Recalibration Procedures for the Structural Asphalt Layer Coefficient in the 1993 AASHTO Pavement Design Guide

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

RESEARCH SYNOPSIS 14-08

Background

The American Association of State Highway and Transportation Officials (AASHTO) released the new standard for pavement thickness design in the U.S. based on mechanistic-empirical concepts in 2007. The new Mechanistic-Empirical Pavement Design Guide (MEPDG) and accompanying software released in 2013, AASHTOWare™ Pavement ME Design, represent many years of research and development to overcome the deficiencies of the long-standing empirically-based pavement design method. The main deficiency of the empirically-based procedure is that it was calibrated primarily to the conditions and observed performance during the AASHO road test conducted from 1958-1960 in Ottawa, Illinois (*1*). The performance resulted from the climate, materials, construction practices and traffic applications representing late 1950's conditions and technology at this one test location. Based on the results of this study, an empirical pavement design guide was developed and has since been through many revisions, with the latest being the 1993 AASHTO Design Guide (*2*). The tremendous advances in pavement engineering, design, materials and construction fields over the past five decades have made the 1993 AASHTO Design Guide (*2*) more outdated with every passing year, forcing designers to extrapolate well beyond the original conditions and subsequent design limitations of the road test. In many cases, this extrapolation can lead to non-optimized pavement cross-sections. For high traffic volume designs, the non-optimized pavement based on extrapolatioin may be too thick.

Though the MEPDG and accompanying software are recognized as a technological leap forward, there are many costs for state agencies considering adopting the new technology. These include software licensing and training, development of data sets required by the new procedure and validation/calibration studies needed prior to full deployment of the MEPDG. Currently, the older empirically-based design procedure is the most popular approach in the U.S. with 78% of states using some edition (i.e., 1972, 1986 or 1993 Design Guide) of the empirical AASHTO procedure (*3*, *4*). A recent survey of state agencies indicates that many states plan to adopt the MEPDG, but only three have currently done so while fourteen expect to implement within the next two years (*4*). The other states are at least two years from implementing the MEPDG and six do not currently plan to implement the MEPDG (*4*). For states that have already begun working toward implementing the MEPDG, there are many data sets (i.e., traffic, material properties, and performance records) that are common between the empirical and mechanistic-empirical approaches, so it would make sense to update the old method while implementing the new approach. Finally, given the complexities of the MEPDG and design software, there may be many design scenarios (e.g., facilities such as city streets, county roads, lower volume state routes) that simply do not warrant such a detailed analysis.

Clearly, there is a gap between the outdated empirically-based procedure and the MEPDG that should be filled to achieve optimal pavement structural designs. The purpose of this document is to provide recommended procedures for updating the AASHTO empirically-based design method to reflect modern pavement performance through recalibrating the structural asphalt layer coefficient. Rationale for recalibrating the asphalt coefficient is that it was AASHTO's original intent that states develop agency-specific structural coefficients. As explained by K.P. George (*5*), "Because of wide variations in environment, traffic and construction practices, it is suggested that each design agency establish layer coefficients based on its own experience and applicable to its own practice."

Structural Asphalt Layer Coefficient

The empirical AASHTO design approach (*2*) is based, in part, on quantifying the relative load carrying capabilities of the various materials used in a flexible pavement system. These "structural coefficients" are actually regression coefficients derived from correlating pavement performance to pavement thickness and were originally determined at the AASHO road test (*1*). Many states (45%) use a coefficient of 0.44 for the asphalt concrete layer, which was originally recommended by AASHO (*1*) in 1962 while 28% of state agencies use a coefficient smaller than this value (*3*). Given the many improvements made within design, construction, specifications, quality control and the material itself, it makes sense that the default value should be re-examined and recalibrated to reflect modern conditions.

Recalibration Procedures

There are a variety of approaches to determining a new structural asphalt layer coefficient, divided into three basic categories, discussed within the recalibration manual and as summarized in Table 1.

Procedure Type	General Process	Advantages	Disadvantages
Deflection-Based	Conduct deflection testing on existing pavement section. Use deflection data to backcalculate pavement properties. Correlate backcalculated properties to structural coefficients using pre-existing equations.	Relatively rapid procedure. Requires only short-term data sets. Relatively little deflection testing needed.	Does not correlate to section-specific performance. Relies primarily on past correlation studies.
Performance-Based	Pavement ride quality data are used to quantify changes in pavement serviceability over time. These changes are correlated to measured traffic levels (Actual ESALs) and the structural number equation is used to provide predicted traffic levels (Predicted ESALs). The structural coefficient is used as a calibration coefficient to minimize the error between actual and predicted ESALs.	Most closely replicates how the original AASHO structural layer coefficients were determined. Calibrates to actual pavement performance. Relatively simple method, once traffic and performance records have been compiled.	Historical performance data needed. Historical traffic data (ESALs) needed.
Mechanistic-Empirical	The MEPDG is locally-calibrated and used to generate pavement thickness designs. The asphalt structural layer coefficient is then recalibrated to provide thicknesses that match the MEPDG thicknesses.	Calibrates both empirical and M-E approaches. Calibrates to actual pavement performance. Provides continuity between design systems.	Most intensive procedure in terms of required data. Requires calibration of the MEPDG, which is a costly and time-consuming process.

