Implementation Benefits

The M-E Pavement Design Guide provides significant potential benefits over the 1993 AASHTO Pavement Design Guide. Most importantly, its user-oriented computational software implements an integrated analysis approach for predicting pavement condition over time that accounts for the interaction of traffic, climate, and pavement structure; allows consideration of special loadings with multiple tires or axles; and provides a means for evaluating design variability and reliability.

The M-E Pavement Design Guide will allow pavement designers to make better-informed, cost-effective pavement design and rehabilitation decisions. Benefits include the following:

- *More appropriate designs.* The M-E Pavement Design Guide method will significantly reduce the degree of uncertainty in the design process and allow the Iowa DOT to specifically design pavement to minimize or mitigate the predominant distress types that occur in Iowa.
- *Better performance predictions.* The M-E Pavement Design Guide will help ensure that major rehabilitation activity occurs closer to the actual design life. A saving of even 1% in maintenance and rehabilitation frequencies (which is considered conservative) will lead to significant long-term savings. Iowa spends approximately $400 million annually in maintenance and rehabilitation; therefore, a 1% savings represents a potential annual savings of approximately $4 million.
- *Better materials-related research.* Materials-related research questions, such as "should richer or leaner HMA base mixtures be promoted?," can be answered through use of the M-E Pavement Design Guide, reducing the need to conduct extensive, lengthy, and costly field trials.
- *Powerful forensic tool.* The software can also serve as a forensic tool for analyzing the condition of existing pavements and pinpointing deficiencies in past designs. By analyzing failed pavements using actual materials, properties, climate, traffic, etc., the Iowa DOT will be capable of avoiding similar problems in future designs.

Implementation Readiness

The current release is only the first draft, meaning that AASHTO has yet to release a provisional design guide. The edition currently available for evaluation will change. In addition to changes to the current release, the M-E Pavement Design Guide will evolve over time. The initial release simple represents a starting point.

It will take most states approximately three years just to prepare to implement the M-E Pavement Design Guide in its current form. Waiting until other states have implemented the guide would not avoid or shorten the three year pre-implementation phase. Incremental evolutionary "patches," such as that for a reflective cracking module, will not impact the general pre-implementation process.

Limitations of the M-E Pavement Design Guide

- In its present form, the M-E Pavement Design Guide does not lend itself to use as a tool for routine, day-to-day production work.
- The M-E Pavement Design Guide and software are available only in U.S. customary units at this time.
- Because the M-E Pavement Design Guide software is a tool for pavement analysis, it does not provide structural thickness as an output.
- The rigid design component considers only jointed plain concrete pavement (JPCP) and continually reinforced concrete pavement (CRCP), but not jointed reinforced concrete pavement (JRCP).
- The flexible design component does not specifically address recycled materials in hot mix asphalt or special mix designs such as stone mastic asphalt (SMA), although the software does allow for analysis of a broad range of HMA mix design types.
- Neither the interlocking concrete pavements concept nor geosynthetic applications are specifically covered in the guide.

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The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, and reliability while improving the learning environment of students, faculty, and staff in transportation-related fields.

Implementing the M-E Pavement Design Guide in Iowa

tech transfer summary

Objectives

- Initiate a strategy to effectively and efficiently implement the new Mechanistic-Empirical (M-E) Pavement Design Guide to replace the current AASHTO Pavement Design Guide.
- Guide state and local transportation agencies in determining which pavement design input parameters have the most effect on pavement distresses such as transverse cracking, faulting, and smoothness.

Problem Statement

The reliability of the 1993 AASHTO Pavement Design Guide design method is questionable. The guide is based on methods that have evolved from the AASHTO Road Test (1958–1961). Through a number of editions from the initial publication (1962), the interim guide (1974), and other later editions, minor changes and improvements have been published. Nonetheless, these later modifications have not materially altered the original methods, which are based on empirical regression techniques relating simple material characterizations, traffic characterization, and measures of performance. In addition, the current AASHTO Pavement Design Guide does not provide performance prediction of pavements.

The newly released M-E Pavement Design Guide includes the following improvements that make it superior to the existing AASHTO Pavement Design Guide: (1) the use of mechanistic-empirical pavement design procedures, (2) the implementation of performance prediction of transverse cracking, faulting, and smoothness for jointed plain concrete pavements, (3) the addition of climatic inputs, (4) better characterization of traffic loading inputs, (5) more sophisticated structural modeling capabilities, and (6) the ability to model real-world changes in material properties.

In order to effectively and efficiently transition to the M-E Pavement Design Guide, state DOTs need a detailed implementation and training strategy. In addition, pavement design input parameters must be determined locally based on their effects on pavement performance.

