MEPDG Work Plan Task No. 8:

Validation of Pavement Performance Curves for the Mechanistic-Empirical Pavement Design Guide

Final Report
February 2009

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16. Abstract

The objective of this research is to determine whether the nationally calibrated performance models used in the Mechanistic-Empirical Pavement Design Guide (MEPDG) provide a reasonable prediction of actual field performance, and if the desired accuracy or correspondence exists between predicted and monitored performance for Iowa conditions. A comprehensive literature review was conducted to identify the MEPDG input parameters and the MEPDG verification/calibration process. Sensitivities of MEPDG input parameters to predictions were studied using different versions of the MEPDG software. Based on literature review and sensitivity analysis, a detailed verification procedure was developed. A total of sixteen different types of pavement sections across Iowa, not used for national calibration in NCHRP 1-47A, were selected. A database of MEPDG inputs and the actual pavement performance measures for the selected pavement sites were prepared for verification. The accuracy of the MEPDG performance models for Iowa conditions was statistically evaluated. The verification testing showed promising results in terms of MEPDG's performance prediction accuracy for Iowa conditions. Recalibrating the MEPDG performance models for Iowa conditions is recommended to improve the accuracy of predictions.

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MEPDG WORK PLAN TASK NO. 8: VALIDATION OF PAVEMENT PERFORMANCE CURVES FOR THE MECHANISTIC-EMPIRICAL PAVEMENT DESIGN GUIDE

Final Report
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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EXECUTIVE SUMMARY

The current American Association of State Highway and Transportation Officials (AASHTO) Design Guide is based on methods that have evolved from the AASHO Road Test (1958–1961). Through a number of editions from the initial publication in 1962, the Interim Guide in 1972 (AASHTO, 1972) and other later editions (AASHTO, 1986; AASHTO, 1993), minor changes and improvements have been made. Nonetheless, these later modifications have not significantly altered the original methods, which are based on empirical regression techniques relating simple material characterizations, traffic characterization and measures of performance.

In recognition of the limitations of the current AASHTO Guide, the new Mechanistic Empirical Pavement Design Guide (MEPDG) and its software were developed through National Cooperative Highway Research Program (NCHRP) 1-37 A project. The mechanistic part of MEPDG is the application of the principles of engineering mechanics to calculate pavement responses (stresses, strains, and deflection) under loads for the predictions of the pavement performance history. The empirical nature of the MEPDG stems from the fact that the laboratory-developed pavement performance models are adjusted to the observed performance measurements (distress) from the actual pavements.

The MEPDG does not provide a design thickness as the end products; instead, it provides the pavement performance throughout its design life. The design thickness can be determined by modifying design inputs and obtaining the best performance with an iterative procedure. The performance models used in the MEPDG are calibrated using design inputs and performance data largely from the national Long-Term Pavement Performance (LTPP) database. Thus, it is necessary to calibrate these models for local highway agencies implementation by taking into account local materials, traffic information, and environmental conditions.

The first step of the local calibration plan is to perform verification runs on the pavement sections using the nationally calibrated MEPDG performance models. The MEPDG recommends that a verification database be developed to confirm that the national calibration factors or functions of performance models are adequate and appropriate for the construction, materials, climate, traffic, and other conditions that are encountered within the local (State) highway system.

The objective of this research is to determine whether the nationally calibrated performance models used in the MEPDG provide a reasonable prediction of actual performance, and if desired accuracy or correspondence exists between predicted and monitored performance for Iowa conditions.

A comprehensive literature review was conducted to identify the MEPDG input parameters and to develop the verification process employed in this study. Sensitivity of MEPDG input parameters to predictions was studied using different versions of the MEPDG software. Sixteen different types of pavements sections across Iowa, not used for national calibration in NCHRP 1-47A, were selected. The MEPDG input parameter database for the selected pavements were prepared from Iowa Department of Transportation (DOT) Pavement Management Information

System (PMIS) and the research reports relevant to MEPDG implementation in Iowa. A database of the actual pavement performance measures was also prepared. The accuracy of the MEPDG performance predictions for Iowa conditions was statistically evaluated. Based on this, specific outcomes of this study include the following:

- The MEPDG-predicted IRI values are in good agreement with the actual IRI values from Iowa DOT PMIS for flexible and HMA overlaid pavements.
- Bias (systematic difference) was found for MEPDG rutting and faulting models, which can be eliminated by recalibrating the MEPDG performance models to Iowa highway conditions and materials.
- The HMA alligator and thermal (transverse) cracking and the JPCP transverse cracking in Iowa DOT PMIS are differently measured compared to MEPDG measurement metrics.
- The HMA longitudinal cracking model included in the MEPDG need to be refined to improve the accuracy of predictions.
- Irregularity trends in some of the distress measures recorded in Iowa DOT PMIS for certain pavement sections are observed. These may need to be removed from for verification and MEPDG local calibration.
- MEPDG provides individual pavement layer rutting predictions while Iowa DOT PMIS provides only accumulated (total) surface rutting observed in the pavement. This can lead to difficulties in the calibration of MEPDG rutting models for component pavement layers.
- The latest version (1.0) of MEPDG software seems to provide more reasonable predictions compared to the earlier versions.

Based on the results of this research, the following recommendations are made:

- Recalibrating the MEPDG performance models to Iowa conditions is recommended to improve the accuracy of predictions.
- Increased number of pavement sections with more reliable data from the Iowa DOT PMIS should be included for calibration.
- Before performing calibration, it should be ensured that pavement distress measurement units between PMIS and MEPDG match.
- All the actual performance data should be subjected to reasonableness check and any presence of irrational trends or outliers in the data should be removed before performing calibration.
- Local calibration of HMA longitudinal cracking model included in the MEPDG should not be performed before it is refined further and released by the MEPDG research team.

INTRODUCTION

The purpose of validation is to determine whether the performance models used in the Mechanistic-Empirical Pavement Design Guide (MEPDG) and its software provide 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.

The flexible and rigid pavement design procedures used in the MEPDG have been calibrated using design inputs and performance data largely from the national Long-Term Pavement Performance (LTPP) database. The distress models specifically calibrated include rutting, fatigue cracking, and thermal cracking for flexible pavements, and Joint Plain Concrete Pavement (JPCP) joint faulting, JPCP transverse cracking, and Continuous Reinforced Concrete Pavement (CRCP) punch outs (with limited crack width calibration) for rigid pavements. The national LTPP database did not adequately represent pavement conditions in Iowa and therefore local calibration/validation is needed for Iowa conditions.

The local calibration/validation process involves three important steps (NCHRP, 2007): verification, calibration, and validation. The term verification refers to assessing the accuracy of the nationally (globally) calibrated prediction models for local conditions. The term calibration refers to the mathematical process through which the total error or difference between observed and predicted values of distress is minimized. The term validation refers to the process to confirm that the calibrated model can produce robust and accurate predictions for cases other than those used for model calibration.

The first step of the local calibration plan is to perform the verification runs on the pavement sections using the calibration factors that were developed during the national calibration of the performance prediction models. The MEPDG recommends that a verification database be developed to confirm that the national calibration factors or functions are adequate and appropriate for the construction, materials, climate, traffic, and other conditions that are encountered within the Iowa highway system. A database of Iowa performance data need to be prepared and the new design procedure results must be compared with the performance of these “local” sections in Iowa.

The objective of this research is to determine whether the nationally calibrated performance models used in the MEPDG provide a reasonable prediction of actual performance, and if desired accuracy or correspondence exists between predicted and monitored performance for Iowa conditions. Based on findings of this research, recommendations are made with respect to future MEPDG local calibration for Iowa conditions.

LITERATURE REVIEW

The objective of this task is the review all of available MEPDG related literature, especially the National Cooperative Highway Research Program (NCHRP) 1-37 A project report (NCHRP,

2004) and different versions of the MEPDG software. A comprehensive literature review was undertaken specifically to identify the following information:

1. Review MEPDG background including the development and the input and output parameters of MEPDG software;
2. Review previous or current research efforts related to MEPDG input parameter sensitivity analysis;
3. Examine previous or current research efforts related to validation of MEPDG performance models in different States.

MEPDG Background

Development of MEPDG

The current American Association of State Highway and Transportation Officials (AASHTO) Design Guide is based on methods that have evolved from the AASHO Road Test (1958–1961) (HRB, 1962). Through a number of editions from the initial publication in 1962, the Interim Guide in 1972 (AASHTO, 1972) and other later editions (AASHTO, 1986; AASHTO, 1993), minor changes and improvements have been published. Nonetheless, these later modifications have not significantly altered the original methods, which are based on empirical regression techniques relating simple material characterizations, traffic characterization and measures of performance.

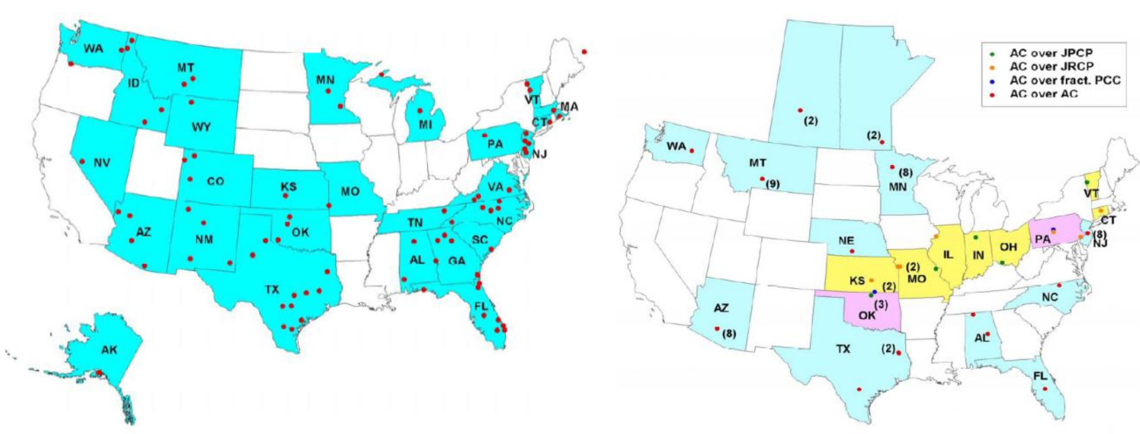
Since the AASHO Road Test, the AASHTO Joint Task Force on Pavements (JTFP) has been responsible for the development and implementation of pavement design technologies. This charge has led to many significant initiatives, including the development of every revision of the AASHTO Guide. More recently, and in recognition of the limitations of the AASHTO Guide, the JTFP initiated an effort to develop an improved Design Guide. As part of this effort, a workshop was convened on March 24-26, 1996, in Irvine, California, to develop a framework for improving the Guide (NCHRP, 2004). The workshop attendees—pavement experts from public and private agencies, industry, and academia—addressed the areas of traffic loading, foundations, materials characterization, pavement performance, and environment to help determine the technologies best suited for the new Design Guide. At the conclusion of that workshop, a major long-term goal identified by the JTFP was the development of a design guide based as fully as possible on mechanistic principles (NCHRP, 2004). The MEPDG and its software are the end result of that goal.

