TECHBRIEF

Improved Guidance for Users of the 1993 AASHTO Flexible Pavement Design Procedures

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Background

A key challenge faced by engineers using the 1993 AASHTO Guide for Design of Pavement Structures (AASHTO Guide) is the determination of appropriate design parameters for the subgrade and pavement materials. The Long-Term Pavement Performance (LTPP) data analysis project, Analyses Relating to Pavement Material Characterizations and Their Effects on Pavement Performance, was undertaken to develop improved guidance for characterization of flexible pavement materials within the AASHTO Guide design process.

Specific discussion of the key findings (and documentation of the research itself) is provided in the project reports: Analysis Relating to Pavement Material Characterizations and Their Effects on Pavement Performance (FHWA-RD-97-085), and Backcalculation of Layer Moduli of LTPP General Pavement Study Sites (FHWA-RD-97-086).

Key Products

This LTPP data analysis has resulted in three design pamphlets to aid in characterizing flexible pavement materials for design.

1. *Determination of Design Subgrade Moduli in Support of the 1993 AASHTO Guide for Design of Pavement Structures* (FHWA-RD-97-083) details recommended procedures to determine the design resilient modulus of subgrade soils. The design pamphlet includes recommendations for characterization and exploration of subsurface soils, laboratory test procedures, and determination of the design subgrade soil resilient modulus. Both the AASHTO Guide serviceability criteria and minimization of permanent deformation in the subgrade are considered.

The Long-Term Pavement Performance (LTPP) program is a 20-year study of inservice pavements across North America. Its goal is to extend the life of highway pavements through various designs of new and rehabilitated pavement structures, using different materials and under different loads, environments, subgrade soil, and maintenance practices. LTPP was established under the Strategic Highway Research Program, and is now managed by the Federal Highway Administration.

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2. *Design Pamphlet for the Determination of Layered Elastic Moduli in Support of the 1993 AASHTO Guide for the Design of Pavement Structures* (FHWA-RD-97-077) details recommended procedures to determine the design resilient modulus of different pavement materials. These suggested procedures consider the seasonal variation of resilient modulus to estimate the structural layer coefficients for use in flexible pavement design. The design pamphlet also includes recommended C-values for adjusting backcalculated linear elastic moduli to laboratory-measured resilient moduli at comparable stress states and/or temperatures.

3. *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) presents the procedures to backcalculate pavement layered elastic moduli. The recommended procedure presented was based on a combination of ASTM D5858 and the procedure developed as a product of the LTPP program of the Strategic Highway Research Program (SHRP).

Impacts of These Products

In the near term, application of these products is expected to facilitate and improve application of the AASHTO Guide flexible pavement design procedures. Their use will provide: (1) improved designs, (2) more realistic estimates of pavement behavior and performance, and (3) more consistent use of the design parameters. Although specifically directed for use with the 1993 AASHTO Guide procedures, use of these products will also give agencies a leg up on implementation of mechanistic-empirical design procedures that will probably require similar materials characterization.

Key Findings

The key analysis findings reflected in the design pamphlets are as follows:

Backcalculated Layer Moduli for Structural Design

- Backcalculation of layer moduli using elastic layer theory can be used to determine the resilient modulus of different pavement layers. However, the *in situ moduli must be adjusted* to represent or equal the laboratory-measured values for those design procedures developed with laboratory-measured moduli (which includes the AASHTO Guide). Layer moduli backcalculated with different programs should *not* be used interchangeably because of the differences found between the various backcalculation programs. The adjustments converting field-calculated moduli to laboratory-measured values (as reported in this study) are only applicable to the MODULUS and WESDEF programs.
- Elastic layer theory is *not* applicable to all types of measured deflection basins. Some deflection basins are considered problem basins because they are not typical of those calculated with linear elastic layer theory. Although equivalent linear elastic layer moduli can be determined from problem deflection basins, the linear elastic modulus may not be representative of the actual in situ material.
- Backcalculated layer elastic moduli are almost always greater than the laboratory-measured values at comparable stress states and/or temperatures.
- Because there is *no* unique solution for a specific deflection, it is critical that the matching error between measured and calculated deflections be as low as possible. A value of 2 percent or less per sensor should be obtained when using the backcalculated moduli for design.

Subgrade Characterization for Structural Design

- Determination of the design subgrade moduli utilizing the relative damage factors, based on the AASHTO serviceability criteria, tends to be greater than the design subgrade moduli calculated using damage factors based on minimizing the subgrade vertical compressive strain at the top of the subgrade. All pavement designs generated with the AASHTO Guide should be checked using the response criteria of minimizing subgrade vertical compressive strains, especially for lower volume roadways.
- Correlations with physical properties of the subgrade soil should *not* be used to estimate the design resilient modulus for pavement structural design for high-volume roadways. The design resilient modulus should be determined from laboratory resilient modulus tests or backcalculated from deflection basins. The possibility of

large errors is simply too high when using gross correlations between physical properties or strength values (such as California Bearing Ratio) and resilient modulus.

Drainage Considerations

- The AASHTO drainage coefficients are not recommended for use in structural design. Instead, the design process should account for a reduction in the resilient modulus to account for saturated conditions through the calculation of a design modulus using relative damage factors for unbound materials.
- The use of positive drainage features in both asphalt concrete- and portland cement concrete-surfaced pavements was not qualified through the use of the LTPP data base. Some of the problems in identifying the potential benefit of subsurface drainage features may be related to the assumption that the positive drainage system is functioning properly. As such, it is recommended that those sites with positive drainage features (i.e., edge drain systems) be inspected by video inspection techniques to confirm that these drainage features are, in fact, functioning.

Determination of Design Layered Moduli

- Seasonal variations of layered moduli (estimated through moisture and/or temperature differences between the seasons) must be considered in determining the design modulus of different materials so that the structural layer coefficients can be determined for use with the AASHTO Guide. The design resilient modulus can be determined using a damage concept similar to that used in determining an effective resilient modulus of the roadbed soil. More specifically, structural designs based on a serviceability criteria should be checked using other pavement response criteria (i.e., asphalt concrete tensile strains, subgrade vertical compressive strains, layer modulus ratios, etc.).

Researcher: This study was performed by Brent Rauhut Engineering, Inc. Contract No. DTFH61-95-C-00029.

Distribution: This TechBrief is being distributed according to a standard distribution.

Availability: The publications related to this TechBrief are *Determination of Design Subgrade Moduli in Support of the 1993 AASHTO Guide for Design of Pavement Structures* (FHWA-RD-97-083), *Backcalculation of Layer Moduli of LTPP General Pavement Study Sites* (FHWA-RD-97-086), and *Design Pamphlet for the Determination of Layered Elastic Moduli in Support of the 1993 AASHTO Guide for Design of Pavement Structures* (FHWA-RD-97-077). These publications will be available in late 1997. Copies will be available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. A limited number of copies will be available from the R&T Report Center, HRD-11, FHWA, 9701 Philadelphia Court, Unit Q, Lanham, MD 20706, Telephone: (301) 577-0818, Fax: (301) 577-1421.

Key Words: AASHTO Guide, resilient modulus, flexible pavement design, layer moduli.