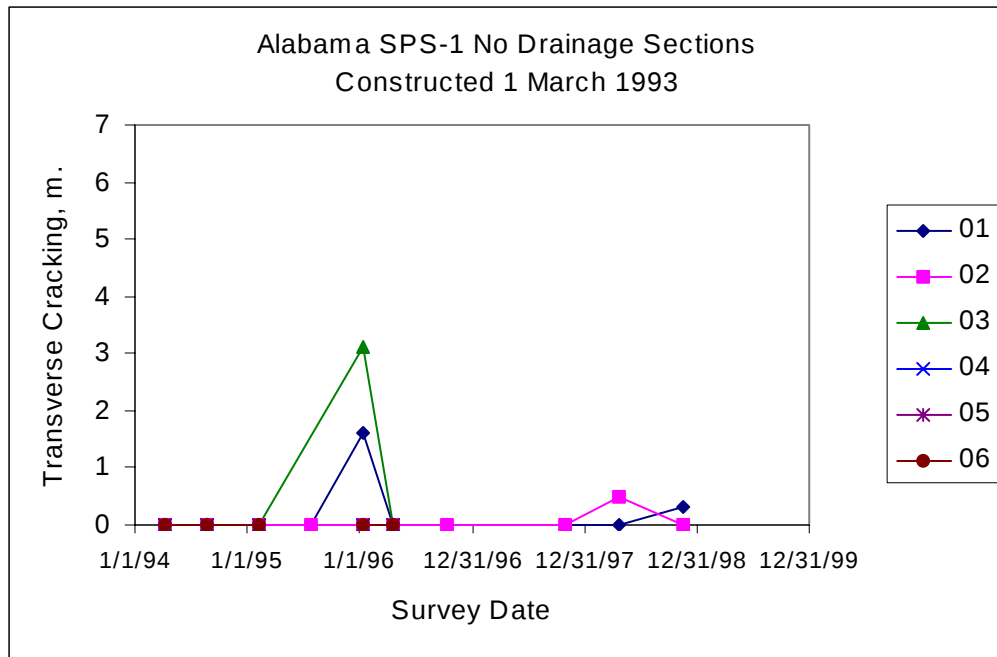


Figure 24. Transverse cracking measured on different dates for the core test sections of the Alabama project.

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

| Performance Indicator | Distress Magnitude<br>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 <sup>2</sup>                 | 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 <sup>2</sup> |                    | 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     |

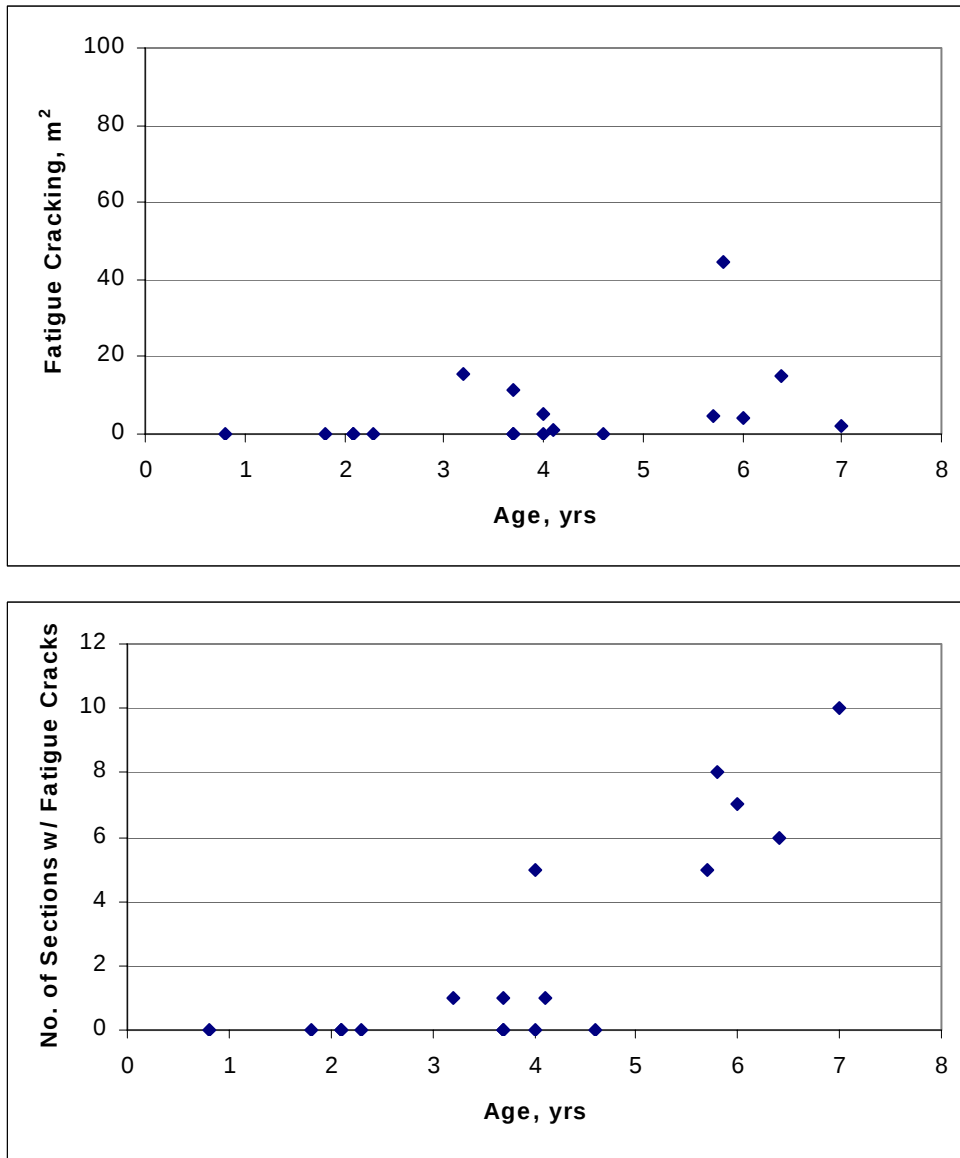


Figure 25. Graphical illustration of the average amount of fatigue cracking observed on each of the projects, as of January 2000.

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<sup>2</sup> 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<sup>2</sup>. 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.<sup>(13)</sup> 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.<sup>(14)</sup>

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 <sup>2</sup>           | 1.5          | 3.5            |
|                                   | Std. Deviation, m <sup>2</sup> | 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 <sup>2</sup>           | 1.6       | 6.2               |
|                                   | Std. Deviation, m <sup>2</sup> | 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 <sup>2</sup>           | 1.8                | 3.5        |
|                                   | Std. Deviation, m <sup>2</sup> | 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 <sup>2</sup>           | 4.0                   | 1.4   |
|                                   | Std. Deviation, m <sup>2</sup> | 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   |

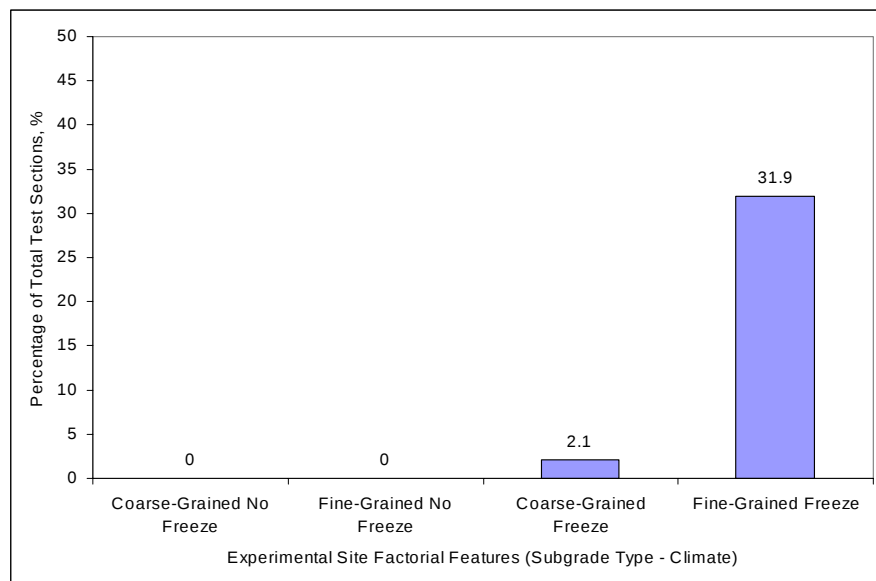


Figure 26. Percentage of the core test sections that exceed an IRI value of 1.2 m/km.