The mechanistic-empirical design procedure in the MEPDG represents a major improvement and paradigm shift from existing empirical design procedures (e.g., AASHTO 1993), both in design approach and in complexity. The use of mechanistic principles to both structurally and climatically (temperature and moisture) model the pavement/subgrade structure requires much more comprehensive input data to run such a model (including axle load distributions, improved material characterization, construction factors, and hourly climatic data). Thus, a significant effort will be required to evaluate and tailor the procedure to the highway agency. This will make the new design procedure far more capable of producing more reliable and cost-effective designs, even for design conditions that deviate significantly from previously experienced conditions (e.g., much heavier traffic).

It is important to realize that even the original (relatively simple) AASHTO design procedures, originally issued in 1962 and updated several times since, required many years of implementation by state highway agencies. The agencies focused on obtaining appropriate inputs, applying calibration values for parameters like the "regional" or climatic factor, subgrade support and its correlation with common lab tests, traffic inputs to calculate equivalent single axle loads, and many other factors. In addition, many agencies set up test sections that were monitored for 10 or more years to further calibrate the design procedure to local conditions. Even for this relatively simple procedure by today's standards, many years were required for successful implementation by many state highway agencies.

Clearly the MEPDG's mechanistic-empirical procedure will require an even greater effort to successfully implement a useful design procedure. Without calibration, the results of mechanistic calculations (fatigue damage) cannot be used to predict rutting, fatigue cracking, and thermal cracking with any degree of confidence. The distress mechanisms are far more complex than can be practically modeled; therefore, the use of empirical factors and calibration is necessary to obtain realistic performance predictions.

The flexible and rigid pavement design procedures used in the MEPDG have been calibrated using design inputs and performance data largely from the national LTPP database which includes sections (See Figure 1and Figure 2) located throughout significant parts of North America (NCHRP, 2004). The distress models specifically calibrated include: rutting, fatigue cracking, and thermal cracking for flexible pavements, and JPCP joint faulting, JPCP transverse cracking, and CRCP punch outs (with limited crack width calibration) for rigid pavements.



(a) (b)

Figure 1. Geographical distribution of the new HMA and rehabilitated HMA pavements used for calibration (NCHRP, 2004); (a) new HMA pavements, (b) rehabilitated HMA pavements

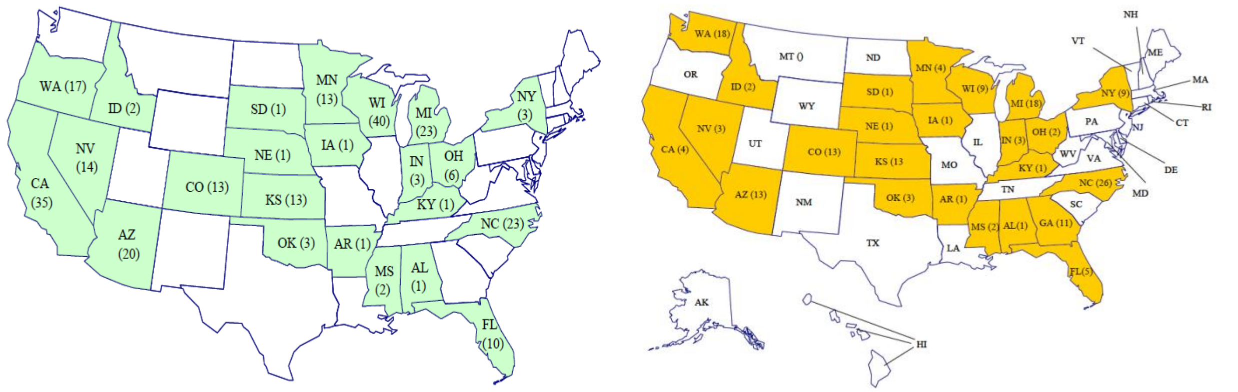


Figure 2. Geographical distribution of the new JPCPs used for calibration (NCHRP, 2004); (a) new JPCPs for faulting, (b) new JPCPs for cracking

This calibration effort was a major iterative work that resulted in distress prediction models with national calibration constants (NCHRP, 2004). The calibration curves generally represent "national" performance of pavements in the LTPP database. Whatever bias included in this calibration data is naturally incorporated into the distress prediction models. The initial calibration was based on 80 percent of the data. The models were then "validated" using the remaining 20 percent of the data. Since both models showed reasonable validation, all data was combined to obtain the final comprehensive national calibration models. However, this national calibration may not be entirely adequate for specific regions of the country and a more local or regional calibration may be needed.

After the release of the MEPDG software (Version 0.7) in July, 2004, the MEPDG software has been updated under NCHRP project 1-40D (2006b) from original version to version 1.0. Especially, the MEPDG version 1.0 released in 2007 would become an interim AASHTO pavement design procedure after approval from the ASHTO Joint Technical Committee. The changes in different version included software changes in general (including changes to traffic and other general topics), as well as changes in the integrated climatic model, in flexible pavement design and analysis, and in rigid pavement design and analysis (NCHRP, 2006b). These changes reflect the recommendations of the NCHRP 1-40A independent reviewers (NCHRP, 2006a), the NCHRP 1-40 panel, the general design community, various other researchers, and the Project 1-40D team itself. A detailed discussion on changes made in the MEPDG software across different versions can be found in NCHRP results digest 308 (NCHRP, 2006b) "*Changes to the Mechanistic-Empirical Pavement Design Guide software through Version 0.900*."

MEPDG Input Parameters

Current AASHTO 1993 procedures require ten and eleven inputs, respectively, for flexible and rigid pavement thickness design. In contrast, the MEPDG software requires over one hundred inputs to characterize the pavement materials, traffic loading, and environment. In addition, the MEPDG allows for three different levels of input for most required inputs. The large number of inputs and the hierarchical nature of the software require the review of all input parameters in

MEPDG software to identify the input parameters having significant effect on one or more outputs trough sensitivity analyses.

Table 1 lists the input parameters used in MEPDG for the design of new flexible and rigid pavements. Table 2 and Table 3 present the additional input parameters required by MEPDG for the design of rehabilitated pavements with the Asphalt Concrete (AC) or Hot Mix Asphalt (HMA) and the Portland Cement Concrete (PCC).

Table 1. MEPDG input parameters for design of new flexible and rigid pavement

Type		Input Parameter
General Information		Design life (years)
		Base / Subgrade construction month
		Pavement construction month
		Traffic open month
		Type of design (Flexible, CRCP, JPCP)
		Restoration (JPCP)
		Overlay (AC, PCC)
Site / Project Identification		Location
		Project I.D
		Section I.D
		Functional class
		Date
		Station/ mile post format
		Station/mile post begin
		Station/ mile post end
		Traffic direction
Analysis Parameter		Initial IRI (in/ mile)
		Terminal IRI (in /mile) limit & reliability
		AC longitudinal cracking (ft/ mi) limit & reliability (Flexible)
		AC alligator cracking (%)limit & reliability (Flexible)
		AC transverse cracking (ft/mi) limit & reliability (Flexible)
		Permanent deformation - Total (in) limit & reliability (Flexible)
		Permanent deformation - AC only (in) limit & reliability (Flexible)
		Transverse Cracking (JPCP)
		Mean Joint Faulting (JPCP)
		CRCP Existing Punch-outs (CRCP)
		Maximum CRCP Crack Width (CRCP)
		Maximum Crack Load Efficiency (CRCP)
		Minimum Crack Spacing (CRCP)
		Maximum Crack Spacing (CRCP)
Traffic Input	General	Two-way average annual daily truck traffic (AADTT)
		Number of lanes in design direction
		Percent of trucks in design direction
		Percent of trucks in design lane
		Operational Speed (mph)
	Traffic Volume Adjustment Factors	Monthly adjustment factor
		Vehicle class distribution
		Hourly truck distribution
		Traffic growth factor
		Axle load distribution factors
	Axle Load Distribution	Axle load distribution
		Axle types
	General Traffic Inputs	Mean wheel location (in)
		Traffic wander standard deviation(in)
		Design lane width (ft)
		Number axle/truck
		Axle configuration: Average axle width (ft), Dual tire spacing (in), Tire pressure for single & dual tire (psi), Axle spacing for tandem, tridem, and quad axle (in)
		Wheelbase: Average axle spacing (ft), Percent of trucks

Table 1. MEPDG input parameters for design of new flexible and rigid pavement (continued)

