LTPP AND THE 2002 PAVEMENT DESIGN GUIDE

2002 PAVEMENT
DESIGN GUIDE

WHY A NEW PAVEMENT DESIGN GUIDE?

The American Association of State Highway and Transportation Official's (AASHTO) *Guide for the Design of Pavement Structures* is widely used in the design of new and rehabilitated highway pavements. However, the current Design Guide, published in 1993, is widely recognized as being inadequate for the design challenges currently faced by highway agencies because it relies on empirically based procedures founded on test data that are not representative of current pavement design conditions.

The limitations of the 1993 Design Guide with regard to pavement rehabilitation are particularly problematic, because pavement rehabilitation requires a major commitment of resources by the Nation's highway agencies. In 1995, highway agencies spent approximately $17 billion on pavement-related projects, with $12.4 billion of the capital outlays going toward pavement-related rehabilitation projects.

The sheer magnitude of annual expenditures on pavements justifies the application of the best available design procedures in order to optimize the use of highway funds. The 1993 Design Guide does not offer the best available design procedures. For this reason, the National Cooperative Highway Research Program (NCHRP) has undertaken Project 1-37A, "Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures."[1]

U.S. Department of Transportation
Federal Highway Administration

WHAT MAKES A NEW DESIGN GUIDE POSSIBLE TODAY?

Three factors make it possible to develop the 2002 Design Guide: (1) the technical foundation for mechanistically based pavement design procedures developed over the last three decades through pavement research in the United States and internationally, (2) the availability of Long Term Pavement Performance (LTPP) in-service pavement performance data to enable calibration and validation of the design procedures, and (3) the processing speed and data storage capacity of today's desktop computers. Together, these factors make it possible to develop a practical mechanistic-empirical pavement design procedure for highway pavements.

BENEFITS OF THE 2002 DESIGN GUIDE

The 2002 Design Guide will:

- Provide tools to enable the designer to evaluate the effects of variation in:
  —Materials.
  —Traffic loading conditions.
  —Design features.
- Consider both long-term (aging) and short-term (temperature and moisture-related) changes in material properties.
- Provide more accurate performance predictions so that the frequency of premature failure is reduced, resulting in an estimated average annual savings in pavement rehabilitation costs of $1.14 billion per year over the next 50 years.
- Improve the ability to evaluate premature failures and the factors contributing to exceptionally good performance.
- Provide broader applicability and greater adaptability than the current Design Guide.

LTPP

The LTPP program is a comprehensive 20-year study of in-service pavements located throughout North America. The program's goal is to provide answers to how and why pavements perform as they do. To this end, LTPP gathers, processes, and analyzes data describing the structure, service condition, and performance of more than 2,400 in-service test sections in all 50 States, the District of Columbia, Puerto Rico, and the 10 Canadian Provinces. Routine LTPP performance monitoring has been ongoing since 1989. Some of the pavements represented in the LTPP database have been in service for up to 30 years.

The collected data are housed in the LTPP database, the most comprehensive source of information on pavement performance in the world. These data document the performance of a broad array of pavement designs, in a wide range of service conditions, making possible the development, calibration, and validation of broadly applicable models to predict pavement performance. The models are key elements in pavement design procedures. The LTPP database also provides a strong basis for the development of guidelines for the selection of default or typical values for design inputs.

The performance models used in the current Design Guide are based on a single measure of performance—the present serviceability index or rating (PSI or PSR), which is a measure of ride quality as perceived by the user. Yet, in many cases, pavement managers today find that distress factors other than ride (such as cracking and rutting) control when pavement rehabilitation is required. Design procedures based on several distress-specific performance models are needed to allow engineers to better consider the potential modes of pavement failure so that the optimal combination of materials, layer thicknesses, and design features can be selected.

The importance of LTPP to the development of the 2002 Design Guide was recognized from the very start. Members of the LTPP staff met with representatives of the 2002 Design Guide development team in order to exchange information regarding what was needed and what LTPP could provide. Where feasible and appropriate, LTPP data processing, release, and analysis schedules were adjusted to ensure that LTPP would be in a position to make the maximum possible contribution to the 2002 Design Guide.