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.<sup>(15)</sup>

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.<sup>(16)</sup>

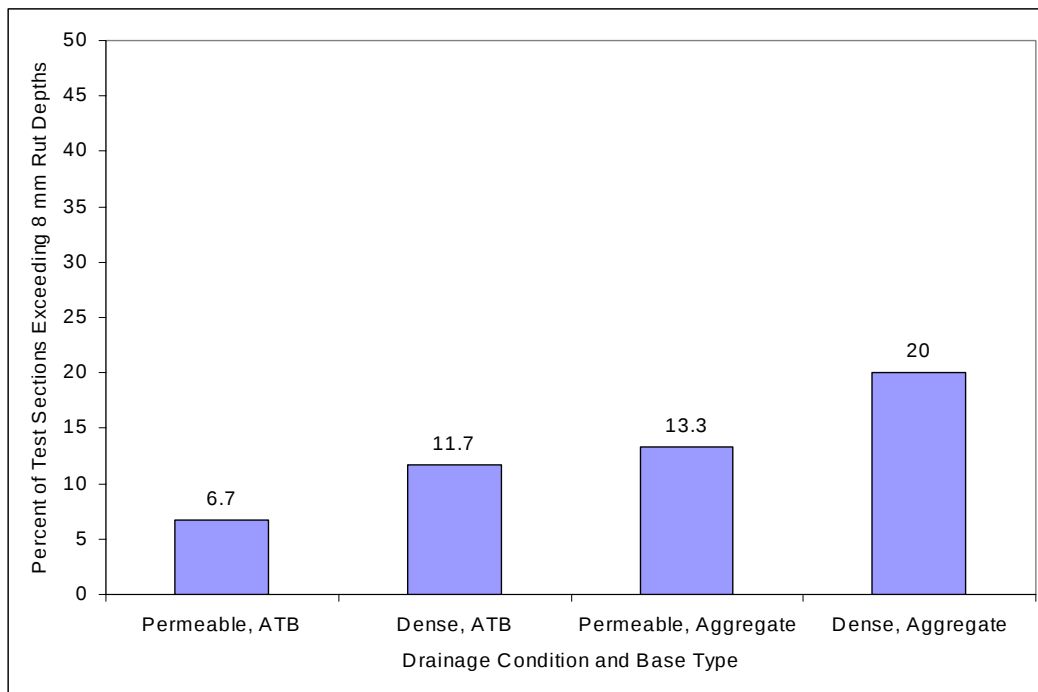


Figure 27. Percentage of the core test sections that exceed 8 mm of rutting.

### 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.

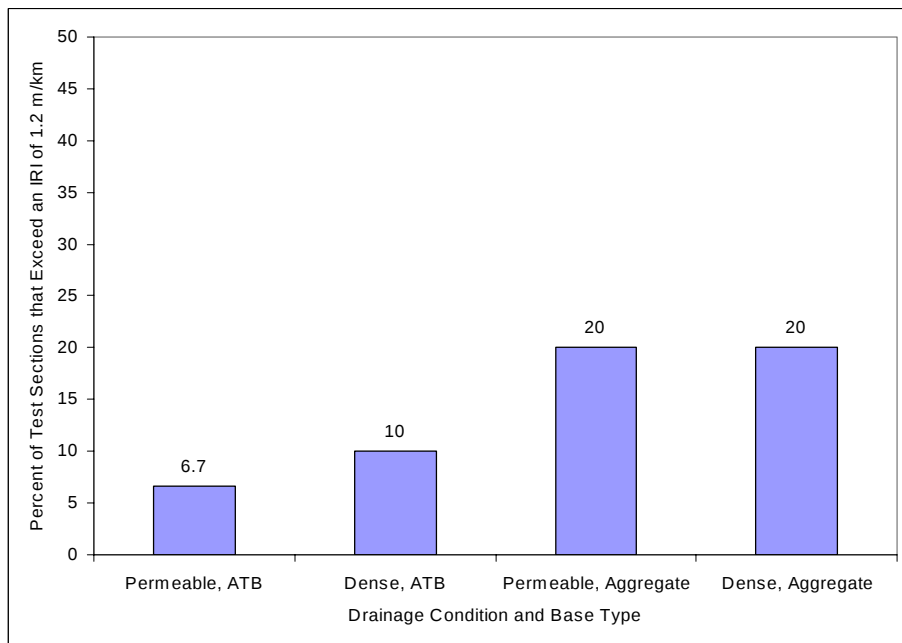
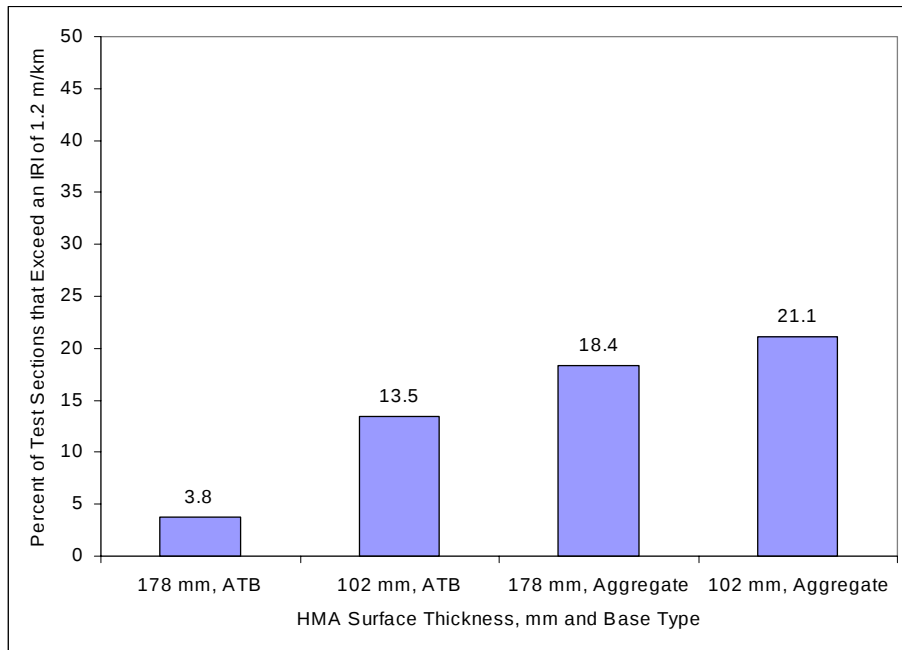


Figure 28. Percentage of test sections that exceed an IRI value of 1.2 m/km.

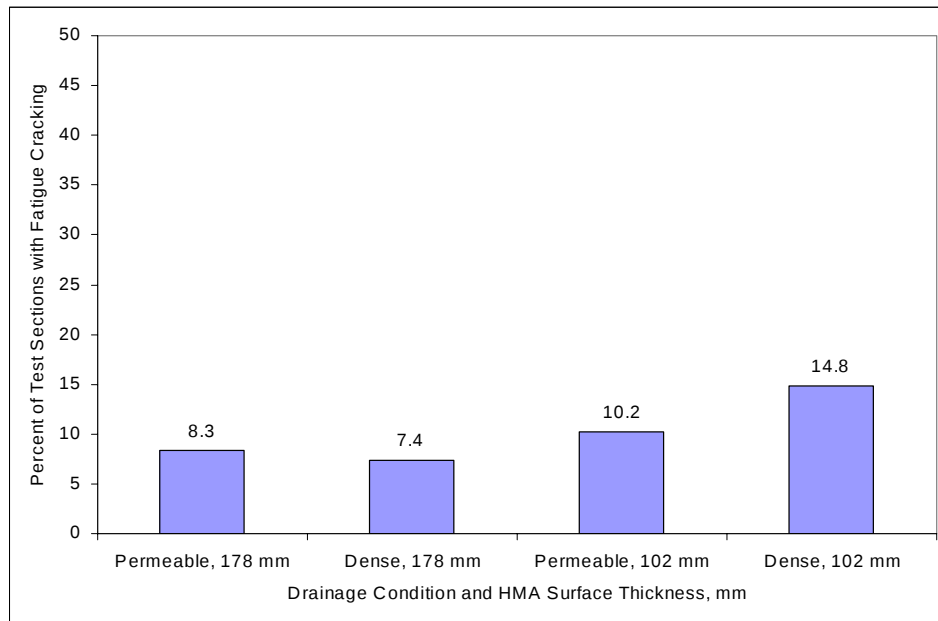


Figure 29. Percentage of core test sections that have fatigue cracking.