Type		Input Parameter
Climate Input		Climate data file
		Depth of water table
Structure Input	Layer	Type
		Material
		Thickness
		Interface
	Design Features	Permanent Curl/Warp Effective Temperature Difference
		Joint Spacing
		Sealant Type
		Doweled Transverse Joints (Dowel Bar Diameter, Dowel Bar Spacing)
		Edge Support (Tied PCC shoulder, Widened Slab)
		Base Type
		PCC-Base Interface
		Erodibility
		Los of full friction
		Steel Reinforcement (CRCP) (Percent Steel, Bar diameter, Steel Depth)
		Crack Spacing (CRCP)
Material Input	PCC	General Properties (PCC Material, Layer Thickness, Unit Weight Poisson's Ratio) Strength
		Thermal Properties (Coeff. of Thermal Expansion, Thermal Conductivity, Heat Capacity)
		Mix Design Properties (Cement Type, Cementitious material content, W/C ratio, Aggregate Type, Zero Stress Temp., Shrinkage properties (Ultimate Shrinkage at 40 %, Reversible Shrinkage, Time to Develop 50 % of Ultimate Shrinkage), Curing Method)
		Strength Properties (PCC Modulus of Rupture, PCC Compressive Strength, PCC Elastic Modulus)
	Asphalt	Asphalt mixer: Asphalt gradation ($R_{3/4}$, $R_{3/8}$, $R_{\#4}$, $P_{\#200}$)
		Asphalt binder: PG grade, Viscosity grade, Pentration grade
		Asphalt general: Reference temp., Volumetric properties (V_{beff}, V_a, total unit weight), Poisson's ratio, Thermal properties (thermal conductivity asphalt, heat capacity asphalt)
	Unbound layer	Strength properties: Poisson ratio, Coefficient of lateral pressure, Analysis type (using ICM, not using ICM), Material properties (Modulus, CBR, R-Value, Layer coefficient, DCP, Based on PI and Gradation)
		ICM: Gradation and plasticity index, Compacted or Uncompacted, Calculated/Derived parameter
	Subgrade	Strength properties: Poisson ratio, Coefficient of lateral pressure, Analysis type (using ICM, not using ICM), Material properties (Modulus, CBR, R-Value, Layer coefficient, DCP, Based on PI and Gradation)
		ICM: Gradation and plasticity index, Compacted or Uncompacted, Calculated/Derived parameter
Thermal cracking (Flexible)		Average tensile strength at 14 ^{O}F (psi) Creep test duration Creep compliance (1/psi) – low, mid, high temp at different loading time (1, 2, 5, 10, 20, 50, and 100 sec) Compute mix coefficient of thermal contraction (VMA, aggregate coefficient of thermal contraction) or Input mix coefficient of thermal contraction

Table 2. MEPDG input parameters for rehabilitation design with HMA

General Description	Variable		Rehabilitation Option		
			ACC over PCC	ACC over PCC (fractured)	ACC over ACC
Rehabilitation of existing rigid pavement	Existing distress	Before restoration, percent slabs with transverse cracks plus previously replaced/repaired slab	Yes (for ACC over JPCP only)	N/R [a]	N/R
		After restoration, total percent of slab with repairs after restoration	Yes (for ACC over JPCP only)	N/R	N/R
		CRCP punch-out (per mile)	Yes (for ACC over CRCP only)	N/R	N/R
	Foundation support	Modulus of subgrade reaction (psi / in)	Yes	N/R	N/R
		Month modulus of subgrade reaction was measured	Yes	N/R	N/R
Rehabilitation of existing flexible pavement	At Levels 1, 2, and 3		N/R	N/R	Milled Thickness (in)
					Placement of geotextile prior to overlay
	At Level 3 only		N/R	N/R	Total rutting (in)
					Subjective rating of pavement condition

a. N/R is “Not Required”

Table 3. MEPDG input parameters for rehabilitation design with PCC

General Description	Variable		MEPDG PCC Rehabilitation Option		
			Bonded PCC over JPCP	Bonded PCC over CRCP, Unbounded PCC over PCC-	PCC over ACC
Rehabilitation for existing pavement	Existing distress	Before restoration, percent slabs with transverse cracks plus previously replaced/repaired slab	Yes	N/R[a]	N/R
		After restoration, total percent of slab with repairs after restoration	Yes	N/R	N/R
		CRCP punch-out (per mile)	N/R	N/R	N/R
	Foundation support	Modulus of subgrade reaction (psi / in)	Yes	Yes	Yes
		Month modulus of subgrade reaction measured	Yes	Yes	Yes
	Flexible rehabilitation	Milled thickness (in)	N/R	N/R	Yes
		Subjective rating of pavement condition	N/R	N/R	Yes

a. N/R is “Not Required”

MEPDG Output Results

MEPDG software projects pavement performance prediction results with time increments as outputs. At time = 0 (i.e., opening to traffic), all distresses are set to zero, except the smoothness parameter, International Roughness Index (IRI), which is set to the initial IRI value provided in the introductory screens.

As time increments, the stress state within the pavement at each time increment is applied to a number of semi-empirical relationships that estimate incremental damage or development of distress. Many of these relationships, or transfer functions, are based in theory (e.g., fracture mechanics) and laboratory testing, and have been “calibrated” to nationally published LTPP field data.

Table 4 summarizes the MEPDG projected flexible and rigid pavement performance results by comparing distress survey results obtained from the Iowa Department of Transportation (DOT) Pavement Management Information System (PMIS). For composite pavements, performance predictions were compared for the topmost layer (PCC or HMA). These results are described in detail by the authors in their final report on Iowa MEPDG Work Plan Task no 7 “*Existing Pavement Input Information for the Mechanistic-Empirical Pavement Design Guide*”. MEPDG performance predictions are generally recorded in Iowa DOT PMIS. However, Iowa DOT PMIS does not provide performance prediction results for Continuously Reinforced Concrete Pavement (CRCP) punch-out, maximum crack width and minimum crack Load Transfer Efficiency (LTE). Also, the measurement units for JPCP transverse cracking and HMA alligator and thermal (transverse) cracking do not agree between Iowa DOT PMIS and MEPDG.

Table 4. Comparison of MEPDG performance prediction results with Iowa DOT PMIS records

Type of Pavement		Performance Prediction	MEPDG	Iowa PMIS
Rigid (PCC)	JPCP	Faulting	Inch	millimeter
		Transverse cracking	% slab cracked	number of crack / km
		Smoothness (IRI)	in/mile	m/km
	CRCP	*Punch-out*	number of punch-out/mile	N/A[a]
		Maximum crack width	mils	N/A[a]
		Minimum crack LTE	%	N/A[a]
		Smoothness (IRI)	in/mile	m/km
Flexible (HMA)		Longitudinal cracking	ft/mile	m/km
		Alligator cracking	%/total lane area	m^2/km
		Thermal (Transverse) cracking	ft/mi	m^2/km
		Rutting	in	millimeter
		Smoothness (IRI)	in/mile	m/km

a. N/A = Not Available

Review of Sensitivity Analyses of MEPDG Input Parameters

The MEPDG method will significantly reduce the degree of uncertainty in the design process and allow the state agencies to specifically design pavement to minimize or mitigate the predominant distress types that occur. It will help ensure that major rehabilitation activity occurs closer to the actual design life by providing better performance predictions. Material-related research questions can be answered through the use of the MEPDG which provides tools for evaluating the variations in materials on pavement performance. The MEPDG can also serve as a powerful forensic tool for analyzing the condition of existing pavements and pinpointing deficiencies in the past designs.

However, prior to the development of any implementation plan, it is important to conduct a sensitivity analysis to determine the sensitivity of different input design parameters in the design process, which can differ from state to state depending on local conditions. Such a sensitivity study may be helpful in developing local calibration recommendations as well as aid designers in focusing on those design inputs having the most effect on desired pavement performance.

Many MEPDG input parameter sensitivity analysis studies have been conducted after the release of the MEPDG software. This section presents a summary of the MEPDG sensitivity studies that have been reported so far.

Sensitivity Analyses of Flexible Pavement Input Parameters

El-Basyouny and Witczak (2005a; 2005b) at Arizona State University conducted flexible pavement input parameter sensitivity analyses as part of the development of the MEPDG design process. This study focused on the sensitivity of fatigue cracking and permanent deformation performance measures to various input parameters. This study identified the general relationship between each of these inputs and the resulting outputs, while generally all other input parameters remained constant. It was found that subgrade stiffness and traffic generally are influential in the prediction of performance, while some of the other parameters have varying degrees of significance.

Lee (2004) looked at the following input parameters for new flexible pavement: Poisson's ratio, surface shortwave absorptive, heat capacity, thermal conductivity, air voids, binder grade, total unit weight, and effective binder content. Two different mixture sizes were evaluated: 0.5 in (12.5 mm) and 1.0 in (25.0 mm) along with 4 different typical gradations from four sources within Arkansas. Their results indicated that for top-down fatigue cracking, only air voids and effective binder content for 0.5 in (12.5 mm) mixes had a significant impact on performance. For bottom-up damage, air voids and effective binder content for both mix sizes were found to be significant. No significant input variable was found for rutting. Only air voids and effective binder content for 0.5 in (12.5 mm) mixes was found to be significant for IRI. It should be noted that these studies were for a single traffic level, subgrade strength and climatic location.

A study by Masad and Little (2004) focused on the effect of unbound granular base layer properties on MEPDG predicted performance. This study indicated that base modulus and thickness have significant influence on the IRI and longitudinal cracking. The influence of these properties on alligator cracking is approximately half of the influence of the properties on longitudinal cracking. It also stated that the granular base material properties did not seem to have an influence on permanent deformation of the pavement.

In support of the initiatives for implementing the new MEPDG in Iowa, Kim et al. (2007) assessed the comparative effect of design input parameters pertaining to material properties, traffic and climate on performance of two existing flexible pavements in Iowa with relatively thick HMA layers. A total of 20 individual inputs were evaluated by studying the effect of each input on MEPDG performance measure for each pavement structure resulting. The study indicated that the predicted longitudinal cracking and total rutting were influenced by most input parameters.

Robinette and Williams (2006) examined the use of the dynamic modulus test and its impact upon MEPDG HMA level 1 analysis. Three pavement structures derived from the 1972 ASHTO Design Guide approach and constructed in Wisconsin during the 2004 construction season were examined. Through iterative changes in the hot mix asphalt layer thickness, air void, and asphalt binder content, the major distresses of permanent deformation and fatigue were examined. All three pavements were predicted to perform well in terms of permanent deformation for the as-designed layer thicknesses.

