# LTPP: The Next Decade

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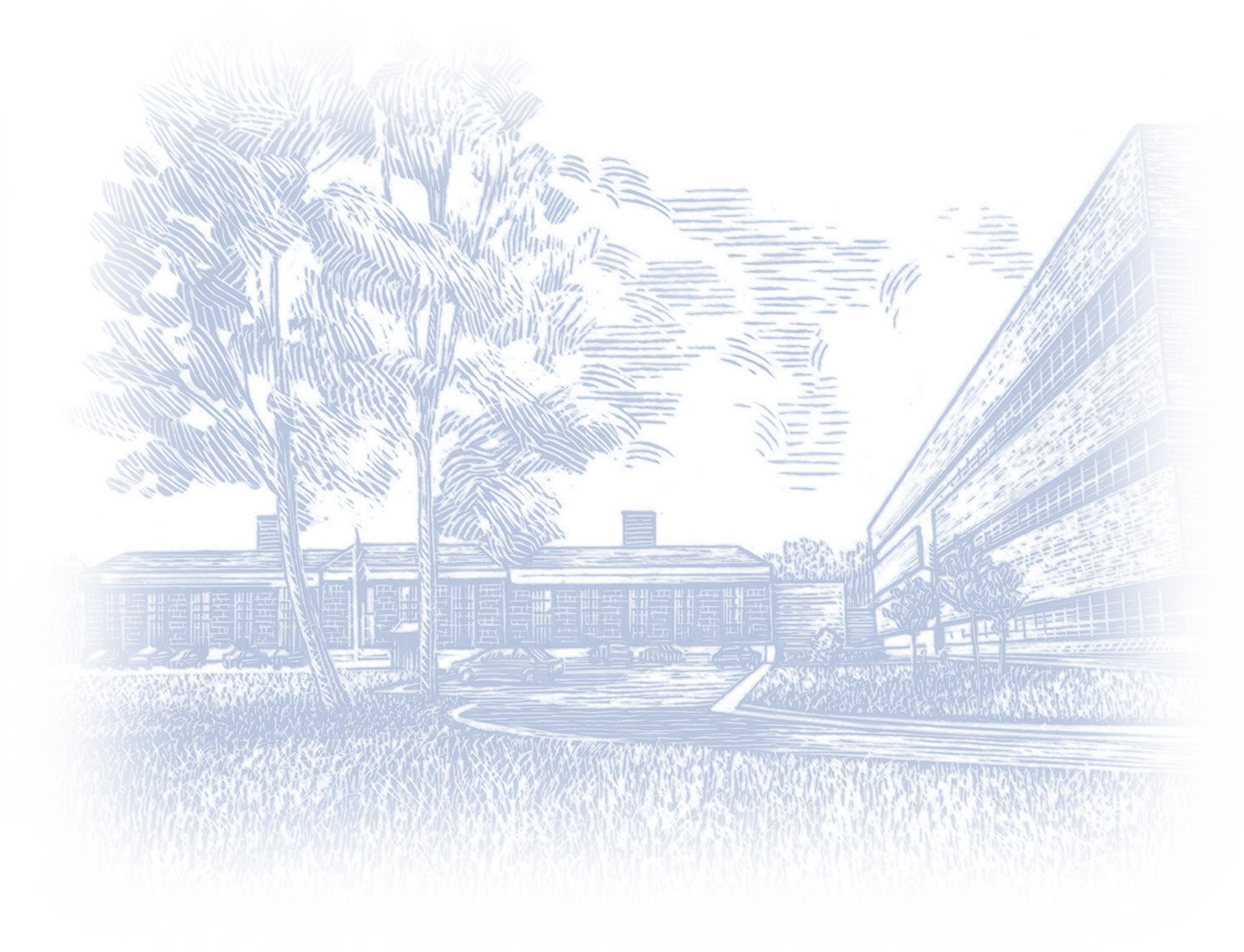

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Federal Highway Administration

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## Foreword

Understanding "why" some pavements perform better than others is key to building and maintaining a cost-effective highway system. That's why in 1987, the Long-Term Pavement Performance (LTPP) program — a comprehensive 20-year study of in-service pavements — began a series of rigorous long-term field experiments monitoring more than 2,400 asphalt and portland cement concrete pavement test sections across the United States and Canada.