### 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                           | <b>IA(1)-7.0:</b><br>Limited AWS climatic data.<br>Limited WIM/AVC traffic data.<br>Limited distress surveys.<br>Subgrade—Missing classification, moisture density (M-D), & permeability data.<br>Aggr. Base—Missing resilient modulus & permeability data & limited classification & M-D data.<br>ATB—Limited mix & asphalt data & missing moist. susc. data.<br>HMA—Missing mix, moist. susc., asphalt & aggregate data. | <b>LA(0)-2.1:</b><br>No WIM equipment installed.<br>Missing recent longitudinal profile.<br>Subg.—Missing permeability data.<br>Aggr. Base—Missing M-D, classification, & permeability data & limited resilient modulus data.<br>ATB—Missing mix, moist. susc., aggregate & asphalt data.<br>HMA—Missing mix, moist. susc., asphalt & aggregate data.                                              | <b>KS(6)-5.8:</b><br>Limited WIM/AVC traffic data.<br>Missing recent deflection survey & transverse profile.<br>Aggr. Base—Missing classification, M-D, resilient modulus, & permeability data.<br>ATB—Missing mix, aggregate, asphalt, & moist. susc. data.<br>HMA—Missing moist. susc., mix, asphalt & aggregate data. | <b>NM(0)-3.7:</b><br>No WIM equipment installed.<br>Missing recent deflection survey & longitudinal profile.<br>Aggr. Base—Missing classification, M-D, & resilient modulus data. |
|                    |                                | <b>OH(2)-4.6:</b><br>No WIM equipment installed.<br>Subg.—Missing classification, M-D, and resilient modulus data & limited permeability data.<br>Aggr. Base—Limited classification & permeability data & missing M-D & resilient modulus data.<br>ATB—Missing moist. susc. data & limited mix, aggregate & asphalt data.<br>HMA—Missing moist. susc. data & limited mix, asphalt & aggregate data.                        | <b>AL(3)-6.4:</b><br>No WIM equipment installed.<br>Missing recent distress survey & transverse profile.<br>Subg.—Missing permeability data.<br>Aggr. Base—Missing resilient modulus & permeability data & limited classification & M-D data.<br>ATB—Missing asphalt, aggregate, & moist. susc. data & limited mix data.<br>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                          | <b>MI(1)-4.0:</b><br>Limited AWS climatic data.<br>Limited WIM/AVC traffic data.<br>Missing recent deflection survey.<br>Subg.—Missing permeability data & limited classification, M-D, & resilient modulus data.<br>Aggr. Base—Missing resilient modulus & permeability data, & limited classification & M-D data.<br>ATB—Missing mix, aggregate, asphalt, & moist. susc. data.<br>HMA—Missing mix, moist. susc., asphalt & aggregate data. | No Projects                                                                                                                                                                                                                                                                                                                          | <b>NB(1)-4.1:</b><br>Limited WIM/AVC traffic data.<br>Subg.—Limited resilient modulus & permeability data.<br>Aggr. Base—Missing resilient modulus & permeability data & limited classification data.<br>ATB—Missing moist. susc. data & limited aggregate & asphalt data.<br>HMA—Missing moist. susc. data & limited mix, asphalt & aggregate data.         | <b>TX(8)-2.3:</b><br>Limited AWS climatic data.<br>Subg.—Missing M-D & permeability data & limited classification data.<br>Aggr. Base—Missing M-D, classification, & permeability data.<br>ATB—Missing mix, moist. susc., aggregate & asphalt data.<br>HMA—Missing mix, moist. susc., asphalt & aggregate data. |
|                    |                                | <b>VA(1):</b><br>Limited WIM/AVC traffic data.<br>Missing recent deflection survey.<br>Subg.—Missing resilient modulus data.<br>Aggr. Base—Missing M-D, resilient modulus & permeability data.<br>ATB—Limited asphalt data.<br>HMA—Limited mix, moist. susc., asphalt & aggregate data.                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                              | <b>OK(2)-2.1:</b><br>No WIM equipment installed.<br>Subg.—Missing M-D & permeability data & limited classification data.<br>Aggr. Base—Missing M-D, classification, resilient modulus, & permeability data.                                                                                                     |
| Coarse-Grained     | 1–12                           | <b>DE(2)-3.2:</b><br>No WIM equipment installed.<br>Subg.—Missing classification, M-D, and permeability data.<br>Aggr. Base—Missing classification, M-D, & resilient modulus data & limited permeability data.<br>ATB—Missing moist. susc. & asphalt data & limited mix & aggregate data.<br>HMA—Missing moist. susc. data & limited mix data.                                                                                               | <b>FL(1)-3.7:</b><br>Limited WIM/AVC traffic data.<br>Missing transverse profile data.<br>Missing recent deflection survey & longitudinal profile.<br>Subg.—Missing gradation & permeability data & limited resilient modulus data.<br>Aggr. Base—Missing resilient modulus & permeability data & limited classification & M-D data. | <b>NV(0)-4.0:</b><br>No AWS equipment installed.<br>Limited WIM/AVC traffic data.<br>Subg.—Limited permeability data.<br>Aggr. Base—Missing M-D & resilient modulus data & limited classification data.<br>ATB—Missing moist. susc., asphalt, & aggregate data & limited mix data.<br>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                          | <b>WI(0)-1.8:</b><br>No construction report.<br>No AWS equipment installed.<br>No WIM equipment installed.<br>Missing recent deflection survey & transverse profile.<br>Subg.—Missing classification, M-D, resilient modulus, & permeability data.<br>Aggr. Base—Missing classification, M-D, resilient modulus & permeability data.<br>ATB—Missing mix, moist. susc., asphalt, & aggregate data.<br>HMA—Missing mix, moist. susc., asphalt, & aggregate data. | <b>AR(1)-5.7:</b><br>Limited WIM/AVC traffic data.<br>Missing recent distress survey & longitudinal & transverse profiles.<br>Subg.—Missing resilient modulus & permeability data.<br>Aggr. Base—Missing M-D, resilient modulus, classification, & permeability data.<br>ATB—Missing mix, asphalt, aggregate, & moist. susc. data.<br>HMA—Missing moist. susc., asphalt & aggregate data & limited mix data. | <b>MT(0)-0.8:</b><br>No construction report.<br>No WIM equipment installed.<br>Subg.—Missing classification, M-D, resilient modulus, & permeability data.<br>Aggr. Base—Missing classification, M-D, resilient modulus, & permeability data.<br>ATB—Missing mix, moist. susc., asphalt & aggregate data.<br>HMA—Missing mix, moist. susc., asphalt & aggregate data. | <b>AZ(5)-6.0:</b><br>Subg.—Limited resilient modulus and missing permeability data.<br>Aggr. Base—Missing permeability & limited resilient modulus data.<br>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, <sup>(1)</sup> 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 <sup>(2)</sup>                                                                                                                    | 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 <sup>(3)</sup> 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, <sup>(4)</sup> Wisconsin, <sup>(4)</sup> 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, <sup>(5)</sup> 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:

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

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.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| <b>OBJECTIVE NO. 1</b><br>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).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                           |
| <b>TOPIC AREA</b><br>Pavement design and performance prediction.<br>Impact of specific design features on performance.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>PROBABILITY OF SUCCESS</b><br>High                     |
| <b>LTPP STRATEGIC PLAN</b><br>7.A, 7.B, 7.C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>SUPPLEMENTAL EXPERIMENTS</b>                           |
| <b>END PRODUCT</b><br>Impact of specific design features and level of significance on pavement performance and the occurrence of pavement distress. <ul style="list-style-type: none"> <li>Identify the test sections that perform well and poorly at each of the SPS-1 project sites.</li> <li>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.</li> <li>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.</li> </ul>                                                                                                                                                                                                      | <b>POTENTIAL PRODUCT USE</b><br>Future analysis projects. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>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.</li> <li>Conduct comparative analyses of the individual test sections at each site, including the supplemental test sections, to identify differences in pavement performance and response.</li> <li>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.</li> <li>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.</li> </ul> |                                                           |

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

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| <b>OBJECTIVE NO. 2</b><br>Determine the effect of the main SPS-1 experimental factors on the performance of the flexible pavements. (Expected timeframe—2002 to 2003).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                       |
| <b>TOPIC AREA</b><br>Pavement design and performance prediction.<br>Impact of specific design features on performance.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>PROBABILITY OF SUCCESS</b><br>High |
| <b>LTPP STRATEGIC PLAN</b><br>7.A, 7.B, 7.C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>SUPPLEMENTAL EXPERIMENTS</b>       |
| <b>END PRODUCT</b><br>Impact of specific design features and level of significance on pavement performance and the occurrence of pavement distress. <ul style="list-style-type: none"> <li>• 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.</li> <li>• Identify the flexible pavement design features and properties that are compatible with permeable base drainage and contribute to improved performance.</li> <li>• Identify the site conditions where different base types will contribute to improved pavement performance.</li> <li>• Determine the significance of seasonal changes on the response of the pavement and materials related to performance and incremental deterioration.</li> <li>• Confirm and quantify the effect of the subgrade on pavement performance and minimum pavement thickness above the subgrade.</li> </ul> |                                       |
| <b>POTENTIAL PRODUCT USE</b> <ul style="list-style-type: none"> <li>• <i>Design new or reconstructed cost-effective and reliable flexible pavements.</i></li> <li>• Calibration and validation of new pavement design procedures/methods and distress prediction models.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review results and findings from each SPS-1 test section and companion project.</li> <li>• Conduct statistical analysis to determine significant factors and interactions on performance.</li> <li>• Conduct mechanistic-empirical analyses for cracking, rutting, and IRI.</li> <li>• Based on the statistical and mechanistic analyses, determine the effect of different experimental factors or design features on pavement performance and response.</li> <li>• 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.</li> </ul>                                                                                                                                                                                                                                                                             |                                       |

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.

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| <b>OBJECTIVE NO. 3</b><br>Quantify the benefits of a good drainage system for flexible pavements. (Expected timeframe—2004 to 2005).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                               |
| <b>TOPIC AREA</b><br>Design and performance predictions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>PROBABILITY OF SUCCESS</b><br>Moderate to high <sup>(1)</sup>              |
| <b>LTPP STRATEGIC PLAN</b><br>7.A, 7.B, 7.C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>SUPPLEMENTAL EXPERIMENTS</b><br>GPS test sections with drainage features   |
| <b>END PRODUCT</b><br>Impact of a positive drainage system on pavement performance and the occurrence of pavement distress.<br><br>A decision tree to identify those site conditions requiring drainage for enhancing the performance of flexible pavements and for selecting the drainage design features.                                                                                                                                                                                                                                                                                                                                                                             | <b>POTENTIAL PRODUCT USE</b><br>Design engineers for designing new pavements. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial stage of the analysis.</li> <li>• Subdivide data or test sections into those test sections with and without drainage features.</li> <li>• Classify each site as to requiring drainage or not requiring drainage.</li> <li>• Complete a regression analysis to determine any differences in performance and establish the relative differences between the two conditions.</li> <li>• Complete an analysis of variance and other analyses to relate the site conditions to the effect of the drainage feature on improving performance.</li> </ul> |                                                                               |

<sup>(1)</sup> 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.