Zaghloul, et al. (2006) performed a sensitivity analysis study of traffic input levels (Level 1 to Level 3). They reported that some cases showed very significant differences when Level 1 data was used rather than Level 3. They speculated that this behavior may be related to an out of range situation for the performance models.

Chehab and Daniel (2006) assessed the sensitivity of assumed binder grade on performance prediction of recycled asphalt pavement (RAP) modified HMA surface layer utilizing the MEPDG software. This study indicated that the influence of the assumed PG binder grade, particularly the high temperature grade, for the RAP mixtures has a significant influence on the predicted amount of thermal cracking and rutting for the given structure. An added benefit of conducting this sensitivity analysis is the identification of issues that need to be considered when incorporating RAP mixtures in pavement design using the software.

Graves and Mahboub (2006) conducted a global sensitivity analysis of the design process using random sampling techniques over the entire MEPDG input parameter space. They used a total of 100 design sections which were randomly sampled from these input parameters. Their results demonstrated that this type of sensitivity analysis may be used to identify important input parameters across the entire parameter space.

Ahn et al. (2009) focused on the effects of input traffic parameters on the MEPDG pavement performance. The input traffic parameters considered in this study are average daily truck traffic (ADTT), monthly adjustment factors (MAF), and axle load distribution factors. This study reported ADTT as having a significant effect on predicted performances, especially fatigue cracking but the effect of MAF was not significant. The accuracy of pavement prediction increased with the use of Arizona default distribution factors based on the WIM data collected in Arizona rather than MEPDG default values. However, the error from using MEPDG default values may be corrected through model calibration efforts (Li et al. 2009a).

Aguiar-Moya et al. (2009) made use of Long Term Pavement Performance (LTPP) SPS-1 sections located in the State of Texas for the purpose of determining the thickness distribution associated with the HMA surface layer, the HMA binder course, and the granular base layer, as determined by Ground Penetrating Radar (GPR). The results indicate that 86.1% of the analyzed pavement layers have normally distributed thicknesses. An analysis of the thickness changes that occur within a given section, as measured along the lane centerline and under the right wheel-path, was also performed. Finally, based on the coefficient of variation identified for the HMA surface and granular base layers, sensitivity analyses were performed using the MEPDG. The results show a considerable change in distress, mainly fatigue cracking, as the layer thicknesses change within a range of ±3 standard deviations from the mean thickness.

Sensitivity Analyses of Rigid Pavement Input Parameters

The NCHRP 1-37 A project report (2004) discusses sensitivity of the performance models to some rigid pavement input variables but misses out some key variables such as traffic volume, axle load distribution and subgrade type.

Selezneva et al. (2004) conducted an extensive sensitivity analysis to test the reasonableness of the CRCP punch-out model. Based on the study results, it was concluded that CRCP punch-out models show reasonable response of key inputs such as PCC thickness, percentage of longitudinal reinforcement, and PCC coefficient of thermal expansion.

Khazanovich et al. (2004) performed an extensive sensitivity analysis to test the reasonableness of the transverse joint faulting prediction model. From this study, it was concluded that joint faulting model show reasonable response of key inputs such as dowel diameter, base erodibility, type of shoulder, and slab widening.

Hall and Beam (2005) evaluated 29 rigid pavement inputs at a time. This study reports that three performance models (cracking, faulting, and roughness) are sensitive for only 6 out of 29 inputs and insensitive to 17 out of 29 inputs, resulting in combinations of only one or two of the distress models sensitive to 6 out of 29 inputs. However, changing only one variable at a time results in little information regarding the interaction among the variables.

Guclu (2005) looked at the effect of MEPDG input parameters on JPCP and CRCP performance for Iowa conditions. The results indicated that the curl/warp effective temperature difference, the PCC coefficient of thermal expansion, and PCC thermal conductivity had the greatest impact on the JPCP and CRCP distresses. Haider et al. (2009) in Michigan also reported that the effect of PCC slab thickness, joint spacing and edge support on performance were significant among design variables while the coefficient of thermal expansion (CTE), modulus of rupture (MOR), base and subgrade characteristics play an important role among material related properties.

Kannekanti and Harvey (2006) examined about 10,000 JPCP cases of MEPDG software runs for California conditions. Based on their study, the cracking model was found to be sensitive to the coefficient of thermal expansion, surface absorption, joint spacing, shoulder type, PCC thickness, and climate zone and traffic volume. It was also found that the faulting values are sensitive to dowels, shoulder type, climate zone, PCC thickness and traffic volume. They concluded that both the cracking and faulting models showed reasonable trends to prevailing knowledge in pavement engineering and California experience but there were some cases where results were counter-intuitive. These included thinner sections performing better than thicker sections, and asphalt shoulders performing better than tied and widened lanes.

A study by Khanum et al. (2006) focused on the effect of traffic inputs on MEPDG JPCP predicted performance for Kansas condition. This study indicated that MEPDG default traffic input causes more severe JPCP slab cracking than the Kansas input. It also stated that variation in the percentage of truck classes does not affect the predicted distresses on JPCP.

Review of Validation of MEPDG Performance Predictions in Local Sections

The national calibration-validation process was successfully completed for MEPDG. Although this effort was comprehensive, the MEPDG recommends that further validation study is highly recommended as a prudent step in implementing a new design procedure that is so different from current procedures. However, only few research studies for MEPDG validation in local sections have been conducted because the MEPDG has constantly been updated through NCHRP projects (2006a; 2006b) after the release of the initial MEPDG software (Version 0.7). This section introduces recent MEPDG validation research for local sections at the national and State level.

At the request of the AASHTO JTFP, NCHRP has initiated the project 1-40 "*Facilitating the Implementation of the Guide for the Design of New and Rehabilitated Pavement Structures*" following NCHRP 1- 37A for implementation and adoption of the recommended MEPDG (TRB, 2009a). A key component of the NCHRP 1-40 is an independent, third-party review to test the design guide's underlying assumptions, evaluate its engineering reasonableness and design reliability, and to identify opportunities for its implementation in day-to-day design production work. Beyond this immediate requirement, NCHRP 1-40 includes a coordinated effort to acquaint state DOT pavement designers with the principles and concepts employed in the recommended guide, assist them with the interpretation and use of the guide and its software and technical documentation, develop step-by-step procedures to help State DOT engineers calibrate distress models on the basis of local and regional conditions for use in the recommended guide, and perform other activities to facilitate its acceptance and adoption.

There are two NCHRP research projects that are closely related to validation of MEPDG performance predictions (Muthadi, 2007). They are the NCHRP 9-30 project (NCHRP, 2003a; NCHRP, 2003b), "*Experimental Plan for Calibration and Validation of Hot Mix Asphalt Performance Models for Mix and Structural Design"*, and NCHRP 1-40B (Von Quintus et al. 2005; NCHRP, 2007; TRB, 2009), "*User Manual and Local Calibration Guide for the Mechanistic-Empirical Pavement Design Guide and Software*". Under the NCHRP 9-30 project, pre-implementation studies involving verification and recalibration have been conducted in order to quantify the bias and residual error of the flexible pavement distress models included in the MEPDG (Muthadi, 2007). Based on the findings from the NCHRP 9-30 study, the current NCHRP 1-40B project focuses on preparing (1) a user manual for the MEPDG and software and (2) detailed, practical guide for highway agencies for local or regional calibration of the distress models in the MEPDG and software. The manual and guide will be presented in the form of a draft AASHTO recommended practices; the guide shall contain two or more examples or case studies illustrating the step-by-step procedures. It is also noted that the longitudinal cracking model be dropped from the local calibration guide development in NCHRP 1-40B study due to lack of accuracy in the predictions (Muthadi, 2007; Von Quintus and Moulthrop, 2007).

The following are the step-by-step procedures provided by NCHRP 1-40B study (NCHRP, 2007) for calibrating MEPDG to local conditions and materials.

Step. 1. *Verification of MEPDG performance models with national calibration factors*: Run the current version of the MEPDG software for new field sections using the best available materials and performance data. The accuracy of the prediction models was evaluated using bias (defined as average over or under prediction) and the residual error (defined as the predicted minus observed distress). If there is a significant bias and residual error, it is recommended to calibrate the models to local conditions leading to the second step.

Step. 2. *Calibration of the model coefficients*: eliminate the bias and minimize the standard error between the predicted and measured distresses.

Step. 3. *Validation of MEPDG performance models with local calibration factors*: Once the bias is eliminated and the standard error is within the agency's acceptable level after the calibration, validation is performed on the models to check for the reasonableness of the performance predictions.

Several states have conducted local calibration studies involving each step. A study by Galal and Chehab (2005) in Indiana compared the distress measures of existing HMA overlay over a rubblized PCC slab section using AASHTO 1993 design with the MEPDG (Version 0.7) performance prediction results using the same design inputs. The results indicated that MEPDG provide good estimation to the distress measure except top–down cracking. They also emphasized the importance of local calibration of performance prediction models.

Kang et al. (2007) prepared a regional pavement performance database for a Midwest implementation of the MEPDG. They collected input data required by the MEPDG as well as measured fatigue cracking data of flexible and rigid pavements from Michigan, Ohio, Iowa and Wisconsin state transportation agencies. They reported that the gathering of data was labor-intensive because the data resided in various and incongruent data sets. Furthermore, some pavement performance observations included temporary effects of maintenance and those observations must be removed through a tedious data cleaning process. Due to the lack of reliability in collected pavement data, the calibration factors were evaluated based on Wisconsin data and the distresses predicted by national calibration factors were compared to the field collected distresses for each state except Iowa. This study concluded that the default national calibration values do not predict the distresses observed in the Midwest. The collection of more reliable pavement data is recommended for a future study.