Established as part of the Strategic Highway Research Program (SHRP) and now managed by the Federal Highway Administration (FHWA), LTPP was designed as a partnership with the States and Provinces. LTPP's goal is to help the States and Provinces make decisions that will lead to better performing and more cost-effective pavements.

To this end, early in the program, LTPP developed pavement monitoring, materials testing, and equipment standards and calibration procedures. More recently, LTPP has developed a new/refined set of tools, such as the improved procedures for the design of jointed concrete pavements that were adopted by the American Association of State Highway and Transportation Officials (AASHTO) in 1997.

Today, as it enters its second decade, LTPP is providing open access to the data it has collected during its first decade. Introduced in 1998, DataPave is a new software package that presents LTPP data on an easy-to-use CD-ROM. DataPave unlocks the potential of LTPP data for the development of products by the States, Provinces, and FHWA.

However, DataPave is only one of a variety of efforts underway. LTPP data are also playing an integral role in the development of the *AASHTO 2002 Pavement Design Guide.* Although these efforts illustrate the enormous value of the LTPP program, the program also faces a significant challenge.

To address this challenge, FHWA has initiated several efforts that require the support and active participation of the States and Provinces. The intent of this document is to describe the challenge LTPP faces and explain the efforts underway to address this challenge.

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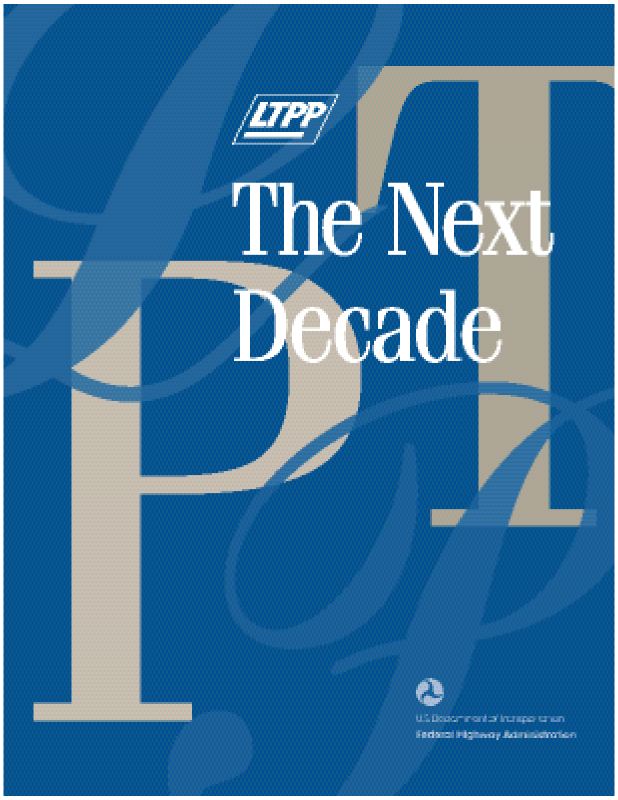


## The Challenge

Understanding pavement performance is a complex task. It is a task that requires not only gaining a knowledge base on "how" pavements perform, but also understanding "why" pavements perform as they do.

What's the difference between understanding "how" pavements perform and "why" pavements perform in a certain way, and why is that important? Simply put, knowing how pavements perform usually enables us to duplicate past successes and avoid recreating past failures. It does not, however, provide enough information to allow us to correct the underlying causes of failure or build upon our successes. Understanding why pavements perform as they do will provide the tools that engineers and managers need to deal with an ever-changing world and more effectively manage the risks inherent in highway design, construction, maintenance, and rehabilitation.

Over the past decade, LTPP has developed a solid knowledge base for understanding how pavements perform. LTPP's challenge throughout its second decade is to build on this foundation — to further the understanding of why pavements perform as they do.

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## Highlights Of LTPP's Accomplishments During The First Decade

In 1997, LTPP analysis findings resulted in the adoption by AASHTO of new design procedures for jointed concrete pavements. These procedures help engineers tailor pavement design to achieve the best balance between initial construction costs and long-term performance.