LTPP DATA ADDRESS THE CURRENT DESIGN GUIDE'S LIMITATIONS

Many of the limitations of previous versions of the Design Guide stem from the limitations of the American Association of State Highway Officials (AASHO) Road Test on which they were based. Other limitations are related to the performance models themselves. LTPP data will help to address many of these limitations as shown below:

1. **The LTPP database has sections with very high traffic loadings.** There is an order-of-magnitude difference between the AASHO Road Test traffic and the traffic carried by modern new and rehabilitated pavements. Road test pavements sustained, at most, 10 million axle-load applications. This was less than that carried by some modern pavements in their first year of use because of the explosive growth of truck traffic over the last 40 years. Using the current Design Guide for today's traffic streams means projecting far beyond the original data. The resulting designs may be either "under-designed" or "over-designed," resulting in a significant economic loss.

2. **Some of the test sections represented in the LTPP database have been in service for 30 years or more.** Another limitation is the short duration of the road test and the fact that the long-term effects of climate and aging on materials were not addressed. The AASHO Road Test was conducted over a 2-year period, while the design lives for many of today's pavements are 20 to 50 years.

3. **The LTPP database has performance data on rehabilitated pavements.** The AASHO Road Test did not provide performance data for rehabilitated pavements.

4. **LTPP sections cover all climatic conditions in the United States.** Since the road test was conducted at one specific geographic location, it did not address the effects of differences in climatic conditions on pavement performance. For example, at the road test, a significant amount of distress occurred in the pavements during the spring thaw, a condition that does not exist in a significant portion of the country.

5. **LTPP sections cover an extremely wide range of subgrade materials.** One type of subgrade was used for all of the test sections in the road test. Many types exist nationally.

6. **LTPP sections have a variety of base materials.** Only unstabilized, dense granular bases were included in the main pavement sections in the road test (limited use of treated bases was included for flexible pavements). Various stabilized types are now used routinely.

7. **The LTPP sections represent the wear from the vehicle fleet of the 1980s and 1990s.** In the road test, vehicle, suspension, axle configurations, and tire types were representative of the types used in the late 1950s. Many of these were out-of-date by the 1990s.

8. **LTPP has some sections with drainage systems.** Pavement designs, materials, and construction were representative of those used at the time of the road test. No subdrainage was included in the road test sections.

9. **LTPP data support distress-specific performance models.** The performance models used in the current Design Guide are based on a single measure of performance—the present serviceability index or rating (PSI or PSR), which is a measure of ride quality as perceived by the user. Yet, in many cases, pavement managers today find that distress factors other than ride (such as cracking and rutting) control when pavement rehabilitation is required. Design procedures based on several distress-specific performance models are needed to allow engineers to better consider the potential modes of pavement failure so that the optimal combination of materials, layer thicknesses, and design features can be selected.

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LTPP DATA USED FOR CALIBRATION AND VALIDATION

Calibration

Calibration is the process of making adjustments to the theoretical models to compensate for model simplifications and limitations in simulating actual pavement behavior and distress development.

- LTPP data will be used to calibrate distress prediction models for fatigue cracking, transverse cracking, and rutting in asphalt concrete (AC) pavements, and for joint faulting, transverse cracking, and punchouts in portland cement concrete (PCC) pavements.
- The model predictions for pavement roughness will be calibrated using the LTPP International Roughness Index (IRI) data.

Validation

The purpose of validation is to determine whether the model provides a reasonable prediction of actual performance, and if the desired accuracy or correspondence exists between predicted and monitored performance. Validation involves using data and information from a different source than was used to develop and calibrate the model:

- A subset of the available LTPP data will be used to validate the accuracy of the component models being considered for the 2002 Design Guide. LTPP data will play a critical role in the validation of the cracking, rutting, and faulting models. Model predictions for cracking, rutting, and faulting will be compared to the actual measurements taken by LTPP. The models' accuracy will be validated over a range of conditions, locations, and climates.
- The 2002 Design Guide will use the International Roughness Index (IRI) as a major performance indicator. One of the strongest data elements in the LTPP database is its longitudinal profile data, which is used to calculate the IRI. Again, model predictions will be validated with actual LTPP IRI values over a range of conditions, locations, and climates.
- The 2002 Design Guide will recommend the use of the Enhanced Integrated Climatic Model (EICM) as a tool to assist in estimating seasonal variations in the pavement materials. The LTPP seasonal monitoring data and the analysis of the data by FHWA staff are helping to make that possible. Early work resulted in the identification of the need for improvements in the moisture prediction capabilities of the model. Subsequent work with the revised and validated model will yield guidelines for its application in the design process.