Deflection-Based Procedures

Deflection-based procedures rely on pre-existing correlations between pavement deflection and pavement performance. Typically, falling weight deflectometer testing provides the necessary deflection measurements from which layer properties are backcalculated. After the properties are determined, they may be entered directly into an established regression equation to provide a structural coefficient. Though deflection-based procedures may provide rapid results and require limited data, they should be validated by other approaches since they do not truly represent the performance of the materials tested. Rather, they rely on backcalculated properties linked to past performance of other pavement sections.

Performance-Based Procedures

Performance-based procedures most closely replicate how the original AASHO structural layer coefficients were determined during the AASHO road test. They rely on long-term evaluation of pavements with careful monitoring of both traffic and performance. The structural coefficient is then derived by finding the value that minimizes the difference between predicted and actual performance. These procedures are more computationally-intensive than deflection-based procedures, but have the advantage of providing a structural asphalt layer coefficient that represents the actual performance of the material tested.

Mechanistic-Empirical Procedures

Mechanistic-empirical procedures rely on using the MEPDG, locally-calibrated with performance data, to establish pavement layer thicknesses from which the structural coefficients may be determined. Though conceptually straightforward, this approach is very time and data intensive. Agencies should consider this approach if efforts are already in progress toward calibrating the MEPDG or if local calibration has been completed. The procedure involves first conducting a local calibration of the MEPDG, which may take years and significant funding to complete, followed by adjusting the structural asphalt layer coefficient so that thicknesses match between the MEPDG and the older AASHTO empirical method.

Examples of Recalibration

Any pavement design procedure should be judged according to how well it predicts pavement performance over time. Whether empirical or mechanistic-empirical, the ultimate test lies in the capability to accurately forecast future pavement distresses. Within the empirically-based 1993 AASHTO Pavement Design Guide (*2*), much of this predictive capability lies within the structural asphalt layer coefficient. Given the many advances made within the asphalt pavement industry since 1962, it is reasonable to re-examine the structural asphalt layer coefficient with the goal of improving the predictive capability of the 1993 AASHTO Design Guide (*1*).

Two recent recalibration studies conducted for the Alabama Department of Transportation (ALDOT) and Washington State DOT (WSDOT) have taken different approaches to recalibrate the structural asphalt layer coefficient yet arrived at very similar conclusions. The ALDOT study (*6*) used a performance-based approach to arrive at a 0.54 coefficient utilizing data from the National Center for Asphalt Technology (NCAT) Test Track. The study for WSDOT (*7*) used a mechanistic-empirical approach that was calibrated with pavement management system data within Washington to arrive at a 0.50 coefficient. These values are now recommended for use in their respective states when conducting designs with the AASHTO 1993 Design Guide. In the case of ALDOT, which changed from 0.44 to 0.54, an 18.5% thickness savings has been realized. As stated by Larry Lockett (*8*), the ALDOT State Materials and Tests Engineer at the time the change was implemented, "This means that our resurfacing budget will go 18% farther than it has in the past. We will be able to pave more roads, more lanes, more miles, because of this 18% savings." Though significant, it should be emphasized that any change considered by a state agency should be carefully evaluated and supported by actual pavement performance data.

References

1. Highway Research Board. *The AASHO Road Test*. Report 5: Pavement Research. Special Report 61E. National Academy of Sciences, National Research Council, Washington, D.C., 1962.
2. American Association of State and Highway Transportation Officials. *AASHTO Guide for Design of Pavement Structures*. Washington, D.C., 1993.
3. Timm, D.H., M. Robbins, N. Tran and C. Rodezno. *Flexible Pavement Design - State of the Practice.* NCAT Report 14-04. National Center for Asphalt Technology, Auburn University, 2014.
4. Pierce, L. M., and G. McGovern. *Implementation of the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) and Software*. Third Draft, NCHRP Project 20-05, Topic 44-06. October, 2013.
5. George, K.P. *Structural Layer Coefficient for Flexible Pavement*. ASCE Journal of Transportation Engineering, Vol. 110, No. 2, 1984, pp. 251-267.
6. Peters-Davis, K., and D. H. Timm. *Recalibration of the Asphalt Layer Coefficient*. NCAT Report 09-03. National Center for Asphalt Technology, Auburn University, 2009.
7. Li, J., J. S. Uhlmeyer, J. P. Mahoney, and S. T. Muench. *Use of the 1993 AASHTO Guide, MEPDG and Historical Performance to Update the WSDOT Pavement Design Catalog*. WA-RD 779.1. Washington State Department of Transportation, 2011.
8. Kuennen, T. *How Alabama Gets More Bang for Its Asphalt Buck.* Hot Mix Asphalt Technology, Vol. 15, No. 1, January/February 2010, pp. 30-35.

Authors

Dr. David Timm, P.E. – Principal Investigator, Dr. Mary Robbins, Dr. Nam Tran, P.E., Dr. Carolina Rodezno

Acknowledgements and Disclaimer

Funding for this study provided by the National Asphalt Pavement Association under the research project "Optimizing Flexible Pavement Design and Material Selection." This document is for general guidance and reference purposes only. NCAT, Auburn University, and the listed sponsoring agencies assume no liability for the contents or their use. Agencies considering modifications to their existing structural layer coefficients should carefully evaluate and support any modifications by actual pavement performance data under their jurisdiction.