Engineers have long believed that the long-term performance of a pavement is related to the initial, as-constructed smoothness. In fact, a number of agencies pay a bonus for smooth pavement. Through analysis of the LTPP data, the long-term performance benefits of building smooth pavements have been quantified.

Analysis of the LTPP traffic data has yielded previously unavailable information on the amount of traffic data needed to accurately estimate total design traffic loads at a particular site.

Testing, monitoring, and calibration procedures developed for LTPP data collection have provided a foundation for AASHTO standards that helps agencies collect high-quality data to support the decisions they make every day. For example, LTPP-developed procedures ensure consistency in resilient modulus testing of soils and LTPP-developed falling-weight deflectometer calibration procedures are now widely used by State and Provincial highway agencies.

These highlights represent just a few of the many outputs LTPP has produced. See the Appendix for a listing of current LTPP reports, TechBriefs, and AASHTO standards.

## Addressing The Challenge

To address the challenge of understanding why pavements perform as they do, LTPP must focus and refine the way it does business. To this end, FHWA has:

Developed a Strategic Analysis Plan that establishes a clear focus for FHWA LTPP analytical activities and drives the data collection activities.

Launched a Data Resolution effort to address the gaps and questions regarding data collected over the past several years.

Initiated a Monitoring Adjustments effort to identify appropriate adjustments to improve the quantity and completeness of the data.

All of these efforts are interrelated. The outcome of the Data Resolution effort will influence the Monitoring Adjustments effort. Both, in turn, will influence the ability to proceed with certain analytical activities. Following is a brief synopsis of each of these efforts.

### Strategic Analysis Plan

The purpose of the Strategic Analysis Plan is to provide a structured approach for addressing LTPP's challenge. The plan establishes a target by which results can be measured and appropriate data collection and analysis efforts can be established.

Within the plan, analysis efforts are organized into four major stages: (1) preliminary analyses; (2) investigation of site and design factors; (3) development of detailed performance prediction models; and (4) development of performance prediction and strategy selection tools. Each analysis stage builds upon the foundation provided by the LTPP data and outcomes of previous analysis stages. Figure 1 (see below) illustrates the time line for each stage of the plan. Throughout all stages of the plan, LTPP will be coordinating with other national research initiatives to maximize the effectiveness of LTPP's contribution to pavement technology.

## Preliminary Analyses

Preliminary analyses focus on determining the quality, quantity, and completeness of LTPP's available data. The results will provide information on variability in pavements, traffic, and the measurements used to monitor and assess their performance. The results derived from these analyses will enable managers and engineers to make better decisions as to where and how to invest monitoring and evaluation resources, as well as maintenance, rehabilitation, and construction funds.

## Site and Design Factors

The second stage of the analysis process focuses on the cause-and-effect relationships inherent in pavement performance. Studies will address both site (the traffic, subgrade, and climatic conditions in which pavements exist)and design factors (the pavement type, structure, layer thicknesses, and details that can be varied or adjusted to suit the conditions and constraints associated with a given project). These studies will yield extensive knowledge of what works and what doesn't and begin to explain the "why" of pavement performance.

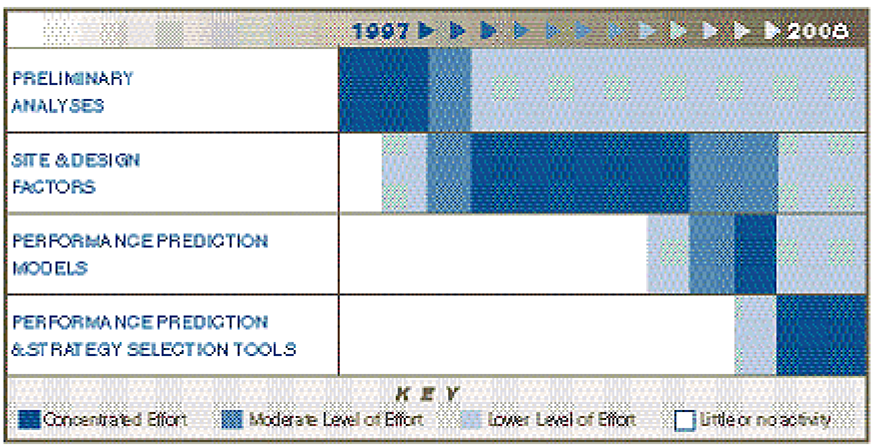


**Figure 1. Analysis Time Line.**

## Performance Prediction Models

In the third stage of the analysis process, component models will be assembled to form complete performance prediction models. Initially, work will focus on evaluating, testing, and calibrating currently available models to see how they fit real-world pavements. New models will be pursued only when necessary. The models resulting from this analysis phase will improve engineers' ability to accurately predict and understand pavement performance and the factors that affect it.