Muthadi (2007) performed the calibration of MEPDG for flexible pavements located in North Carolina (NC). Two distress models, rutting and alligator cracking, were used for this effort. A total of 53 pavement sections were selected from the Long-Term Pavement Performance (LTPP) program and the NC DOT databases for the calibration and validation process. Based on calibration procedures suggested by NCHRP 1-40B study, the flow chart presented in Figure 3 was made for this study. The verification results of MEPDG performance models with national calibration factors showed bias (systematic difference) between the measured and predicted distress values. The Microsoft Excel Solver program was used to minimize the sum of the squared errors (SSE) of the measured and the predicted rutting or cracking by varying the coefficient parameters of the transfer function. This study concluded that the standard error for the rutting model and the alligator cracking model is significantly less after the calibration.

The Washington State DOT (Li et al., 2006; Li et al., 2009b) developed procedures to calibrate the MEPDG rigid and flexible pavement performance models using data obtained from the Washington State Pavement Management System (WSPMS). Some significant conclusions from this study are as follows: (a) WSDOT rigid and flexible pavements require calibration factors significantly different from default values; (b) the MEPDG software does not model longitudinal cracking of rigid pavement, which is significant in WSDOT pavements; (c) WSPMS does not separate longitudinal and transverse cracking in rigid pavements, a lack that makes calibration of the software's transverse cracking model difficult; (d) the software does not model studded tire wear, which is significant in WSDOT pavements; and (e) a software bug does not allow calibration of the roughness model of flexible pavement. This study also reported that: (a) the calibrated software can be used to predict future deterioration caused by faulting, but it cannot be used to predict cracking caused by the transverse or longitudinal cracking issues in rigid pavement (Li et al., 2006), and (b) with a few improvements and resolving software bugs, MEPDG software can be used as an advanced tool to design flexible pavements and predict future pavement performance.

Similar to the study conducted in NC (Muthadi, 2007), Banerjee et al. (2009) minimized the SSE between the observed and the predicted surface permanent deformation to determine the coefficient parameters of asphalt concrete (AC) permanent deformation performance model after values based on expert knowledge were assumed for the subgrade permanent deformation calibration factors. Pavement data from the Texas SPS-1 and SPS-3 experiments of the LTPP database were used to run the MEPDG and calibrate the guide to Texas conditions. The set of state-default calibration coefficients for Texas was determined from joint minimization of the SSE for all the sections after the determination of the Level 2 input calibration coefficients for each section.

Recently, Montana DOT conducted the local calibration study of MEPDG for flexible pavements (Von Quintus and Moulthrop, 2007). In this study, results from the NCHRP 1-40B (Von Quintus et al. 2005) verification runs were used to determine any bias and the standard error, and compare that error to the standard error reported from the original calibration process that was completed under NCHRP Project 1-37A (NCHRP, 2004). Bias was found for most of the distress transfer functions. National calibration coefficients included in Version 0.9 of the MEPDG were used initially to predict the distresses and smoothness of the Montana calibration refinement test sections to determine any prediction model bias. These runs were considered a part of the validation process, similar to the process used under NCHRP Projects 9-30 and 1-40B. The findings from this study are summarized for each performance model as shown below:

- Rutting prediction model: the MEPDG over-predicted total rut depth because significant rutting was predicted in unbound layers and embankment soils.
- Alligator cracking prediction model: the MEPDG fatigue cracking model was found to be reasonable.
- Longitudinal cracking prediction model: no consistent trend in the predictions could be identified to reduce the bias and standard error, and improve the accuracy of this prediction model. It is believed that there is a significant lack-of-fit modeling error for the occurrence of longitudinal cracks.
- Thermal cracking prediction model: the MEPDG prediction model with the local calibration factor was found to be acceptable for predicting transverse cracks in HMA pavements and overlays in Montana.

- Thermal cracking prediction model: the MEPDG prediction model with the local calibration factor was found to be acceptable for predicting transverse cracks in HMA pavements and overlays in Montana.
- Smoothness prediction model: the MEPDG prediction equations are recommended for use in Montana because there are too few test sections with higher levels of distress in Montana and adjacent States to accurately revise this regression equation.

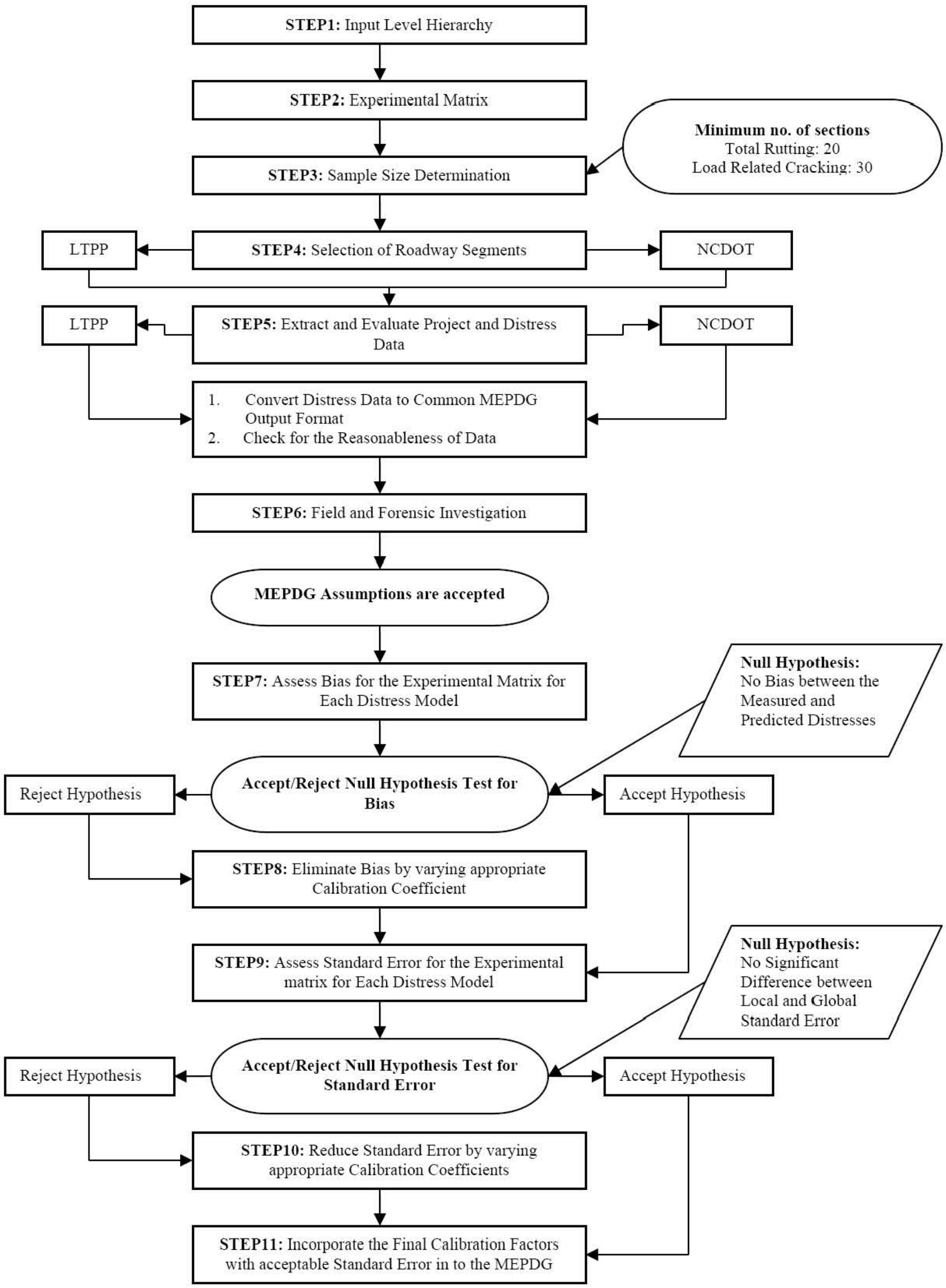


Figure 3. Flow chart made for local calibration in North Carolina (Adapted from Muthadi, 2007)

MEPDG SENSITIVITY ANALYSES OF IOWA PAVEMENT SYSTEMS

It is noted that the preliminary sensitivity studies have already been completed under Iowa Highway Research Board (IHRB) Project TR-509 (Coree et. al., 2005) and the results reported identified the key flexible and rigid pavement design inputs that are of significant sensitivity in Iowa. However, the MEPDG software has been updated from original version (0.7) to version 1.0. It is necessary to identify how sensitivity results change through different versions of MEPDG software. Two MEPDG software versions, version 0.9 and 1.0, were run using same input parameters in sensitivity studies under IHRB Project TR-509 (Coree et. al., 2005). Especially, the MEPDG version 1.0 most recently released would become an interim AASHTO pavement design procedure after approval from the ASHTO Joint Technical Committee.

Based on the sensitivity analysis results, required inputs can be divided into three groups:

1. Those that have very significant effect (highly sensitive) on one or more outputs.
2. Those that have a moderate effect on one or more outputs.
3. Those that have only minor effect (insensitive) on one or more outputs.

Those inputs that belong to group No. 1 should be carefully selected than No. 3 as they will have a significant effect on design. The sensitive analysis results of the MEPDG version 0.9 and 1.0 were compared with the results of MEPDG 0.7 under IHRB Project TR-509.

Iowa Flexible Pavement Sensitivity Analyses

A study was conducted to evaluate the relative sensitivity of MEPDG input parameters to HMA material properties, traffic, and climatic conditions based on field data from an existing Iowa flexible pavement system (I-80 in Cedar County). Twenty key input parameters were selected as varied input parameters for the flexible pavement structure. More detailed information about input parameters and sensitivity analysis procedure used in this study are described in Kim et. al (2007).

As shown in Figure 4, predicting IRI using the MEPDG software versions 0.9 and 1.0 is more sensitive to inputs rather than in the 0.7, which shows more the engineering reasonableness. It is also observed that the predicted alligator cracking in the MEPDG 0.9 and 1.0 versions is relatively smaller in magnitude compared to that predicted by version 0.7 (see Figure 5). This might be due to recalibration of distress prediction model based on the most up-to-date database (NCHRP, 2006b). With MEPDG software update, the predicted longitudinal cracking decreased as illustrated in Figure 6.

