# Implementing the *Mechanistic–Empirical Pavement Design Guide* for Cost Savings in Indiana

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The *Mechanistic–Empirical Pavement Design Guide* (MEPDG) presents a new paradigm for pavement design and analysis. Developed under the National Cooperative Highway Research Program and adopted and published by the American Association of State Highway and Transportation Officials, the MEPDG approach considers the input parameters that influence pavement performance—including traffic, climate, and pavement layer thickness and properties—and applies the principles of engineering mechanics to predict critical pavement responses (*1*). The MEPDG changes not only the design process and inputs but the way that engineers develop and implement effective and efficient pavement design.

## Problem

The MEPDG design and analysis process incorporates a hierarchical approach to design inputs for subgrade, materials, environment, traffic, and project information. The design team selects the inputs and determines the types and quantities of data needed for a reliable design case by case. This task requires a thorough evaluation of all of the design parameters and an analysis of how the values will affect the predicted performance.

Implementation of the MEPDG design process therefore demands that the designers must be knowledgeable about pavement design inputs and pavement performance. In addition, interaction is necessary among the highway agency engineers who work in traffic, materials, geotechnical areas, and pavement structures to identify the proper input parameters for the design. The design team must have sufficient knowledge in pavement engineering to ensure successful outcome of the analysis and design process.


Concrete pavement construction project in Indiana; the MEPDG design and analysis procedure has allowed a 2-in. reduction in pavement thickness and has optimized joint spacing.

## Solution

In implementing the MEPDG, the Indiana Department of Transportation (DOT) first identified candidate projects and initiated research to quantify the input parameters for pavement design. The research included traffic, materials, pavement structure, and testing. One important activity was to ensure that the team of pavement design engineers—agency staff and outside consultants—had a knowledge and understanding of the design procedure.

Consultants often have strong backgrounds in structural design, but limited familiarity with pavement design. They may have to undergo intensive pavement training to reach the required level of knowledge.

Also important is coordination with other involved parties, such as the Federal Highway Administration (FHWA), state pavement associations, and contractor associations. FHWA must approve use of the MEPDG design procedure on projects supported with federal funds. Because contractor associations represent the groups that build the pavements—and sometimes warrant or design pavements as part of design–build projects—their familiarity with the MEPDG can help in providing long-lasting pavements.

## Application

Indiana DOT began implementing the MEPDG on January 1, 2009. The early implementation was made possible by efforts that started in 2002.

The Indiana DOT Pavement Steering Committee coordinates all MEPDG implementation activities, with participation from agency pavement design engineers, FHWA, pavement associations, and contractor associations. The committee meets monthly to discuss issues in implementation and to approve the next steps. Training sessions were conducted with the cooperation of all parties in November 2008, with another session initiated by the pavement associations in March 2009.

As training and implementation progressed, Indiana DOT needed to provide customer support to pavement design engineers and consultants, to facilitate use of the MEPDG software and ensure its proper application. Most of the pavement designers and consultants gained familiarity with the new pavement design procedure within six months. They applied this knowledge in the design of projects funded through the American Recovery and Reinvestment Act of 2009. Consultants also demonstrated their knowledge and readiness to implement the MEPDG in several projects for local public agencies.

## Benefits

From January to December 2009, Indiana DOT staff and consultants designed more than 100 pavement sections using the MEPDG procedure. As required by the FHWA Indiana Division, Indiana DOT documented the pavement thickness design of all new pavements and provided comparisons between the thicknesses estimated according to the 1993 *AASHTO Guide for Design of Pavement Structures* (2) and those estimated according to the MEPDG procedures.

In addition, the Indiana DOT executive staff reviewed the cost savings attributed to the pavements designed with the MEPDG. Because the AASHTO 1993 Guide and its adaptations are in common use by state and provincial highway agencies, the cost comparison is valid. Table 1 (page 36) lists the estimated and actual cost savings for all new pavement projects let for contract from late 2008 to early 2010.

The savings shown in Table 1 result from optimized pavement structures achieved through MEPDG's more efficient design and analysis procedure and its enhanced characterization of traffic data and pavement material properties. Most of the savings came from the reduced thickness of the asphalt pavements and from a combination of the reduced thickness and the optimized joint spacing of concrete pavements.

The thickness of most of the concrete pavements on the Interstate and U.S. highway systems is reduced by 2 inches; a less prominent reduction applied to pavements on state routes. The cost savings were estimated as the difference from the average contract unit price of pavements in the Indiana DOT database. For the five completed projects, however, the total savings of $3,024,954 were calculated using the actual contract cost.

The table does not include cost savings for pavement rehabilitation projects—that is, for structural overlays. These savings are expected to be high—possibly more than $20 million for one construction season—because pavement rehabilitation projects outnumber new pavement projects.

The cost comparisons assumed that the initial construction costs for pavement structures would have a similar traffic level over a similar service life. The optimized pavement structures resulting from the MEPDG analysis procedure, however, may require different maintenance and rehabilitation actions from those determined with the earlier AASHTO design procedures; the life-cycle cost savings, therefore, would differ from the initial construction cost savings.

### Developing the *Mechanistic–Empirical Pavement Design Guide*

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The *Mechanistic–Empirical Pavement Design Guide* (MEPDG) incorporates the design methodology developed under National Cooperative Highway Research Program (NCHRP) Project 1-37A, Guide for the Design of New and Rehabilitated Pavement Structures, by ERES Consultants, Inc. (later part of Applied Research Associates, Inc.), with Arizona State University as a subcontractor. The pavement design methodology is based on engineering mechanics and validated with extensive road test performance data.