## Performance Prediction and Strategy Selection Tools

In the fourth stage of the analysis process, the models and information, validated or developed in prior stages, will be developed into practical tools for use in routine pavement engineering practice. The outputs will be in the form of procedures and guidelines for pavement design and management to facilitate wise strategy selection and reliable performance prediction.

## Data Resolution

To resolve uncertainty about some of the available data and to fill in some of the missing data, FHWA launched a Data Resolution effort in 1997. The first stage of this effort involved modernizing LTPP's computer hardware and software, along with reorganizing its data processing procedures to ensure that data backlogs would be kept to a minimum and that missing and questionable data would be identified in a timely manner.

The second stage of this effort involved processing all of the LTPP data collected to date and compiling results into Data Status Reports that identify where there are gaps and questions regarding the current data for each State and Province.

In the final stage of the effort, FHWA will conduct a series of data resolution meetings with the States and Provinces during the summer of 1998. The purpose of these meetings is to review the Data Status Reports, discuss both data completeness and quality issues related to specific test sections, identify which data issues can be resolved, and develop a data resolution action plan for data issues that can be resolved.

The Data Resolution effort applies equally to State- and Province-supplied data, as well as data collected by FHWA. As such, FHWA will resolve two key issues — the asphalt resilient modulus test procedures and photographic distress surveys — by mid-1998.

Resolving issues relating to missing and questionable data will enable the States, Provinces, and FHWA to focus their resources on those test sections with the maximum potential for contributing to an improved understanding of pavement performance. In those cases where critical data issues cannot be resolved, the States, Provinces, and FHWA will be able to reduce or eliminate the need for future monitoring, enabling all to allocate resources more effectively.

## Monitoring Adjustments

With the completion of the Data Resolution effort in fall 1998, adjustments in the data collection program and monitoring frequency will be made. This effort will include not only altering the frequency of collection for data already being collected, but also the collection of additional data at some of the test sites.

Key considerations that will drive monitoring adjustments include:

> Today, LTPP has a decade's worth of monitoring data — factual information it can use to adjust monitoring programs for maximum effectiveness.
>
> Test sections that have the most complete data sets have greater potential to contribute to the development of meaningful conclusions.
>
> Some of the data needed to explain why pavements perform as they do, do not have to be collected at every site.
>
> The States, Provinces, and FHWA have limited resources. Increases in data collection in one area must be offset by decreases in another area.

Working with the States and Provinces, FHWA will adjust the data collection program by mid-1999.

## Critical Issues

Three critical issues affect LTPP's ability to achieve its potential in the short and long terms. They are:

Data Resolution

The success of the Data Resolution effort is vital to LTPP. Since data are the foundation of and the means for verification for new pavement design procedures for years to come, the consequences of missing or incomplete data are quite significant. While much can be done with the available data, LTPP cannot fully deliver its promised benefits without resolving the current data issues.

Resources

It goes without saying that adequate funding for the States, Provinces, and FHWA is essential to the successful conduct of LTPP. For LTPP to be fully effective, the activities undertaken by FHWA must be funded at or above 1997 budget levels. In addition, the States and Provinces must provide additional funds to support their contributions to LTPP data collection, as well as their efforts to use the data.

However, money alone is not enough. The resource that may be even more critical to the ultimate success of LTPP is the availability within the States, Provinces, and FHWA of experienced and capable staff to get the job done. The ever-shrinking staff levels within most public agencies pose a serious threat to our ability to effectively deliver on LTPP's potential.