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| <b>OBJECTIVE NO. 4</b><br>Determine the effect of thickness variations on long-term pavement performance and initial ride quality. (Expected timeframe—2003 to 2004).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                     |
| <b>TOPIC AREA</b><br>Design                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>PROBABILITY OF SUCCESS</b><br>Moderate to high <sup>(1)</sup>                                    |
| <b>LTPP STRATEGIC PLAN</b><br>2.D, 7.B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>SUPPLEMENTAL EXPERIMENTS</b><br>SPS-5 experiment                                                 |
| <b>END PRODUCT</b><br>Impact of layer thickness and the variation of thickness on pavement performance and the occurrence of pavement distress.<br><br>A relationship or tabulation between increased thickness variances or standard deviations (coefficient of variations) and reduced ride quality or reduced pavement service life.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>POTENTIAL PRODUCT USE</b><br>Development of pay reduction factors based on thickness deviations. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial stage.</li> <li>• Establish the thickness variability along each test section.</li> <li>• 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.</li> <li>• Accumulate and/or determine the initial IRI measured at each test section.</li> <li>• 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.</li> <li>• Develop reduction in service life based on these increased variances in HMA thickness.</li> </ul> |                                                                                                     |

<sup>(1)</sup> 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.

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| <b>OBJECTIVE NO. 5</b><br>Determine the effect of base material selection and type on the performance of flexible pavements. (Expected timeframe—2003 to 2004).                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                         |
| <b>TOPIC AREA</b><br>Design                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>PROBABILITY OF SUCCESS</b><br>High                                                                                                                                                                                                   |
| <b>LTPP STRATEGIC PLAN</b><br>2.A, 2.D, 7.A, 7.B, 7.C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>SUPPLEMENTAL EXPERIMENTS</b><br>GPS-1 and GPS-2 experiments                                                                                                                                                                          |
| <b>END PRODUCT</b><br>Impact of the base material type and condition on pavement performance and the occurrence of pavement distress.<br><br>A decision tree and/or specifications for selecting base material types (material specifications) and when to stabilize the base layer.                                                                                                                                                                                                                                                                                                                   | <b>POTENTIAL PRODUCT USE</b><br>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. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Conduct a regression study or analyses of the SPS-1 data to determine the effect of base thickness and type on performance.</li> <li>• Evaluate the effect of material noncompliance on performance and make adjustments for those test sections with noncomplying materials.</li> <li>• Determine the increase in performance or service life for the stabilized bases and the effect of base thickness on pavement life.</li> </ul> |                                                                                                                                                                                                                                         |

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.

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| <b>OBJECTIVE NO. 6</b><br>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).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                    |
| <b>TOPIC AREA</b><br>Materials characterization and pavement management.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>PROBABILITY OF SUCCESS</b><br>High                                                                                              |
| <b>LTPP STRATEGIC PLAN</b><br>2.A, 3.C, 3.E                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>SUPPLEMENTAL EXPERIMENTS</b><br>GPS-1 and GPS-2                                                                                 |
| <b>END PRODUCT</b><br>Improvement of environmental effects and considerations in pavement design, material selection (or specifications), and performance predictions.<br><br>A table summarizing the seasonal modulus ratio and a map showing locations or areas with significant seasonal effects for different pavement types.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>POTENTIAL PRODUCT USE</b><br>Allow designers and pavement management engineers to identify typical times of low modulus values. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Categorize the pavement structure with different soil types and base/subbase types and thicknesses in different climatic areas.</li> <li>• Identify and select those projects and test sections with sufficient time series deflection data (three or four measurements during different seasons of the year).</li> <li>• Calculate the modulus ratio for each season or measurement date from a “standard” modulus value or time of year.</li> <li>• 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).</li> </ul> |                                                                                                                                    |

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

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| <b>OBJECTIVE NO. 7</b><br>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).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                |
| <b>TOPIC AREA</b><br>Materials characterization and pavement design.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>PROBABILITY OF SUCCESS</b><br>High                                                                                                                                          |
| <b>LTPP STRATEGIC PLAN</b><br>2.A, 3.A, 7.B, 7.C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>SUPPLEMENTAL EXPERIMENTS</b><br>GPS-1 and GPS-2                                                                                                                             |
| <b>END PRODUCT</b><br>Improvement in materials characterization of soils for design and development/confirmation of design criteria to protect the subgrade soils.<br><br>Minimum pavement thickness design criteria for selected soil types to protect and maintain ride quality.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>POTENTIAL PRODUCT USE</b><br>Minimum pavement design standards over specific soil types and identification of minimum pavement thickness to maintain selected ride quality. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Categorize the pavement structure with different soil types and base/subbase type and thickness in different climatic areas.</li> <li>• Identify and select those projects and test sections with sufficient time series deflection data (three or four measurements during different seasons of the year).</li> <li>• 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).</li> <li>• 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.</li> </ul> |                                                                                                                                                                                |

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

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| <b>OBJECTIVE NO. 8</b><br>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).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                 |
| <b>TOPIC AREA</b><br>Design and construction.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>PROBABILITY OF SUCCESS</b><br>Moderate to high <sup>(1)</sup>                                                                                                                                                |
| <b>LTPP STRATEGIC PLAN</b><br>2.A, 2.B, 2.D, 2.E, 3.A, 7.A, 7.B, 7.C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>SUPPLEMENTAL EXPERIMENTS</b><br>GPS-1 and GPS-2 experiments                                                                                                                                                  |
| <b>END PRODUCT</b><br>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.<br><br>A tabulation of base condition (density, moisture content, gradation, and other physical properties) to design values—modulus and moisture sensitivity.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>POTENTIAL PRODUCT USE</b><br>Development of performance related specifications and design/construction criteria or properties as related to performance, and assistance in developing pay reduction factors. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Evaluate the as-built moisture contents, density, gradations, and quality of base material and categorize the different test sections with significant differences.</li> <li>• Evaluate the structural response (deflections) and backcalculated layer modulus of the base layer.</li> <li>• Correlate the physical properties and response properties to the condition of the base.</li> <li>• Determine the effect, if any, on the performance and individual distresses of the pavement, including the decrease in ride quality with time and traffic.</li> <li>• Establish threshold limits or other criteria that can be used in design and construction—effect of construction variability of the base properties and performance.</li> </ul> |                                                                                                                                                                                                                 |

<sup>(1)</sup> 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.

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| <b>OBJECTIVE NO. 9</b><br>Determine the effect of HMA compaction and material properties (gradation and resilient modulus) on pavement performance. (Expected timeframe—2003 to 2004).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                      |
| <b>TOPIC AREA</b><br>Design and construction.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>PROBABILITY OF SUCCESS</b><br>High                                                                                                                                                                                                                                                |
| <b>LTPP STRATEGIC PLAN</b><br>2.A, 2.D, 2.E, 3.C, 3.E, 7.B, 7.C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>SUPPLEMENTAL EXPERIMENTS</b><br>SPS-5, GPS-1, GPS-2 and SPS-9 experiments                                                                                                                                                                                                         |
| <b>END PRODUCT</b><br>Improvement of HMA mixture characterization and impact of HMA properties after construction and specifications on pavement performance and the occurrence of pavement distress.<br><br>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.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>POTENTIAL PRODUCT USE</b><br>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. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Determine the physical properties at construction for each HMA layer of each test section.</li> <li>• 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.</li> <li>• 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.</li> <li>• Establish threshold properties and/or criteria that result in an increased level of distresses or a reduction in ride quality.</li> <li>• Establish whether some of the material related distresses (raveling or bleeding) are related to these values.</li> <li>• Develop criteria for mixture design and construction acceptance criteria.</li> </ul> |                                                                                                                                                                                                                                                                                      |

Table 38. Identification of future research studies from the SPS-1 experiment—quantification of remaining life of cracked or damaged HMA layers.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |
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| <b>OBJECTIVE NO. 10</b><br>Quantification of the remaining life of cracked or damaged asphalt concrete layers. (Expected timeframe—2004 to 2005).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                   |
| <b>TOPIC AREA</b><br>Pavement management and overlay design.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>PROBABILITY OF SUCCESS</b><br>High                                                                                                                                             |
| <b>LTPP STRATEGIC PLAN</b><br>4.B, 5.B, 5.C, 6.B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>SUPPLEMENTAL EXPERIMENTS</b><br>SPS-5, SPS-9, GPS-1, GPS-2, GPS6A & B experiments                                                                                              |
| <b>END PRODUCT</b><br>Improvement in HMA layer characterization and guidance for maintenance and rehabilitation strategy selection and HMA overlay performance prediction.<br><br>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.                                                                                                                                                                                                                                                                                  | <b>POTENTIAL PRODUCT USE</b><br>Pavement management studies to determine the expected time for maintenance and/or rehabilitation, and overlay designs and rehabilitation studies. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Backcalculate the modulus of test sections with different types, extents, and severity levels of cracking.</li> <li>• Estimate the HMA modulus to the uncracked condition taking into account aging and temperature effects on the HMA modulus.</li> <li>• Relate these modulus values to the laboratory test results and compute a modulus damage ratio.</li> <li>• Complete a regression analysis of all ratios to define in mathematical terms the equivalent modulus ratio based on the initial or uncracked value.</li> </ul> |                                                                                                                                                                                   |

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.