The results of the sensitivity analyses are summarized in Table 5. These results indicate that the results of sensitivity analyses did not change much with the upgrade of MEDPG software except transverse cracking and IRI.

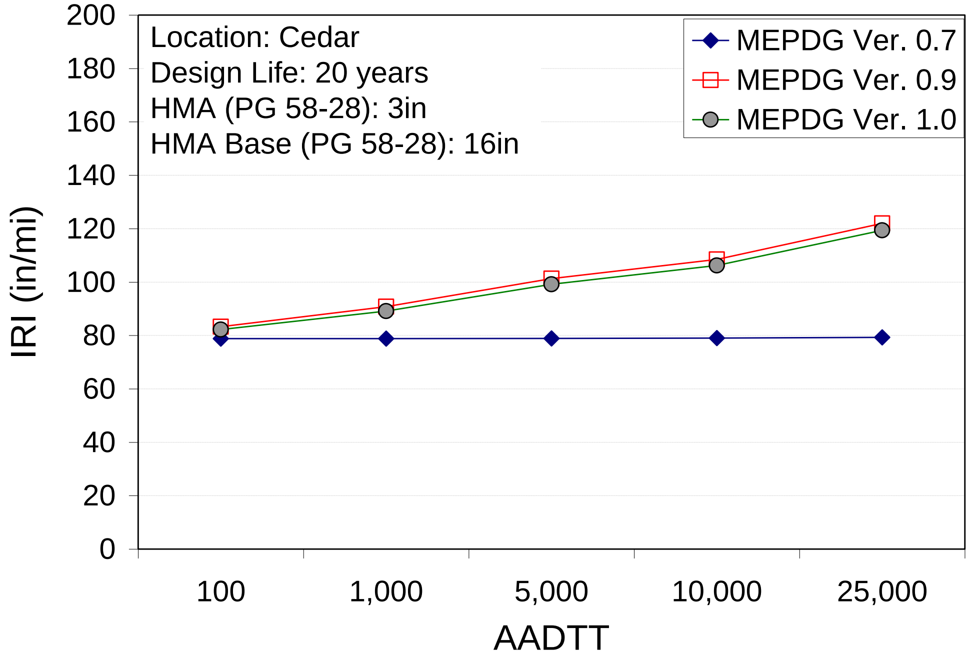


Figure 4. Effect of AADTT on IRI for different versions of MEPDG software

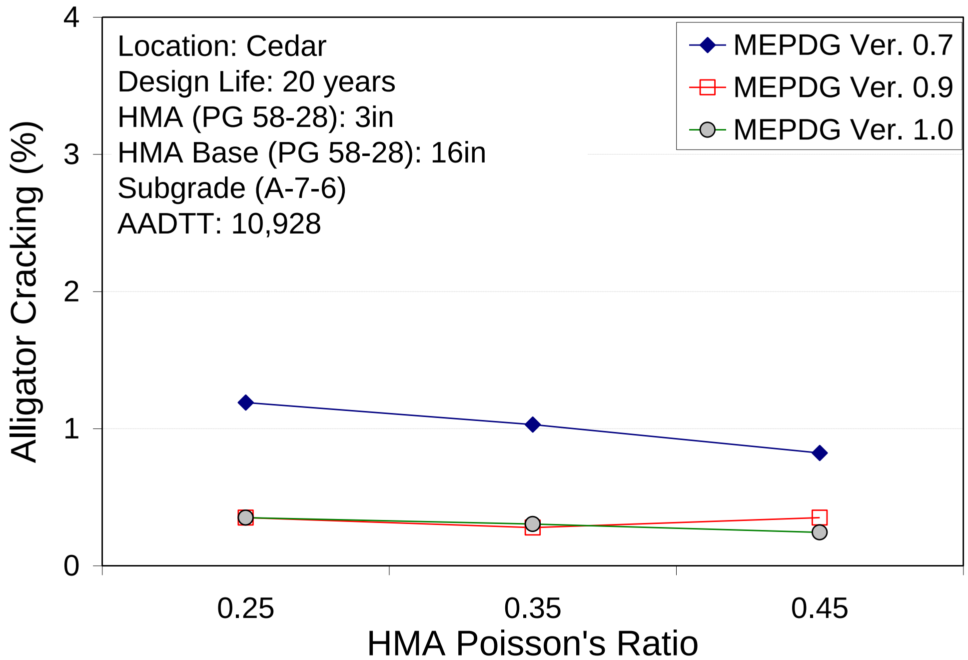


Figure 5. Effect of HMA Poisson's ratio on alligator cracking for different versions of MEPDG software

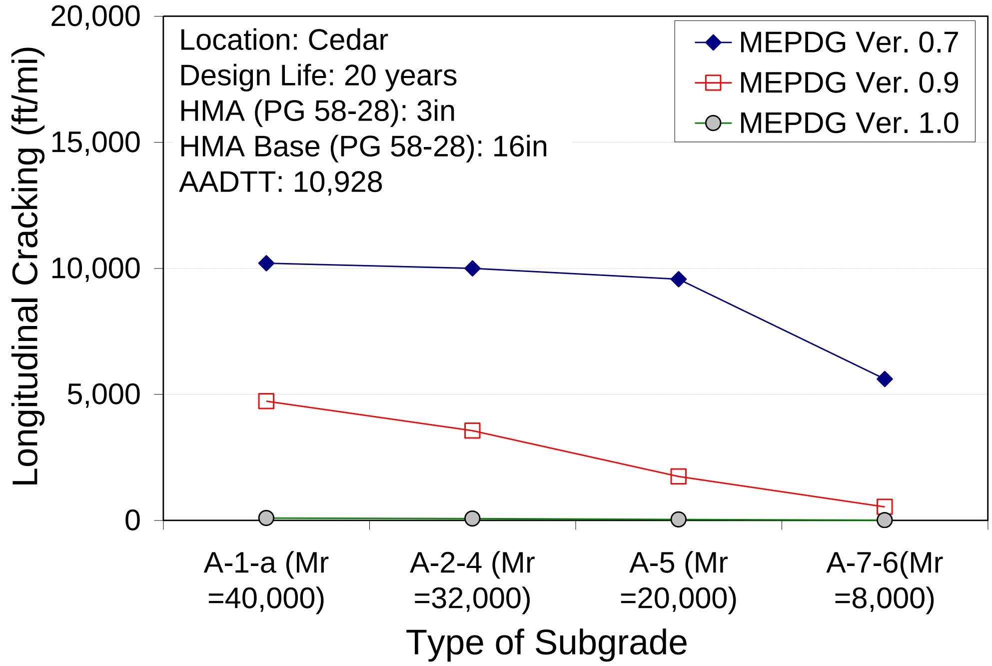


Figure 6. Effect of subgrade type on longitudinal cracking for different versions of MEPDG software

Table 5. Summary of the MEPDG sensitivity analysis results for flexible pavement

Flexible Design Inputs	Performance Models							
	Cracking			Rutting				IRI
	Long.	Alli.	Trans.	AC Surf.	AC Base	Sub-grade	Total	
AC Surface Thick.	S	S	I	S	S	S	S	I
NMAS.	S	I	I	S	I	I	S	I
PG Grade	VS	S	S	S	I	I	S	S
AC Volumetric	VS	S	I *(S*)*	S	I	I	S	S
AC Unit Weight	S	I	I	S	I	I	S	I
AC Poisson's Ratio	S	I	I	S	I	I	S	S*(I*)*
AC Thermal Cond.	S	I	I	S	I	I	S	I
AC Heat Capacity	VS	I	I	S	I	I	S	S*(I*)*
AADTT	VS	S	I	VS	S	S	VS	S*(I*)*
Tire Pressure	VS	I	I	S	I	I	S	S*(I*)*
Traffic Distribution	VS	S	I	S	I	I	S	S*(I*)*
Traffic Speed	VS	S	I	VS	S	I	VS	S*(I*)*
Traffic Wander	S	S	I	I	I	I	S	I
Climate (MAAT)	VS	S	I *(S*)*	S	I	I	S	S
AC Base Thick.	VS	VS	I	VS	S	S	VS	S
Base M_r	S	VS	I	VS	S	S	VS	VS
Subbase Thick.	S	S	I	I	I	S	I	I
Subgrade M_r	VS	S	I	I	I	S	S	S*(I*)*
Agg. Therm. Coeff.	I	I	I	I	I	I	I	I

Note: VS = Very Sensitive/S = Sensitive/NS = Not Sensitive/* The results of version 0.7

Iowa Rigid Pavement Sensitivity Analyses

This sensitivity study focused on JPCP in Iowa using the different versions of MEPDG software (0.7, 0.9 and 1.0 versions). The initial study focused on identifying the sensitivity of input parameters needed for designing JPCP in Iowa (Guclu, 2005). Two JPCP sections, also part of the LTPP program (LTPP 2005), were selected from the Iowa DOT's PMIS for performing sensitivity analysis. A history of pavement deflection tests, material tests, traffic, and other related data pertaining to two JPCP sections are available in the LTPP database and they were used to establish default or baseline values for MEPDG design input parameters. For unknown parameters needed to run the MEPDG software, the nationally calibrated default values were used. For simplicity, sensitivity analyses were conducted on a standard representative pavement section formed from two JPCP sections. Several hundred sensitivity runs were conducted using the MEPDG software and plots were obtained. Based on the visual inspection of the sensitivity graphs, the input parameters were categorized from most sensitive to least sensitive, in terms of their effect on performance.

Sensitivity analyses were also conducted on a representative CRCP section to identify the sensitivity of input parameters needed for designing CRCP in Iowa using the MEPDG. It is noted that CRCP is not widely used in Iowa. For the CRCP, the same traffic and material input values as JPCP were used. This was done for consistency and for comparing the JPCP and CRCP results.