State and Provincial Participation

It is crucial that the States and Provinces maintain their full and active participation in LTPP. This includes providing materials testing and traffic data, traffic control for data collection, and participation in any additional data collection that may be needed.

# THE PARTNERSHIP

Since its inception, LTPP has depended on the cooperative efforts of the highway engineering community. Figure 2 (see below) presents LTPP's partners and their respective roles. As LTPP moves into its second decade, each of these partners will continue to play a key role in helping LTPP achieve its full potential.

## The States And Provinces

As the owner agencies of the LTPP test sections, the State and Provincial highway agencies have been critical to LTPP's achievements to date, and play a pivotal role in LTPP's future. In addition to providing the test sections, the States and Provinces collect traffic volume and weight data, perform materials testing, report maintenance and rehabilitation activities, and provide traffic control for pavement data collection activities.

As builders of today's highways, the States and Provinces also play the lead role as the primary users of the results garnered from the LTPP program. Now, with the availability of DataPave, the States and Provinces can expand this role to include using the actual LTPP data to address local and regional pavement technology needs.

## Federal Highway Administration

FHWA's Office of Engineering R&D manages the day-to-day operation of LTPP. This includes the collection, processing, and dissemination of data, along with national analysis activities.

In 1996, FHWA established an LTPP Implementation Team composed of engineers from FHWA Regional Offices. The team's mission is to take LTPP research findings and turn them into practical engineering tools. Its most notable accomplishment has been the introduction of DataPave in 1998. For the longer term, FHWA is working to integrate LTPP product development and delivery activities into its broader Pavement Technology Program.[1]

## American Association Of State Highway And Transportation Officials

While the individual States and Provinces play the key role in getting the LTPP data collected, the collective leadership role of AASHTO has been critical to past successes in test section recruitment and the adoption of LTPP-developed methods, procedures, and guidelines as standards for pavement engineering. Continued leadership and support are critical to the success of the current data resolution initiative and the adoption of future LTPP outputs.

## Transportation Research Board

The Transportation Research Board (TRB) provides an independent forum in which the States, Provinces, industry, and academia can provide input and advice on the conduct of LTPP research and implementation activities. The TRB-LTPP Committee provides management-level input on the conduct of LTPP. A subcommittee that provides advice and counsel on matters relating to strategic planning, data resolution, and monitoring adjustments supports the TRB-LTPP Committee. In addition, several topic-specific Expert Task Groups provide input on technical details.

[1]Contact the Pavement Division, Office of Engineering at paul.teng@fhwa.dot.gov for more information on the Pavement Technology Program.