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| <b>OBJECTIVE NO. 11</b><br>Confirm the hypothesis of surface initiated fatigue cracks and identify those properties or conditions most conducive to the development of surface initiated fatigue cracks.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                        |
| <b>TOPIC AREA</b><br>Design                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>PROBABILITY OF SUCCESS</b><br>Moderate to high <sup>(1)</sup>                                                                                                                                                       |
| <b>LTPP STRATEGIC PLAN</b><br>2.A, 5.C, 7.B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>SUPPLEMENTAL EXPERIMENTS</b><br>GPS-2 experiment                                                                                                                                                                    |
| <b>END PRODUCT</b><br>Improvement in HMA mixture characterization for distress prediction, and development of new pavement response model and performance/distress prediction models applicable to pavement design.<br><br>Mixture design criteria to minimize the occurrence of surface initiated fatigue cracks.<br><br>Identification and listing of those factors and/or properties that increase the probability of surface initiated fatigue cracks.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>POTENTIAL PRODUCT USE</b><br>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. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Identify and prioritize the test sections that are susceptible to fatigue cracks initiating at the surface.</li> <li>• Verify that those sites have fatigue cracks that initiated at the surface of the HMA layer (through distress surveys and coring studies).</li> <li>• 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.</li> <li>• Establish pavement response criteria (for example, deflection criteria) that can be used to design pavements to minimize the occurrence of surface initiated fatigue cracks.</li> <li>• 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.</li> </ul> |                                                                                                                                                                                                                        |

<sup>(1)</sup> 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.

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| <b>OBJECTIVE NO. 12</b><br>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).                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                       |
| <b>TOPIC AREA</b><br>Design                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>PROBABILITY OF SUCCESS</b><br>Moderate to high <sup>(1)</sup>                                                                                                                      |
| <b>LTPP STRATEGIC PLAN</b><br>5.A, 5.B, 5.C, 7.C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>SUPPLEMENTAL EXPERIMENTS</b><br>GPS-1 and GPS-2 experiments                                                                                                                        |
| <b>END PRODUCT</b><br>Improvement in subgrade soil characterization for design, and development/confirmation of design criteria to protect the subgrade soil and foundation layers.<br><br>Limiting subgrade vertical strain and deflection criteria if found to be appropriate.                                                                                                                                                                                                                                                                                                                    | <b>POTENTIAL PRODUCT USE</b><br>Identifying the conditions for which subgrade protection is required and would control the design, and determining the criteria to be used in design. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Identify and prioritize the test sections that are susceptible to distortions in the subgrade.</li> <li>• Verify that those sites have subgrade distortion (either through distress surveys, transverse profiles, or trenches).</li> <li>• Determine the limiting subgrade vertical strains and the conditions (soil conditions, traffic levels, and pavement structure) for which the subgrade protection is required.</li> </ul> |                                                                                                                                                                                       |

<sup>(1)</sup> 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.

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| <b>OBJECTIVE NO. 13</b><br>Compare and quantify any differences between backcalculated modulus values using “MODCOMP” and laboratory measured resilient modulus. (Expected timeframe—2003 to 2004).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                         |
| <b>TOPIC AREA</b><br>Materials and pavement design.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>PROBABILITY OF SUCCESS</b><br>High                                                                                                                                   |
| <b>LTPP STRATEGIC PLAN</b><br>2.B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>SUPPLEMENTAL EXPERIMENTS</b><br>GPS-1 and GPS-2                                                                                                                      |
| <b>END PRODUCT</b><br>Improvement in pavement and subgrade soils material characterization for pavement design and evaluation.<br><br>A table or graph showing the differences (ratios between laboratory and backcalculated modulus values).<br><br>Confirmation of the C-value and the factors that affect its magnitude.                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>POTENTIAL PRODUCT USE</b><br>To define those conditions in which the laboratory and field derived values are different for use in design and rehabilitation studies. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• 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.</li> <li>• Extract the resilient modulus test data for all pavement layers.</li> <li>• Determine the resilient modulus for each layer and subgrade from laboratory measurements for the conditions during each deflection survey.</li> <li>• Compare the backcalculated values to the laboratory-measured values at similar stress states and temperatures.</li> </ul> |                                                                                                                                                                         |

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

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>OBJECTIVE NO. 14</b><br>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).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                       |
| <b>TOPIC AREA</b><br>Pavement design and construction.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>PROBABILITY OF SUCCESS</b><br>Moderate to high                                                                                                                                                                                                                                     |
| <b>LTPP STRATEGIC PLAN</b><br>2.D, 7.B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>SUPPLEMENTAL EXPERIMENTS</b>                                                                                                                                                                                                                                                       |
| <b>END PRODUCT</b><br>Evaluation and/or development of new pavement response and performance prediction models applicable to pavement design and performance predictions.<br><br>In-depth field verified knowledge as to the effects of critical measured structural responses that will be useful in pavement design, evaluation, and rehabilitation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>POTENTIAL PRODUCT USE</b><br>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. |
| <b>GENERAL TASKS</b> <ul style="list-style-type: none"> <li>• Review specific findings from each SPS-1 project related to the initial analysis stage.</li> <li>• Establish a comprehensive input database that includes design, construction, materials test results, traffic, climate, monitoring data, and structural monitoring data (deflections).</li> <li>• 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.</li> <li>• 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.</li> <li>• Analyze the results and develop findings and recommendations as to the impacts of loading and material properties on the performance of flexible pavements.</li> </ul> |                                                                                                                                                                                                                                                                                       |

## 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.<sup>(17)</sup> 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.<br>Unnecessary construction traffic on PATB layer. |        |                     | Weighing-In-Motion:        |                   | None               |               |
| Site key information summary                                                        |                        |        |                                                                                    |        |                     |                            |                   |                    |               |
| ID                                                                                  | Surface                |        | Base                                                                               |        |                     |                            | Materials Testing |                    |               |
|                                                                                     | Thickness, mm          |        | Thickness, mm                                                                      |        |                     |                            | Percent Complete  |                    |               |
|                                                                                     | 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                                                                                | Yes    | 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 |                        |        |                                                                                    |        |                     |                            |                   |                    |               |
| ID                                                                                  | IRI (Date at Initial.) | FWD    | Distress                                                                           |        | Rut                 | Friction                   | Traffic           | Comments           | Adequacy Code |
|                                                                                     |                        |        | Manual                                                                             | PASCO  | Depth               |                            |                   |                    |               |
| 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.

| <b>Alabama SPS-1 Materials Testing Summary</b> |                                  |                             |                               |
|------------------------------------------------|----------------------------------|-----------------------------|-------------------------------|
| <b>Test</b>                                    | <b>Minimum No.<br/>per Layer</b> | <b>Number<br/>Conducted</b> | <b>Percent at<br/>Level E</b> |
| <b>Subgrade:</b>                               |                                  |                             |                               |
| 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                           |
| <b>Unbound Base:</b>                           |                                  |                             |                               |
| 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                         |
| <b>Permeable Asphalt Treated Base:</b>         |                                  |                             |                               |
| Asphalt Content                                | 3                                | 0                           | 0.0                           |
| Aggregate Gradation                            | 3                                | 0                           | 0.0                           |
| <b>Asphalt Treated Base:</b>                   |                                  |                             |                               |
| 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                           |
| <b>Asphalt Surface:</b>                        |                                  |                             |                               |
| 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.<sup>(18)</sup>

### **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                |                                  | Base          |        |               | Drainage                   | Materials Testing |                 |          |
|                                                                                     | Thickness, mm          |                                  | Thickness, mm |        | Type          |                            | Percent Complete  |                 |          |
|                                                                                     | Design                 | Actual                           | Design        | Actual |               |                            | 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      |        | Rut           | Friction                   | Traffic           | Comments        | Adequacy |
|                                                                                     |                        |                                  | Manual        | PASCO  |               |                            |                   |                 | Depth    |
| 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.

| <b>Arizona SPS-1 Materials Testing Summary</b> |                                  |                             |                               |
|------------------------------------------------|----------------------------------|-----------------------------|-------------------------------|
| <b>Test</b>                                    | <b>Minimum No.<br/>per Layer</b> | <b>Number<br/>Conducted</b> | <b>Percent at<br/>Level E</b> |
| <b>Subgrade:</b>                               |                                  |                             |                               |
| 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                           |
| <b>Unbound Base:</b>                           |                                  |                             |                               |
| 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                           |
| <b>Permeable Asphalt Treated Base:</b>         |                                  |                             |                               |
| Asphalt Content                                | 3                                | 3                           | 100.0                         |
| Aggregate Gradation                            | 3                                | 3                           | 100.0                         |
| <b>Asphalt Treated Base:</b>                   |                                  |                             |                               |
| 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                         |
| <b>Asphalt Surface:</b>                        |                                  |                             |                               |
| 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.<sup>(19)</sup> 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 on 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                |                                                       | Base          |        |            | Drainage                   | Materials Testing |                 |          |
|                                                                                     | Thickness, mm          |                                                       | Thickness, mm |        | Type       |                            | 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      |        | Rut Depth  | Friction                   | Traffic           | Comments        | Adequacy |
|                                                                                     |                        |                                                       | Manual        | PASCO  |            |                            |                   |                 | 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 over 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.