As shown in Figure 7, the predicted JPCP faulting in the MEPDG 0.9 and 1.0 versions is more sensitive to inputs rather than in the 0.7. Also, the magnitude of predicted JPCP faulting values in MEPDG 0.9 and 1.0 are relatively higher compared to that of version 0.7. It is also observed that the magnitude of predicted JPCP cracking values using MEPDG 0.9 and 1.0 is smaller compared to that of version 0.7 (see Figure 8). Figure 9 indicates that the magnitude of CRCP punchout predictions using MEPDG 0.9 and 1.0 are higher compared to that of 0.7. Once again, these results might be due to recalibration of distress prediction models in the recent versions based on the most up-to-date database (NCHRP, 2006b).

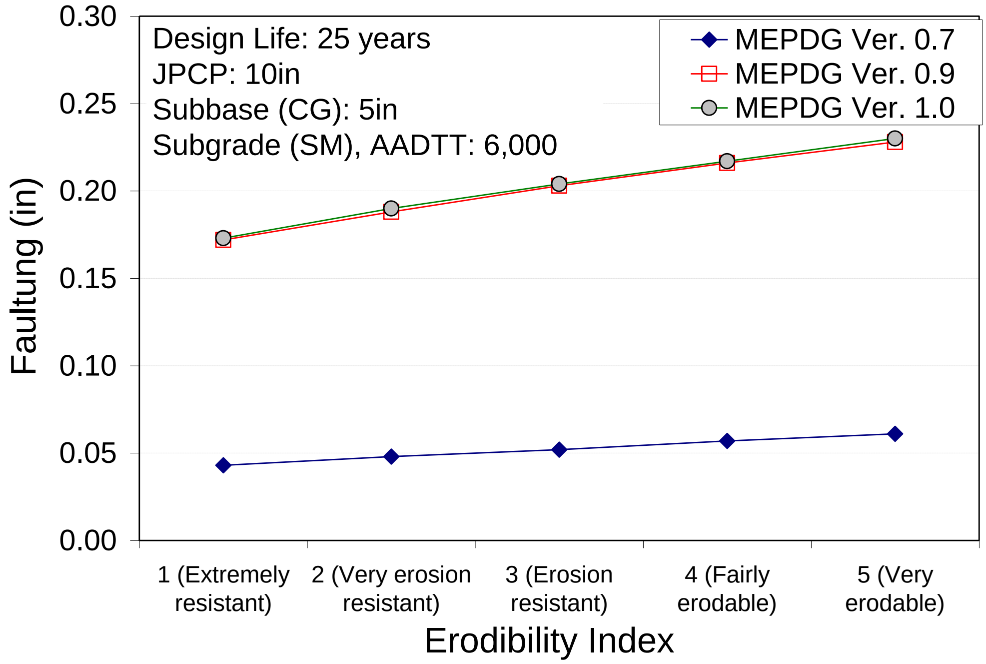


Figure 7. Effect of erodibility index on faulting for different versions of MEPDG software

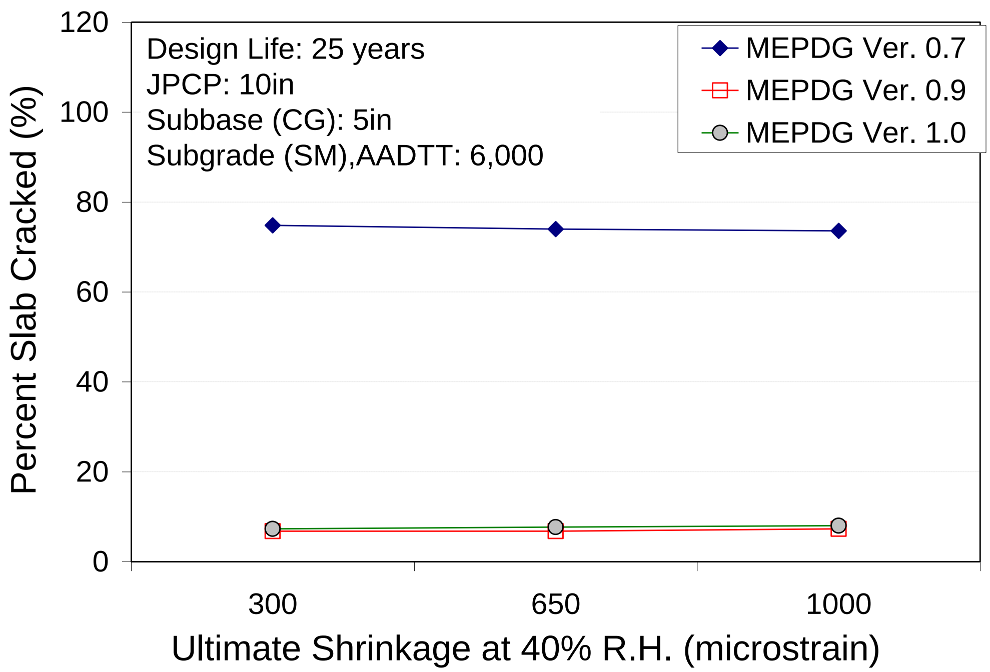


Figure 8. Effect of ultimate shrinkage on percent slab cracked for different versions of MEPDG software

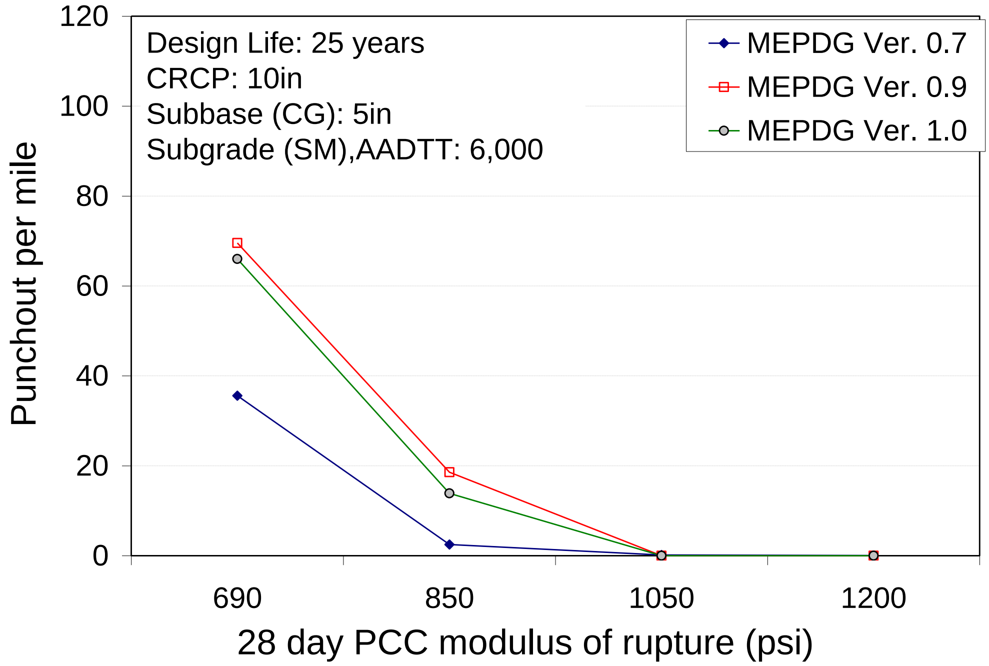


Figure 9. Effect of 28 day PCC modulus of rupture on punch-out for different versions of MEPDG software

The results of the sensitivity analyses for JPCP and CRCP are summarized in Table 6 and Table 7, respectively. From these tables, most of the changes in sensitivity analyses results are observed in JPCP faulting and IRI predictions.

Table 6. Summary of MEPDG sensitivity analysis results for JPCP

JPCP Design Inputs	Performance Models		
	Faulting	Cracking	IRI
Curl/warp effective temperature difference	VS	VS	VS
Joint spacing	S (NS*)	VS	S
Sealant type	NS	NS	NS
Dowel diameter	S(NS*)	NS	S(NS*)
Dowel spacing	NS	NS	NS
Edge support	S(NS*)	NS(S*)	S(NS*)
PCC-base interface	NS	NS	NS
Erodibility index	S(NS*)	NS	S(NS*)
PCC layer thickness	NS	VS	S
Unit weight	S(NS*)	S	NS
Poisson's ratio	S(NS*)	S	S
Coefficient of thermal expansion	VS(S*)	VS	S(VS*)
Thermal conductivity	S	VS	S(VS*)
Heat capacity	NS	NS	NS
Cement type	NS	NS	NS
Cement content	S	NS	S
Water/cement ratio	S	NS	S
Aggregate type	NS	NS	NS
PCC set (zero stress) temperature	S(NS*)	NS	NS
Ultimate shrinkage at 40% R.H.	S(NS*)	NS	NS
Reversible shrinkage	NS	NS	NS
Time to develop 50% of ultimate shrinkage	NS	NS	NS
Curing method	NS	NS	NS
28-day PCC modulus of rupture	NS	VS	S
28-day PCC compressive strength	NS	VS	S
**Infiltration of surface water	NS	NS	NS
**Drainage path length	NS	NS	NS
**Pavement cross slope	NS	NS	NS

Note:
VS = Very Sensitive
S = Sensitive
NS = Not Sensitive
* The results of version 0.7
** Drainage parameters were not included in version 0.9 and 1.0

Table 7. Summary of MEPDG sensitivity analysis results for CRCP

CRCP Design Inputs	Performance Models	
	Punch-out	IRI
Curl/warp effective temperature difference	VS	S
Percent Steel	VS	VS
PCC-base slab friction	NS	NS
Surface shortwave absorptivity	NS	NS
PCC layer thickness	VS	VS
Unit weight	S(NS*)	NS
Poisson's ratio	S(NS*)	NS
Coefficient of thermal expansion	VS	S
Thermal conductivity	NS	NS
Heat capacity	NS	NS
Aggregate type	NS	NS
28-day PCC modulus of rupture	VS	VS
**Infiltration of surface water	NS	NS
**Drainage path length	NS	NS
**Pavement cross slope	NS	NS

Note:
VS = Very Sensitive
S = Sensitive
NS = Not Sensitive
* The results of version 0.7
** Drainage parameters were not included in version 0.9 and 1.0

DEVELOPMENT OF VERIFICATION PROCEDURE FOR PERFORMANCE PREDICTIONS

Based on literature review and sensitivity analyses results described in previous sections, the procedure for verifying the MEPDG performance predictions was developed in consultation with the Iowa DOT engineers. The following steps were followed to determine whether the performance models used in the MEPDG provide a reasonable prediction of actual performance with the desired accuracy or correspondence.