LTPP DATA AND PROCEDURES USED AS INPUTS AND FOR EVALUATION

In addition to the calibration and validation roles, the LTPP data and procedures play a working part in the 2002 Design Guide. The LTPP data will be used by pavement designers to supplement project-specific data or when such data are not available. The LTPP procedures for testing materials, computing design inputs, and evaluation of existing pavement conditions will also be part of the 2002 Design Guide. Specific examples are:

1. The LTPP database contains traffic loading data histories for a wide array of locations across the United States and Canada. When project-specific traffic data are not available, the LTPP database can provide reasonable estimates of traffic loadings. LTPP is also developing traffic volume and loading projection procedures. These procedures may also be useful to pavement designers for estimating future traffic loadings or for estimating the past cumulative traffic loads that a pavement has carried.

2. The LTPP database is a source of pavement and subgrade material properties. The LTPP data can be used when site-specific data are not available or to supplement or confirm limited existing data. Some examples of material properties that are available from LTPP are subgrade gradations, moisture content, resilient modulus, density, and portland cement concrete thermal expansion values.

3. One of the materials tests that LTPP performs on the soils is the resilient modulus test. The procedure developed by LTPP is superior to the previous test method and has been adopted by AASHTO. The LTPP resilient modulus test procedure will form the basis for the procedure recommended in the 2002 Design Guide.

4. The LTPP database includes extensive climatic information for all of the LTPP test sites. For most sites, the data are estimates derived from National Oceanic and Atmospheric Administration (NOAA) weather data from the five weather stations closest to the test site. Climatic data for the SPS-1 and SPS-2 projects[2] are obtained from on-site weather stations, and these data have been used to validate the procedures used to estimate climatic information for the other test sites. With the wide dispersion of the LTPP sites, the LTPP database is an excellent source of climatic information for pavement design inputs in the 2002 Design Guide.

5. LTPP collects a number of basic properties or data elements and uses these data to calculate a parameter or summary statistic for use in pavement engineering. Among these are backcalculated material layer moduli. The backcalculation procedures to be recommended in the 2002 Design Guide will be based on LTPP procedures. In addition, the backcalculation results in the LTPP database will be used to define typical values that can be used when falling-weight deflectometer (FWD) test data are not available or to supplement or confirm available data.

6. The FWD is used by more than 35 highway agencies and numerous consultants in evaluating the structural condition of pavements. The FWD is a complex piece of test equipment and must be operated properly to produce accurate and reliable results. To ensure accurate FWD data, LTPP has developed standardized calibration procedures and has also set up four regional calibration centers owned and operated by State highway agencies. The LTPP FWD calibration procedures and periodic calibration will be recommended in the 2002 Design Guide.

THE ROLE OF LTPP DATA IN THE FUTURE ENHANCEMENT OF THE 2002 DESIGN GUIDE

The LTPP program will be the source of additional data and research findings to support the future enhancement of the 2002 Design Guide. Specifically:

- The SPS-1 and SPS-2 projects (new construction for AC and PCC, respectively) are relatively young and LTPP has only a few years of performance data from these projects. As these projects age, LTPP will be able to produce definitive information on the impact of the different design features considered in these experiments on performance, and thus, further advance understanding of how and why pavements perform as they do. These findings can, in turn, be used to further enhance the Design Guide.

- The SPS-5 and SPS-6 projects[3] address rehabilitation for AC and PCC test sections. Again, continued monitoring and future analysis will provide valuable information on the long-term performance of the different rehabilitation treatments that can be used to enhance the Design Guide.

- The 2002 Design Guide is restricted to models now available. Ongoing and planned analysis of the LTPP data will increase our understanding of pavement performance. These results will contribute to the enhancement of the Design Guide performance models or replacement of those models with more accurate ones.

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[1]The 2002 Design Guide is being developed under NCHRP Project 1-37A, under contract with ERES Consultants, Inc. The responsible NCHRP officer is Dr. Amir Hanna, NCHRP, 2101 Constitution Avenue, NW, Washington, DC 20418, ahanna@nas.edu.

[2]SPS-1 focuses on the Strategic Study of Structural Factors for Flexible Pavements. SPS-2 focuses on the Strategic Study of Structural Factors for Rigid Pavements.

[3]SPS-5 focuses on the Rehabilitation of Asphalt Concrete Pavements. SPS-6 focuses on the Rehabilitation of Jointed Portland Cement Concrete Pavements.