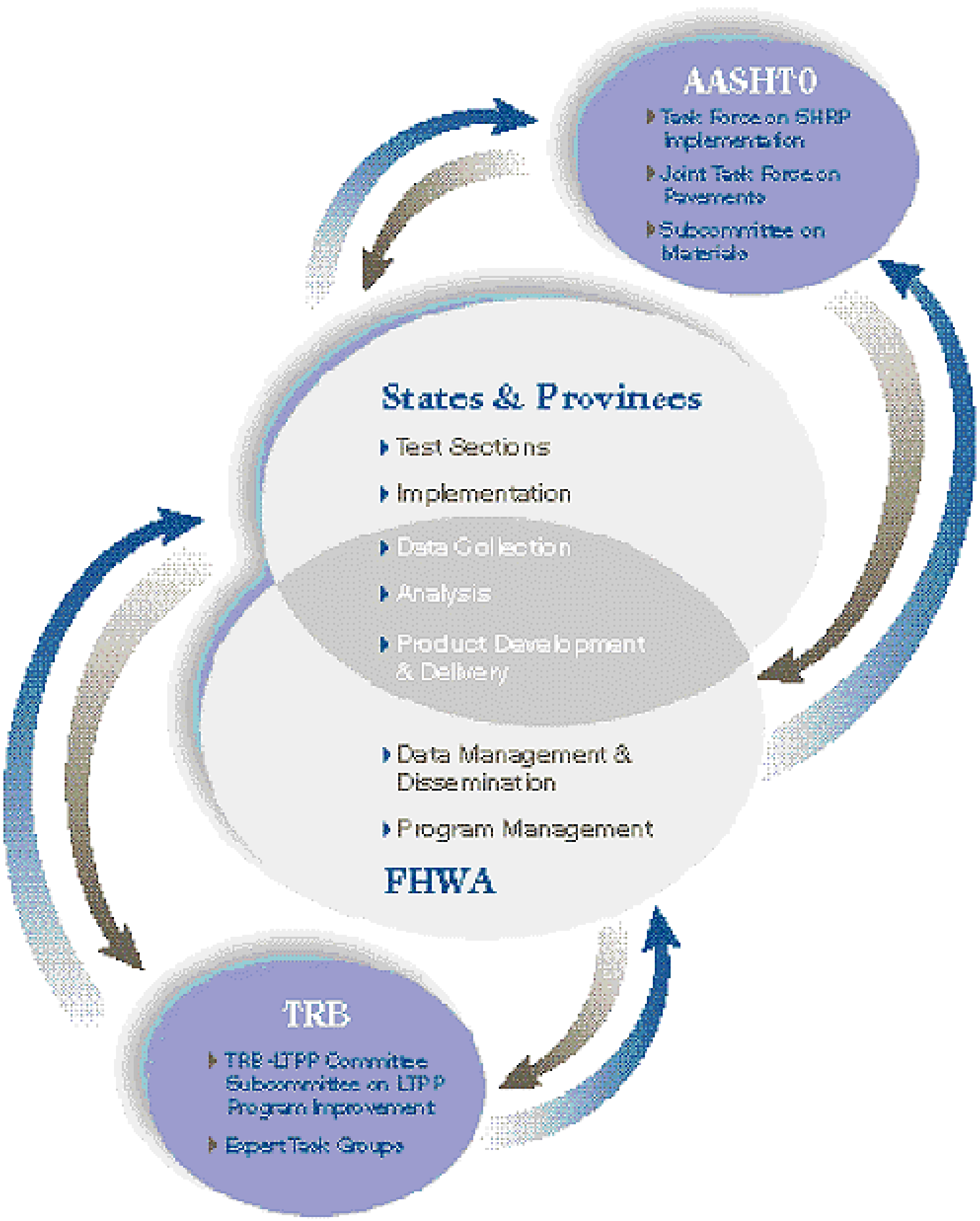


**Figure 2. The Partnership.**

## Future Opportunities

LTPP is the largest and most comprehensive pavement study in the world. The data it has collected since its inception represent a wealth of information — information that can be used to benefit not only its partners, but the global highway community as well.

Indeed, this is already happening. LTPP data were used to develop a module for the World Bank's Highway Design and Maintenance Model software. It is also being used for the development of the AASHTO 2002 Pavement Design Guide. And perhaps, most significantly, LTPP data are now readily available to the entire highway community via DataPave.

Today, any State or Provincial highway agency, pavement manager, pavement engineer, or researcher can access all of LTPP's data at any time. The potential for advancing the state of pavement technology is clearly enormous. Analysis efforts can be tailored to local sites, yielding products that directly meet local or regional needs. State or Provincial highway agencies can develop pavement strategies that cost-effectively address their own unique requirements.

Understanding pavement performance is vital to building and maintaining highway systems. Throughout its first decade, LTPP has furthered the understanding of "how" pavements perform. As it moves into its second decade, LTPP seeks to build on these efforts to further knowledge of "why" pavements perform as they do.

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## Appendix

### LTPP Methodology

To ensure that its results were technically sound, valid, and defensible, LTPP undertook a scientific approach to the study of pavement performance. Significant variables were identified. These included: pavement structure; materials properties of the pavement layers; traffic loads applied to the pavement structures; climatic conditions; pavement conditions; and related influencing factors such as quality of construction, the influence of maintenance, and other special or unique design features. Experimental designs were then developed under two broad categories — General Pavement Studies and Specific Pavement Studies. Lastly, analytical procedures were put in place for analyzing the information and data acquired from LTPP studies.