| <b>Arkansas SPS-1 Materials Testing Summary</b> |                                  |                             |                               |
|-------------------------------------------------|----------------------------------|-----------------------------|-------------------------------|
| <b>Test</b>                                     | <b>Minimum No.<br/>per Layer</b> | <b>Number<br/>Conducted</b> | <b>Percent at<br/>Level E</b> |
| <b>Subgrade:</b>                                |                                  |                             |                               |
| 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                           |
| <b>Unbound Base:</b>                            |                                  |                             |                               |
| 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                           |
| <b>Permeable Asphalt Treated Base:</b>          |                                  |                             |                               |
| Asphalt Content                                 | 3                                | 0                           | 0.0                           |
| Aggregate Gradation                             | 3                                | 0                           | 0.0                           |
| <b>Asphalt Treated Base:</b>                    |                                  |                             |                               |
| 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                           |
| <b>Asphalt Surface:</b>                         |                                  |                             |                               |
| 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.<sup>(20)</sup> 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                                                        |                        |                  |               |        |           |                            |                   |              |          |
|                                                                                     | Surface                |                  | Base          |        |           |                            | Materials Testing |              |          |
| ID                                                                                  | 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.

| <b>Delaware SPS-1 Materials Testing Summary</b> |                                  |                             |                               |
|-------------------------------------------------|----------------------------------|-----------------------------|-------------------------------|
| <b>Test</b>                                     | <b>Minimum No.<br/>per Layer</b> | <b>Number<br/>Conducted</b> | <b>Percent at<br/>Level E</b> |
| <b>Subgrade:</b>                                |                                  |                             |                               |
| 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                           |
| <b>Unbound Base:</b>                            |                                  |                             |                               |
| Sieve Analysis                                  | 3                                | 0                           | 0.0                           |
| Atterberg Limits                                | 3                                | 2                           | 0.0                           |
| Moisture-Density Relations                      | 3                                | 2                           | 0.0                           |
| Resilient Modulus                               | 3                                | 0                           | 0.0                           |
| Permeability                                    | 3                                | 2                           | 50.0                          |
| Natural Moisture Content                        | 3                                | 2                           | 0.0                           |
| <b>Permeable Asphalt Treated Base:</b>          |                                  |                             |                               |
| Asphalt Content                                 | 3                                | 2                           | 100.0                         |
| Aggregate Gradation                             | 3                                | 2                           | 0.0                           |
| <b>Asphalt Treated Base:</b>                    |                                  |                             |                               |
| 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                           |
| <b>Asphalt Surface:</b>                         |                                  |                             |                               |
| 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.<sup>(21)</sup> 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                |                | Base          |        |              | Drainage                   | Materials Testing |                 |          |
|                                                                                     | Thickness, mm          |                | Thickness, mm |        | Type         |                            | 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      |        | Rut<br>Depth | Friction                   | Traffic           | Comments        | Adequacy |
|                                                                                     |                        |                | Manual        | PASCO  |              |                            |                   |                 | 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.

Over 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                   |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| 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                  |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 1                   | 100.0                 |
| Aggregate Gradation                        | 3                        | 1                   | 100.0                 |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                 |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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.<sup>(22)</sup> 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 that 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 prior to 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                                                        |                        |                                                |               |        |            |                            |                   |              |          |
| ID                                                                                  | Surface                |                                                | Base          |        |            | Drainage                   | Materials Testing |              |          |
|                                                                                     | Thickness, mm          |                                                | Thickness, mm |        | Type       |                            | Percent Complete  |              |          |
|                                                                                     | 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 Depth  | Friction                   | Traffic           | Comments     | Adequacy |
|                                                                                     |                        |                                                | Manual        | PASCO  |            |                            |                   |              | 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                   |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| 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                   |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 6                   | 100.0                 |
| Aggregate Gradation                        | 3                        | 6                   | 0.0                   |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                   |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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                                                        |                        |                                             |               |        |              |                            |                   |              |          |
| ID                                                                                  | Surface                |                                             | Base          |        |              |                            | Materials Testing |              |          |
|                                                                                     | Thickness, mm          |                                             | Thickness, mm |        | Type         | Drainage                   | Percent Complete  |              |          |
|                                                                                     | 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 |                        |                                             |               |        |              |                            |                   |              |          |
| ID                                                                                  | IRI (Date at Initial.) | FWD                                         | Distress      |        | Rut<br>Depth | Friction                   | Traffic           | Comments     | Adequacy |
|                                                                                     |                        |                                             | Manual        | PASCO  |              |                            |                   |              | 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. Over 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                   |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| 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                   |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 0                   | 0.0                   |
| Aggregate Gradation                        | 3                        | 0                   | 0.0                   |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                   |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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.<sup>(23)</sup> 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                                                        |                        |                                         |               |        |            |                            |         |                 |          |
| ID                                                                                  | Surface                |                                         | Base          |        | Drainage   | Materials Testing          |         |                 |          |
|                                                                                     | Thickness, mm          |                                         | Thickness, mm |        |            | Percent Complete           |         |                 |          |
|                                                                                     | 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 |                        |                                         |               |        |            |                            |         |                 |          |
| ID                                                                                  | IRI (Date at Initial.) | FWD                                     | Distress      |        | Rut Depth  | Friction                   | Traffic | Comments        | Adequacy |
|                                                                                     |                        |                                         | Manual        | PASCO  |            |                            |         |                 | 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                   |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| Sieve Analysis                             | 3                        | 0                   | 0.0                   |
| Atterberg Limits                           | 3                        | 0                   | 0.0                   |
| Moisture-Density Relations                 | 3                        | 0                   | 0.0                   |
| Resilient Modulus                          | 3                        | 1                   | 100.0                 |
| Permeability                               | 3                        | 0                   | 0.0                   |
| Natural Moisture Content                   | 3                        | 0                   | 0.0                   |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 0                   | 0.0                   |
| Aggregate Gradation                        | 3                        | 0                   | 0.0                   |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                   |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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                                                        |                        |        |               |        |              |                            |                   |                      |              |
| ID                                                                                  | Surface                |        | Base          |        |              | Drainage                   | Materials Testing |                      |              |
|                                                                                     | Thickness, mm          |        | Thickness, mm |        | Type         |                            | Percent Complete  |                      |              |
|                                                                                     | 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 |                        |        |               |        |              |                            |                   |                      |              |
| ID                                                                                  | IRI (Date at Initial.) | FWD    | Distress      |        | Rut<br>Depth | Friction                   | Traffic           | Comments             | Adequacy     |
|                                                                                     |                        |        | Manual        | PASCO  |              |                            |                   |                      | 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.

| <b>Michigan SPS-1 Materials Testing Summary</b> |                                  |                             |                               |
|-------------------------------------------------|----------------------------------|-----------------------------|-------------------------------|
| <b>Test</b>                                     | <b>Minimum No.<br/>per Layer</b> | <b>Number<br/>Conducted</b> | <b>Percent at<br/>Level E</b> |
| <b>Subgrade:</b>                                |                                  |                             |                               |
| 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                           |
| <b>Unbound Base:</b>                            |                                  |                             |                               |
| Sieve Analysis                                  | 3                                | 2                           | 100.0                         |
| Atterberg Limits                                | 3                                | 2                           | 100.0                         |
| Moisture-Density Relations                      | 3                                | 2                           | 100.0                         |
| Resilient Modulus                               | 3                                | 2                           | 0.0                           |
| Permeability                                    | 3                                | 0                           | 0.0                           |
| Natural Moisture Content                        | 3                                | 2                           | 100.0                         |
| <b>Permeable Asphalt Treated Base:</b>          |                                  |                             |                               |
| Asphalt Content                                 | 3                                | 0                           | 0.0                           |
| Aggregate Gradation                             | 3                                | 0                           | 0.0                           |
| <b>Asphalt Treated Base:</b>                    |                                  |                             |                               |
| 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                           |
| <b>Asphalt Surface:</b>                         |                                  |                             |                               |
| 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.