The MEPDG approach presents a major change from the pavement design methods in the 1993 *AASHTO Guide for Design of Pavement Structures*, which are based on limited empirical performance equations developed from the AASHO Road Test in the late 1950s. The design methodology applies to all pavement types by considering the same inputs in terms of climate and traffic. Through a process of modeling and consideration of material properties, distress is predicted. The designer defines an acceptable level of distress and then determines the properties and layer thicknesses that would produce the level of distress at the desired time in the pavement's life.

The mechanistic–empirical pavement design procedure relates the pavement thickness and the material properties to performance. The more detailed characterization of traffic generates a more accurate estimate of its effect on performance. In addition, the effect of construction and material variability on performance can be estimated.

The pavement can be engineered to address particular distress types. Various NCHRP projects developed Version 1.0 of the MEPDG software; AASHTO is pursuing the development of Version 2.0, expected to be available in early 2011. In addition, research under several NCHRP projects aims to enhance the applicability of the MEPDG. For more information, visit the NCHRP website, www.trb.org/NCHRP/.

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Indiana DOT asphalt pavement construction project; the agency has coordinated with contractor associations in implementing the new MEPDG procedures.

For example, the concrete pavements designed with the MEPDG procedure have a shorter joint spacing (16 ft versus 18 ft) and thus approximately 15 percent more joints that may require maintenance. Nevertheless, only a slight difference is expected, because the pavements are designed to provide similar performance and therefore should require similar maintenance.

In summary, Indiana DOT's experience has confirmed that implementation of the MEPDG results in efficient pavement designs that can be built at a lower cost, producing much-needed cost savings.

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## References

1. *Mechanistic–Empirical Pavement Design Guide: A Manual of Practice*. American Association of State Highway and Transportation Officials, Washington, D.C., July 2008.
2. *AASHTO Guide for Design of Pavement Structures*. American Association of State Highway and Transportation Officials, Washington, D.C., 1993.

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**TABLE 1 Cost Savings Attributed to Implementation of the MEPDG**

| Road | Letting Date | AASHTO 1993 Thickness, Joint Spacing | MEPDG Thickness, Joint Spacing | Estimated Contract Savings | Actual Contract Savings |
|---|---|---|---|---|---|
| I-465 | 11/19/2008 | 16", 18' JPCP | 14", 18' JPCP | $1,475,000 | $1,000,000 |
| I-465 ramps (10th St.) | 11/19/2008 | 12.5", 18' JPCP | 11", 18' JPCP | $112,000 | |
| I-80 (mainline) | 11/19/2008 | 16", 18' JPCP | 14", 18' JPCP | $361,000 | $775,170 |
| I-80 (ramp) | 11/19/2008 | 12", 18' JPCP | 10.5", 18' JPCP | $520,000 | |
| SR 14 | 3/8/2008 | 15" HMA | 13.5" HMA | $333,000 | $155,440 |
| US 231 | 11/8/2008 | 15.5" HMA | 13" HMA | $557,000 | $673,796 |
| SR 62 | 11/8/2008 | 16" HMA | 13" HMA | $403,000 | $420,548 |
| US 24 | 3/11/2009 | 12.5" JPCP | 10.5" JPCP | $720,000 | |
| SR 32 | 2/11/2009 | 15.5" HMA | 13.5" HMA | $283,000 | |
| SR 66 | 2/11/2009 | 13.5" HMA | 13" HMA | $90,000 | |
| US 31 | 2/11/2009 | 15.5" HMA | 14" HMA | $287,000 | |
| SR 641 | 3/11/2009 | 15.5" HMA | 13" HMA | $292,000 | |
| SR 3 | 3/11/2009 | 14" HMA | 13.5" HMA | $103,000 | |
| SR 23 | 4/8/2009 | 18" HMA | 13.5" HMA | $430,000 | |
| I-465 | 9/10/2009 | 16", 15' JPCP | 14", 18' JPCP | $432,000 | |
| I-70 @ I-465 & ramps | 9/10/2009 | 16", 15' JPCP | 14", 18' JPCP | $665,000 | |
| I-465 | 9/10/2009 | 16", 15' JPCP | 14", 18' JPCP | $391,000 | |
| AE @ I-465 & ramps | 9/10/2009 | 18" HMA | 14.5" HMA | $598,000 | |
| I-465 | 1/13/2010 | 16", 15' JPCP | 14", 18' JPCP | $494,000 | |
| I-74 @ I-465 & ramps | 1/13/2010 | 14.5", 15' JPCP | 12.5", 18' JPCP | $234,000 | |
| SR 37 @ I-465 | 3/3/2010 | 13.5", 15' JPCP | 12", 16' JPCP | $90,000 | |
| SR 25 Segment 3, Phase C | TBA | 14" HMA | 12.5" HMA | $484,000 | |
| US 24 Phase 2 | 2/10/2010 | 15" HMA | 13" HMA | $375,000 | |
| **Total cost savings** | | | | **$10,268,000** | |

AASHTO 1993 = *AASHTO Guide for Design of Pavement Structures,* 1993; MEPDG = *Mechanistic–Empirical Pavement Design Guide*; JPCP = jointed plain concrete pavement; HMA = hot-mix asphalt pavement; I = Interstate; SR = state route; AE = airport expressway.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2952; gjayaprakash@nas.edu).