To date, this approach has yielded the following results:

LTPP Reports

Analyses Relating to Pavement Material Characterizations and Their Effects on Pavement Performance (FHWA-RD-97-085)

Backcalculation of Layer Moduli of LTPP General Pavement Study (GPS) Sites (FHWA-RD-97-086)

Common Characteristics of Good and Poorly Performing PCC Pavements (FHWA-RD-97-131)

Concrete Pavement Maintenance Treatment Performance Review, SPS-4 5-Year Data Analysis (FHWA-RD-97-155)

Design and Construction of PCC Pavements — Volume I (FHWA-RD-98-052)

Design Pamphlet for the Backcalculation of Pavement Layer Moduli in Support of the 1993 AASHTO Guide for the Design of Pavement Structures (FHWA-RD-97-076)

Design Pamphlet for Determination of Design Subgrade in Support of the 1993 AASHTO Guide for the Design of Pavement Structures (FHWA-RD-97-083)

Design Pamphlet for the Determination of Layered Elastic Moduli for Flexible Pavement Design in Support of the 1993 AASHTO Guide for the Design of Pavement Structures (FHWA-RD-97-077)

Determining Soil Volumetric Moisture Content Using Time Domain Reflectometry (FHWA-RD-97-139)

Investigation of Development of Pavement Roughness (FHWA-RD-97-147)

Long-Term Pavement Performance Information Management System Data Users Reference Manual (FHWA-RD-97-001)

LTPP Materials Characterization Program: Resilient Modulus of Unbound Materials (LTPP Protocol P46) Laboratory Startup and Quality Control Procedures (FHWA-RD-96-176)

LTPP Seasonal AC Pavement Temperature Model (FHWA-RD-97-103)

LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines (FHWA-RD-94-110)

Mechanistic Evaluation of Test Data From LTPP Flexible Pavement Test Sections (FHWA-RD-98-012)

Mechanistic Evaluation of Test Data From LTPP Jointed Concrete Pavement Test Sections (FHWA-RD-98-094)

Pavement Treatment Effectiveness, 1995 SPS-3 and SPS-4 Site Evaluation, National Report (FHWA-RD-96-208)

Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction (FHWA-RD-96-198)

Rehabilitation Performance Trends: Early Observations From Long-Term Pavement Performance (LTPP) Specific Pavement Studies (SPS) (FHWA-RD-97-099)

Temperature Predictions and Adjustment Factors for Asphalt Pavements (FHWA-RD-98-085)

## LTPP TechBriefs

Advanced Methods for Using FWD Deflection-Time Data to Predict Pavement Performance (FHWA-RD-97-093)

Improved Guidance for Users of the 1993 AASHTO Flexible Pavement Design Procedures (FHWA-RD-97-091)

Improving Accuracy of Unbound Resilient Modulus Testing (FHWA-RD-97-090)

LTPP Data Analysis: Frequently Asked Questions About Joint Faulting With Answers From LTPP (FHWA-RD-97-101)

LTPP Data Analysis: Improved Low Pavement Temperature Prediction (FHWA-RD-97-104)

LTPP Data Analysis: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction (FHWA-RD-97-035)

Pavement Treatment Effectiveness, 1995 SPS-3 and SPS-4 Site Evaluation, National Report (FHWA-RD-97-029)

*LTPP Reports and TechBriefs are available from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, Telephone: (703) 486-4600.

## AASHTO Standards

AASHTO PP7-94 Practice for Calibrating the Load Cell and Deflection Sensors for a Falling Weight Deflectometer

AASHTO PP8-94 Practice for Calibrating the Reference Load Cell Used for Reference Calibration for Falling Weight Deflectometer

AASHTO PP31-97 Standard Practice for Measuring Pavement Profile Using a Rod and Level

AASHTO PP32-97 Standard Practice for Measuring Pavement Profile Using a Dipstick®.

AASHTO TP29-94 Standard Test Method for Determining the Shear Strength at the Interface of Bonded Layers of Portland Cement Concrete

AASHTO TP31-94 Standard Test Method for Determination of the Resilient Modulus of Bituminous Mixtures by Indirect Tension

AASHTO TP33-94 Uncompacted Void Content of Fine Aggregate

AASHTO TP46-94 Standard Test Method for Determining the Resilient Modulus of Soils and Aggregate Materials

*AASHTO Standards are available from: AASHTO Publications Office, P.O. Box 96716, Washington, DC 20090-6716, Telephone: (800)231-3475, Fax: 1(800)525-5562.