Over 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                |                | Base          |        |              | Drainage                   | Materials Testing |              |          |
|                                                                                     | Thickness, mm          |                | Thickness, mm |        | Type         |                            | 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      |        | Rut<br>Depth | Friction                   | Traffic           | Comments     | Adequacy |
|                                                                                     |                        |                | Manual        | PASCO  |              |                            |                   |              | 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                   |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| 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                   |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 0                   | 0.0                   |
| Aggregate Gradation                        | 3                        | 0                   | 0.0                   |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                   |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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.<sup>(24)</sup> 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                                                        |                        |                                            |               |        |           |                            |                   |              |          |
|                                                                                     | Surface                |                                            | Base          |        |           |                            | Materials Testing |              |          |
| ID                                                                                  | Thickness, mm          |                                            | Thickness, mm |        | Type      | Drainage                   | 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      |        | Rut       | Friction                   | Traffic           | Comments     | Adequacy |
|                                                                                     |                        |                                            | Manual        | PASCO  | Depth     |                            |                   |              | 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                 |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| 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                   |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 2                   | 100.0                 |
| Aggregate Gradation                        | 3                        | 3                   | 66.7                  |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                   |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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.<sup>(25)</sup> 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                                        |                        |                                                   |               |        |              |                                   |                   |              |          |
|-------------------------------------------------------------------------------------|------------------------|---------------------------------------------------|---------------|--------|--------------|-----------------------------------|-------------------|--------------|----------|
| <b>Age as of Aug. 1999:</b>                                                         |                        | 4.0 years                                         |               |        |              | <b>Construction Date:</b>         |                   | 8/1/95       |          |
| <b>Subgrade type:</b>                                                               |                        | Coarse Grained                                    |               |        |              | <b>Climatic Zone:</b>             |                   | Dry - Freeze |          |
| <b>Subgrade Treatment:</b>                                                          |                        | Lime-treated                                      |               |        |              | <b>Automated Weather Station:</b> |                   | None         |          |
| <b>Climatic data availability:</b>                                                  |                        | 17 years                                          |               |        |              | <b>Automated Vehicle Class:</b>   |                   | 299 Days     |          |
| <b>Construction Problems:</b>                                                       |                        | Plant breakdown. Intermittent ATB and HMA paving. |               |        |              | <b>Weighing-In-Motion:</b>        |                   | 338 Days     |          |
| Site key information summary                                                        |                        |                                                   |               |        |              |                                   |                   |              |          |
| ID                                                                                  | Surface                |                                                   | Base          |        |              | Drainage                          | Materials Testing |              |          |
|                                                                                     | Thickness, mm          |                                                   | Thickness, mm |        | Type         |                                   | 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      |        | Rut<br>Depth | Friction                          | Traffic           | Comments     | Adequacy |
|                                                                                     |                        |                                                   | Manual        | PASCO  |              |                                   |                   |              | 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                 |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| Sieve Analysis                             | 3                        | 3                   | 100.0                 |
| Atterberg Limits                           | 3                        | 3                   | 100.0                 |
| Moisture-Density Relations                 | 3                        | 3                   | 100.0                 |
| Resilient Modulus                          | 3                        | 0                   | 0.0                   |
| Permeability                               | 3                        | 3                   | 100.0                 |
| Natural Moisture Content                   | 3                        | 3                   | 100.0                 |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 4                   | 100.0                 |
| Aggregate Gradation                        | 3                        | 4                   | 100.0                 |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                 |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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.<sup>(26)</sup> 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                                                        |                        |                 |               |                            |            |                 |                   |          |          |
| ID                                                                                  | Surface                |                 | Base          |                            |            | Drainage        | Materials Testing |          |          |
|                                                                                     | Thickness, mm          |                 | Thickness, mm |                            | Type       |                 | Percent Complete  |          |          |
|                                                                                     | 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 |                        |                 |               |                            |            |                 |                   |          |          |
| ID                                                                                  | IRI (Date at Initial.) | FWD             | Distress      |                            | Rut        | Friction        | Traffic           | Comments | Adequacy |
|                                                                                     |                        |                 | Manual        | PASCO                      |            |                 |                   |          | Depth    |
| 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                  |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| 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                 |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 1                   | 100.0                 |
| Aggregate Gradation                        | 3                        | 1                   | 100.0                 |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                 |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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.<sup>(26)</sup> 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                                                        |               |                      |               |        |           |                            |                   |              |          |
| ID                                                                                  | Surface       |                      | Base          |        |           | Drainage                   | Materials Testing |              |          |
|                                                                                     | Thickness, mm |                      | Thickness, mm |        | Type      |                            | Percent Complete  |              |          |
|                                                                                     | 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 |               |                      |               |        |           |                            |                   |              |          |
| ID                                                                                  | IRI           | FWD                  | Distress      |        | Rut Depth | Friction                   | Traffic           | Comments     | Adequacy |
|                                                                                     |               |                      | Manual        | PASCO  |           |                            |                   |              | 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 over 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                   |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| Sieve Analysis                             | 3                        | 1                   | 0.0                   |
| Atterberg Limits                           | 3                        | 0                   | 0.0                   |
| Moisture-Density Relations                 | 3                        | 0                   | 0.0                   |
| Resilient Modulus                          | 3                        | 0                   | 0.0                   |
| Permeability                               | 3                        | 2                   | 0.0                   |
| Natural Moisture Content                   | 3                        | 0                   | 0.0                   |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 4                   | 100.0                 |
| Aggregate Gradation                        | 3                        | 4                   | 25.0                  |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                   |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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.<sup>(27)</sup> 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                                                        |                        |                                    |               |        |           |                            |                   |                 |          |
| ID                                                                                  | Surface                |                                    | Base          |        |           | Drainage                   | Materials Testing |                 |          |
|                                                                                     | Thickness, mm          |                                    | Thickness, mm |        | Type      |                            | Percent Complete  |                 |          |
|                                                                                     | 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 |                        |                                    |               |        |           |                            |                   |                 |          |
| ID                                                                                  | IRI (Date at Initial.) | FWD                                | Distress      |        | Rut       | Friction                   | Traffic           | Comments        | Adequacy |
|                                                                                     |                        |                                    | Manual        | PASCO  |           |                            |                   |                 | Depth    |
| 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 over 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.

| <b>Oklahoma SPS-1 Materials Testing Summary</b> |                                  |                             |                               |
|-------------------------------------------------|----------------------------------|-----------------------------|-------------------------------|
| <b>Test</b>                                     | <b>Minimum No.<br/>per Layer</b> | <b>Number<br/>Conducted</b> | <b>Percent at<br/>Level E</b> |
| <b>Subgrade:</b>                                |                                  |                             |                               |
| 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                           |
| <b>Unbound Base:</b>                            |                                  |                             |                               |
| 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                         |
| <b>Permeable Asphalt Treated Base:</b>          |                                  |                             |                               |
| Asphalt Content                                 | 3                                | 3                           | 100.0                         |
| Aggregate Gradation                             | 3                                | 3                           | 100.0                         |
| <b>Asphalt Treated Base:</b>                    |                                  |                             |                               |
| 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                         |
| <b>Asphalt Surface:</b>                         |                                  |                             |                               |
| 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.<sup>(28)</sup> 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 completed, 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-I n-Motion:       |                   | None            |          |
| Site key information summary                                                        |                            |                                  |               |        |            |                            |                   |                 |          |
| ID                                                                                  | Surface                    |                                  | Base          |        |            | Drainage                   | Materials Testing |                 |          |
|                                                                                     | Thickness, mm              |                                  | Thickness, mm |        | Type       |                            | Percent Complete  |                 |          |
|                                                                                     | 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      |        | Rut Depth  | Friction                   | Traffic           | Comments        | Adequacy |
|                                                                                     |                            |                                  | Manual        | PASCO  |            |                            |                   |                 | 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                  |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| Sieve Analysis                             | 7                        | 7                   | 42.9                  |
| Atterberg Limits                           | 7                        | 7                   | 42.9                  |
| Moisture-Density Relations                 | 7                        | 7                   | 42.9                  |
| Resilient Modulus                          | 7                        | 0                   | 0.0                   |
| Permeability                               | 7                        | 7                   | 42.9                  |
| Natural Moisture Content                   | 7                        | 2                   | 50.0                  |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 3                   | 100.0                 |
| Aggregate Gradation                        | 3                        | 3                   | 100.0                 |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                 |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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                                                        |                        |                |               |        |              |                            |                   |                 |          |
| ID                                                                                  | Surface                |                | Base          |        |              | Drainage                   | Materials Testing |                 |          |
|                                                                                     | Thickness, mm          |                | Thickness, mm |        | Type         |                            | Percent Complete  |                 |          |
|                                                                                     | 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 |                        |                |               |        |              |                            |                   |                 |          |
| ID                                                                                  | IRI (Date at Initial.) | FWD            | Distress      |        | Rut<br>Depth | Friction                   | Traffic           | Comments        | Adequacy |
|                                                                                     |                        |                | Manual        | PASCO  |              |                            |                   |                 | 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                 |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| 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                 |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 9                   | 33.3                  |
| Aggregate Gradation                        | 3                        | 9                   | 22.2                  |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                   |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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                                                        |                        |           |               |        |              |                            |                   |          |          |
| ID                                                                                  | Surface                |           | Base          |        |              | Drainage                   | Materials Testing |          |          |
|                                                                                     | Thickness, mm          |           | Thickness, mm |        | Type         |                            | Percent Complete  |          |          |
|                                                                                     | 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 |                        |           |               |        |              |                            |                   |          |          |
| ID                                                                                  | IRI (Date at Initial.) | FWD       | Distress      |        | Rut<br>Depth | Friction                   | Traffic           | Comments | Adequacy |
|                                                                                     |                        |           | Manual        | PASCO  |              |                            |                   |          | 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.<br>per Layer | Number<br>Conducted | Percent at<br>Level E |
| <b>Subgrade:</b>                           |                          |                     |                       |
| 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                   |
| <b>Unbound Base:</b>                       |                          |                     |                       |
| 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                   |
| <b>Permeable Asphalt Treated Base:</b>     |                          |                     |                       |
| Asphalt Content                            | 3                        | 3                   | 100.0                 |
| Aggregate Gradation                        | 3                        | 3                   | 0.0                   |
| <b>Asphalt Treated Base:</b>               |                          |                     |                       |
| 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                   |
| <b>Asphalt Surface:</b>                    |                          |                     |                       |
| 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 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 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  |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |                  |     |     |     |     |     |     |     |     |     |

| <b>Arkansas (5)</b>                      | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |
| 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  |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   | 4   | 4   |     |     | 4   | 4   | 4   | 4   | 4   |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |

| <b>Delaware (10)</b>                     | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 159 | 160 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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  |     |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   | 4   | 4   |     |     | 4   | 4   | 4   | 5   | 4   |     |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   | 2   | 2   | 2   | 6   | 6   | 6   |     |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |

| <b>Florida (12)</b>                      | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 161 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 2% Passing #200                        |     |     |     |     |     |     | 3   |     |     |     |     |     |     |
| 2 - 2.5% Asphalt Content                 |     |     |     |     |     |     | 3   |     |     |     |     |     |     |
| 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   |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 2% Passing #200                        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 2 - 2.5% Asphalt Content                 |     |     |     |     |     |     |     | 2   | 2   | 2   | 2   | 2   | 2   |
| Roller type (Steel Wheel)                |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Drainage Location                        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Drainage Type                            |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |     |     |     |     |     |

| <b>Kansas (20)</b>                       | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 159 | 160 | 161 | 162 | 163 | 164 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |     |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |     |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |     |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |     |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |     |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   | 4   | 4   |     |     | 4   | 4   | 4   | 4   | 4   |     |     |     |     |     |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |     |     |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

| <b>Louisiana (22)</b>                    | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |
| 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  |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   | 8   | 12  |     |     | 4   | 4   | 4   | 8   | 12  |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   | 2   | 2   | 2   | 6   | 6   | 6   |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |

| <b>Michigan (26)</b>                     | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 159 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   | 53  | 34  |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      | 11  | 8   |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   | NP  | NP  |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 2% Passing #200                        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 2 - 2.5% Asphalt Content                 |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Roller type (Steel Wheel)                |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Drainage Location                        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Drainage Type                            |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |
| 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  |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   |     |     |     |     | 5   | 5   | 5   | 8   | 8   |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 2% Passing #200                        |     |     |     |     |     |     |     |     |     |     |     |     |
| 2 - 2.5% Asphalt Content                 |     |     |     |     |     |     |     |     |     |     |     |     |
| Roller type (Steel Wheel)                |     |     |     |     |     |     |     |     |     |     |     |     |
| DOUBLE-DRUM VIBR.                        |     |     |     |     |     |     |     |     |     |     |     |     |
| Drainage Location                        |     |     |     |     |     |     |     | 1   | 1   |     |     |     |
| Drainage Type                            |     |     |     |     |     |     |     | 6   | 6   |     |     |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |     |     |     |     |

| <b>Nebraska (31)</b>                     | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121               | 122 | 123 | 124   |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-------------------|-----|-----|-------|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |                   |     |     |       |
| 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     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |                   |     |     |       |
| 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     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |                   |     |     |       |
| AC Surface                               |     |     |     |     |     |     |     | 102 | 102               |     |     |       |
| ATB                                      |     |     |     |     |     |     |     | 203 | 305               |     |     |       |
| PATB                                     |     |     |     |     |     |     |     | 102 | 102               |     |     |       |
| DGAB                                     |     |     |     |     |     |     |     | 0   | 0                 |     |     |       |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |                   |     |     |       |
| AC Surface                               |     |     |     |     |     |     |     |     |                   |     |     |       |
| ATB                                      |     |     |     |     |     |     |     |     |                   |     |     |       |
| PATB                                     |     |     |     |     |     |     |     |     |                   |     |     |       |
| DGAB                                     |     |     |     |     |     |     |     |     |                   |     |     |       |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |                   |     |     |       |
| AC Surface                               |     |     |     |     |     |     |     |     |                   |     |     |       |
| ATB                                      |     |     |     |     |     |     |     |     |                   |     |     |       |
| PATB                                     |     |     |     |     |     |     |     |     |                   |     |     |       |
| DGAB                                     |     |     |     |     |     |     |     |     |                   |     |     |       |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |                   |     |     |       |
| AC Surface                               |     |     |     |     |     |     |     |     |                   |     |     |       |
| ATB                                      |     |     |     |     |     |     |     |     |                   |     |     |       |
| PATB                                     |     |     |     |     |     |     |     |     |                   |     |     |       |
| DGAB                                     |     |     |     |     |     |     |     |     |                   |     |     |       |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |                   |     |     |       |
| AC Surface                               |     |     |     |     |     |     |     |     |                   |     |     |       |
| ATB                                      |     |     |     |     |     |     |     |     |                   |     |     |       |
| PATB                                     |     |     |     |     |     |     |     |     |                   |     |     |       |
| DGAB                                     |     |     |     |     |     |     |     |     |                   |     |     |       |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |                   |     |     |       |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |                   |     |     |       |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |                   |     |     |       |
| LL < 25                                  |     |     |     |     |     |     |     |     |                   |     |     |       |
| PI < 4                                   |     |     |     |     |     |     |     |     |                   |     |     |       |
| Max Lift Thickness < 6                   |     |     |     |     |     |     |     | 6   |                   |     |     |       |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |                   |     |     |       |
| 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                   |     |     |     |     |     |     |     |     |                   |     |     |       |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |                   |     |     |       |
| < 2% Passing #200                        |     |     |     |     |     |     |     |     | 7                 |     |     |       |
| 2 - 2.5% Asphalt Content                 |     |     |     |     |     |     |     |     | 5                 |     |     | 2.5   |
| Roller type (Steel Wheel)                |     |     |     |     |     |     |     |     | DOUBLE-DRUM VIBR. |     |     |       |
| Drainage Location                        |     |     |     |     |     |     |     |     |                   |     |     |       |
| Drainage Type                            |     |     |     |     |     |     |     |     |                   |     |     |       |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |                   |     |     |       |
| Marshall                                 |     |     |     |     |     |     |     |     |                   |     |     |       |
| 75 blows                                 |     |     |     |     |     |     |     |     |                   |     |     |       |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |                   |     |     |       |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |                   |     |     |       |

| <b>Nevada (32)</b>                       | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |     |     |     |     |

| <b>New Mexico (35)</b>                   | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |
| 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  |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   | 4   | 6   |     |     | 4   | 4   | 4   | 4   | 6   |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 2% Passing #200                        |     |     |     |     |     |     |     |     |     |     |     |     |
| 2 - 2.5% Asphalt Content                 |     |     |     |     |     |     |     |     |     |     |     |     |
| Roller type (Steel Wheel)                |     |     |     |     |     |     |     |     |     |     |     |     |
| 2                                        |     |     |     |     |     |     |     |     |     |     |     |     |
| 2                                        |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |     |     |     |     |

| <b>Ohio (39)</b>                         | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 160 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   | 10  | 8   |     |     | 7   | 7   | 7   | 10  | 8   |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 2% Passing #200                        |     |     |     |     | 7   |     |     |     |     |     |     |     |     |
| 2 - 2.5% Asphalt Content                 |     |     |     |     | 6   |     |     |     |     |     |     |     |     |
| Roller type (Steel Wheel)                |     |     |     |     |     |     |     |     |     |     |     |     |     |
|                                          |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |     |     |     |     |     |

| <b>Oklahoma (40)</b>                     | 113 | 114 | 115 | 116 | 117 | 118 | 119              | 120 | 121 | 122 | 123 | 124 | 160 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|------------------|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 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   |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 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  |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 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   |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| Max Lift Thickness < 6                   | 4   | 6   |     |     | 4   | 4   | 4                | 4   | 6   |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 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   |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| < 2% Passing #200                        |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 2 - 2.5% Asphalt Content                 |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| Roller type (Steel Wheel)                |     |     |     |     |     |     |                  |     |     |     |     |     |     |
|                                          |     |     |     |     |     |     | 3                |     |     | 1   | 2   |     |     |
|                                          |     |     |     |     |     |     | 3                |     |     | 2   | 2   |     |     |
|                                          |     |     |     |     |     |     | 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   |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |                  |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |                  |     |     |     |     |     |     |

183

| Virginia (51)                            | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 159 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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  |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |     |
| < 2% Passing #200                        |     |     |     |     |     |     |     |     | 4   |     |     |     |     |
| 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   |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 75 blows                                 | 75  |     | 75  | 75  | 75  | 75  | 75  | 75  | 75  | 75  | 75  | 75  |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |     |     |     |     |     |

| <b>Wisconsin (55)</b>                    | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 |
|------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Required Thickness</b>                |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>L05B Thickness</b>                    |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>SPS Construction Thickness</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| 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   |
| <b>Rod &amp; Level</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Std Dev</b>           |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Min</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>Rod &amp; Level Max</b>               |     |     |     |     |     |     |     |     |     |     |     |     |
| AC Surface                               |     |     |     |     |     |     |     |     |     |     |     |     |
| ATB                                      |     |     |     |     |     |     |     |     |     |     |     |     |
| PATB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| DGAB                                     |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>DGAB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 50% Passing #4 Sieve                   |     |     |     |     |     |     |     |     |     |     |     |     |
| < 10 % Passing #200                      |     |     |     |     |     |     |     |     |     |     |     |     |
| LL < 25                                  |     |     |     |     |     |     |     |     |     |     |     |     |
| PI < 4                                   |     |     |     |     |     |     |     |     |     |     |     |     |
| Max Lift Thickness < 6                   |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>ATB Material Requirements</b>         |     |     |     |     |     |     |     |     |     |     |     |     |
| 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                   |     |     |     |     |     |     |     |     |     |     |     |     |
| <b>PATB Material Requirements</b>        |     |     |     |     |     |     |     |     |     |     |     |     |
| < 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   |     |     |     |
| <b>HMAC Binder Material Requirements</b> |     |     |     |     |     |     |     |     |     |     |     |     |
| Marshall                                 |     |     |     |     |     |     |     |     |     |     |     |     |
| 75 blows                                 |     |     |     |     |     |     |     |     |     |     |     |     |
| Min Stability 8 kN                       |     |     |     |     |     |     |     |     |     |     |     |     |
| Flow 2 mm - 4 mm                         |     |     |     |     |     |     |     |     |     |     |     |     |



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