Overview of M-E Pavement Design Guide

The M-E Pavement Design Guide includes (1) a guide for mechanistic-empirical design and analysis, (2) companion software with documentation and user manual, and (3) an extensive series of supporting technical documentation.

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The new mechanistic-empirical procedure uses the principles of both engineering mechanics and field verification to come up with a design process. Mechanistic methods are used to predict pavement responses, and pavement performance is predicted based on performance data collected from "real world" pavements.

The M-E Pavement Design Guide considers the response of pavement performance to the following influences:

- Traffic
- Environment
- Pavement

Traffic

Traditionally, traffic has been treated by single numbers, such as the average annual daily traffic (AADT) or by the notional equivalent single axle load (ESAL). In developing the M-E Pavement Design Guide, it was recognized that these parameters do not sufficiently recognize the differing effects of different axle loads and configurations on pavement. Consequently, the use of "traffic spectra" is now recommended. In this approach, the anticipated traffic is classified by axle type (single, tandem, tridem, etc.), and within each type, the distribution of axle weights is prescribed. Further, daily, weekly, and seasonal volume distributions are possible.

Environment

In order to incorporate environmental effects within the M-E Pavement Design Guide software, three elements are required: (1) a site-specific environmental data set (external), (2) a material-specific set of thermal-related properties such as heat capacity, thermal conductivity, etc. (internal), and (3) an algorithm to compute the transmission of heat and moisture within the pavement structure.

With the M-E Pavement Design Guide, an Iowa DOT pavement designer should be able to access climate records for at least two and preferably three locations within 25 miles from any specific project site and/or access a regional climate record covering the general area of the state in which the project is located.

Pavement

As with any pavement design procedure, it is necessary to define the materials used in the structure, their properties, thicknesses, and sequence. The M-E Pavement Design Guide can be used for the design of portland cement concrete (PCC) and hot mix asphalt (HMA) pavements, both new and rehabilitated overlay pavements.

Implementation Recommendations

- It is recommended that the Iowa DOT seek to implement the M-E Pavement Design Guide as the preferred approach to pavement design and evaluation. However, immediate implementation is neither feasible nor possible. Therefore, the Iowa DOT should seek to position itself such that general implementation is possible in approximately three years, and allow a further two years for full implementation.
- A training program for pavement engineers with an emphasis on obtaining the relevant level of design inputs should be implemented. In order to adequately implement the use of the M-E Pavement Design Guide, it will be necessary to train all Iowa DOT staff involved with the design process. Training should also be provided for representatives from the areas of traffic, materials, pavement management, and special investigations from central and district offices.
- Since the new design approach includes the use of mechanistic-empirical procedures and prediction of performance models, in-depth knowledge about use of design inputs for pavement designs is required. An expert system should be established to help pavement design engineers determine which design inputs to modify.
- A detailed comparison of M-E Pavement Design Guide results and actual field data observed should be carried out to further calibrate the M-E Pavement Design Guide locally.

Effect of Input Factors on Pavement Performance

The effect of pavement design input factors on pavement performance was evaluated.

Sensitivity of pavement performance to input factors: PCC

	Extremely sensitive	Sensitive to very sensitive
Transverse cracking	Curl/warp effective temperature difference Coefficient of thermal expansion Thermal conductivity PCC layer thickness PCC strength properties Joint spacing	Edge support Mean wheel location Unit weight Poisson's ratio Climate Surface shortwave absorptivity AADT
Faulting	Curl/warp effective temperature difference Doweled transverse joints	AADT Mean wheel location Unbound layer modulus Cement content Water/cement ratio Coefficient of thermal expansion Thermal conductivity
Smoothness	Curl/warp effective temperature difference Coefficient of thermal expansion Thermal conductivity	Doweled transverse joints AADT Mean wheel location Joint spacing PCC layer thickness PCC strength properties Poisson's ratio Surface shortwave absorptivity Unbound layer modulus Cement content Water/cement ratio

Sensitivity of pavement performance to input factors: HMA

	Extremely sensitive	Sensitive to very sensitive
Longitudinal cracking	Performance grade (PG) binder Type of subgrade	HMA layer thickness Nominal maximum size Volumetric Thermal conductivity Heat capacity Tire pressure AADT Traffic distribution Traffic velocity Climate data from different stations Base layer thickness
Transverse cracking	Performance grade (PG) binder Climate data from different stations	Volumetric Thermal conductivity Heat capacity
Rutting	AADT	Poisson's ratio Traffic velocity Climate data from different stations Base layer thickness Type of base
Smoothness		Climate data from different stations Type of base