Step 1: Select typical pavement section around state
Step 2: Identify available sources to gather input data and determine the desired level for obtaining each input data
Step 3: Prepare MEPDG input database from available sources including Iowa DOT PMIS and research project reports relevant to MEPDG implementation in Iowa
Step 4: Prepare a database of performance data for the selected Iowa pavement sections from Iowa DOT PMIS
Step 5: Input design data and run MEPDG software
Step 6: Compare MEPDG performance prediction results with performance data of the selected Iowa pavement sections
Step 7: Evaluate the adequacy of the MEPDG results by comparing with the Iowa DOT PMIS pavement performance experience

MEPDG INPUT DATA PREPERATION

To develop the database for MEPDG verification testing, pavement sections identified in MEPDG Work Plan Task 7 were utilized. Representative pavement sites across Iowa were selected in consultation with Iowa DOT engineers with the following considerations:

- Different pavement types (flexible, rigid, and composite)
- Different geographical locations
- Different traffic levels

Five HMA and five JPCP sections were selected under flexible and rigid pavement categories, respectively. These pavements were not used for national calibration through NCHRP 1-37A. A total of six composite pavement sites, three HMA over JPCP and three HMA over HMA sections, were also selected. Table 8 summarizes the pavement sections selected for this study and Figure 10 illustrates the geographical locations of these sites in Iowa. Among the selected pavement sections, highway US 18 in Clayton County was originally constructed as JPCP in 1967 and overlaid with HMA in 1992. This section was again resurfaced with HMA in 2006. However, this study did not consider the pavement performance data after HMA resurfacing in 2006 to avoid irregularity of data.

Table 8. Summary information for selected pavement sections

Type		Route	Dir.	County	Begin post	End post	Construct-ion year	Resurface year	AADTT[a]
Flexible (HMA)		US218	1	Bremer	198.95	202.57	1998	N/A[b]	349
		US30	1	Carroll	69.94	80.46	1998	N/A	562
		US61	1	Lee	25.40	30.32	1993	N/A	697
		US18	1	Kossuth	119.61	130.08	1994	N/A	208
		IA141	2	Dallas	137.60	139.27	1997	N/A	647
Rigid (JPCP)		US65	1	Polk	82.40	83.10	1994	N/A	472
		US75	2	Woodbury	96.53	99.93	2001	N/A	330
		I80	1	Cedar	275.34	278.10	1991	N/A	7,525
		US151	2	Linn	40.04	45.14	1992	N/A	496
		US30	2	Story	151.92	158.80	1992	N/A	886
Com po-site	HMA over JPCP	IA9	1	Howard	240.44	241.48	1992	1973	510
		US18[c]	1	Clayton	285.82	295.74	1992	1967	555
		US65	1	Warren	59.74	69.16	1991	1972	736
	HMA over HMA	US18	1	Fayette	273.05	274.96	1991	1977	2,150
		US59	1	Shelby	69.73	70.63	1993	1970	3,430
		IA76	1	Allamakee	19.78	24.82	1994	1964	1,340

a. Average Annual Daily Truck Traffic at construction year
b. N/A = Not Available
c. Resurfaced again with HMA in 2006

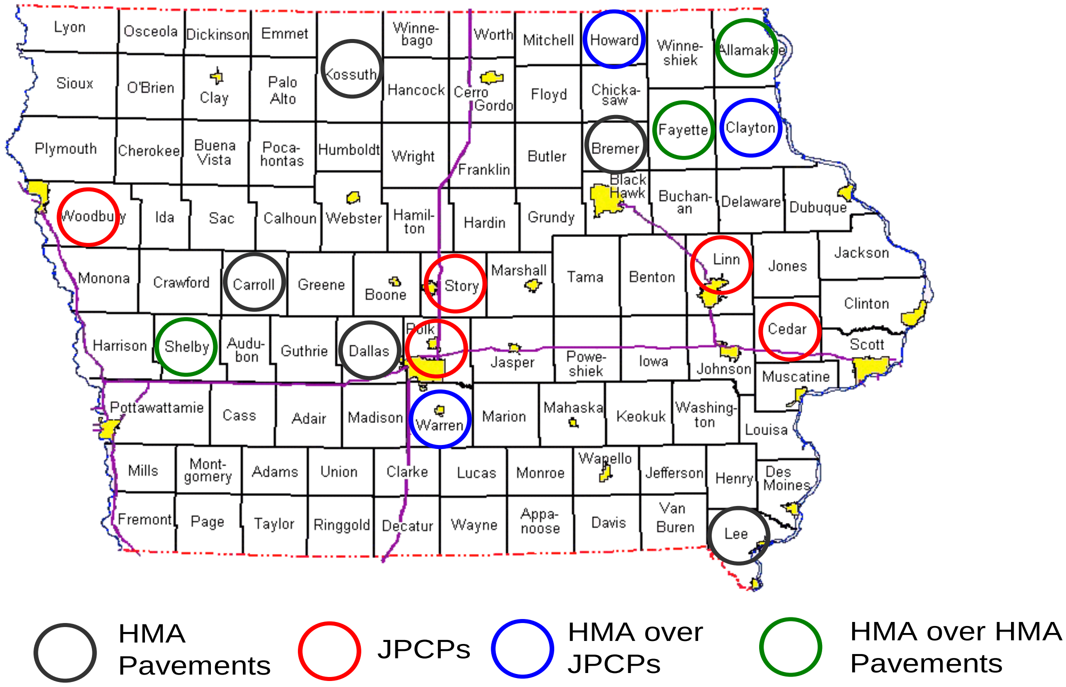


Figure 10. Geographical location of selected pavement sites in Iowa

The MEPDG pavement inputs related to the selected sections were primarily obtained from the Iowa DOT PMIS. Other major sources of the data include online project reports relevant to MEPDG implementation in Iowa (http://www.iowadot.gov/operationsresearch/reports.aspx; http://www.ctre.iastate.edu/research/reports.cfm). If a specific input data was not available, the default value or best estimate was inputted considering its level of sensitivity with respect to MEPDG predicted performance (see Table 5 and Table 6). Level 3 inputs were selected since most data are typical Iowa values or user-selected default value. A detailed database was prepared and formatted in a manner suitable for input to the MEPDG software. All of formatted MEPDG input database are provided in Appendix A. The descriptions of the input data and sources are presented at length below.

General Project Inputs

The general project inputs section of the MEPDG is categorized into general information, site/project identification information, and the analysis parameters. General information consists of information about the pavement type, design life, and time of construction. Sit/project identification information includes pavement location and construction project identification. The analysis parameters require initial smoothness (IRI), distress limit criteria and reliability values. Most of this information in general project inputs section, except distress limit criteria, can be obtained from Iowa DOT's PMIS. The MEPDG default values were applied to distress limit criteria.

Traffic Inputs

The base year for the traffic inputs is defined as the first calendar year that the roadway segment under design is opened to traffic. Four basic types of traffic data at base year are required for the MEPDG: (1) Traffic volume, (2) Traffic volume adjustment factors, (3) Axle load distribution factors, and (4) General traffic inputs. Iowa DOT's PMIS provides annual average daily truck traffic (AADTT) at base year under traffic volume. Since the other traffic input data required were not available in both of Iowa DOT's PMIS and previous project reports reviewed, the traffic input values of this case are either the default values of MEPDG software or the values recommended by NCHRP 1-47A reports.

Climate Inputs

The MEPDG software includes climate data at weather stations in each state. The MEPDG software can also generate climate data by extrapolating nearby weather stations if the latitude and longitude are known. The specific location information of selected sections obtained from Iowa DOT PMIS was inputted and then the climate data of each section was generated.

Pavement Structure Inputs

The MEPDG pavement structure inputs include types of layer material and layer thicknesses. This information can be obtained from Iowa DOT PMIS. For selected HMA over PCC and HMA over HMA pavements under composite pavement category, additional MEPDG input parameters are required for rehabilitation design (See Table 2). Iowa DOT PMIS can provide some of this information including milled thickness, total rutting of existing pavement, and subjective rating of pavement condition. The MEPDG default values were also applied to unavailable input parameters for rehabilitation design.

Material Property Inputs

Detailed material properties were difficult to obtain from Iowa DOT PMIS, especially for older pavements. It is difficult to ascertain if the MEPDG default values are applicable to Iowa conditions. Previous project reports related to MEPDG implementation in Iowa were reviewed. Typical PCC materials properties for Iowa pavements can be obtained from the final report on CTRE Project 06-270 "*Iowa MEPDG Work Plan Task 4: Testing Iowa Portland Cement Concrete Mixtures for the AASHTO Mechanistic-Empirical Pavement Design Procedure*" (Wang et al. 2008a). Similarly, Typical HMA materials properties in Iowa can be obtained from the final reports on IHRB Project TR-509 "*Implementing the Mechanistic – Empirical pavement design guide: Technical Report*." (Coree et al. 2005) and IHRB Project TR-483 "*Evaluation of Hot Mix Asphalt Moisture Sensitivity Using the Nottingham Asphalt Test Equipment*" (Kim and Coree, 2005). Typical thermal properties of HMA and PCC in Iowa can be obtained from final report on CTRE Project 06-272 "*Iowa MEPDG Work Plan Task 6: Material Thermal Input for Iowa Materials*" (Wang et al. 2008b). Typical Iowa soil and aggregate properties can be extracted from final report on "*Iowa MEPDG Work Plan Task 5: Characterization of Unbound*

Materials (Solis/Aggregates) for Mechanistic-Empirical Pavement Design Guide", which is about to be released soon.

VERIFICATION TESTING FOR MEPDG PERFORMANCE PREDICTIONS

A number of MEPDG simulations were run using the MEPDG input database. Level 3 analyses were used in MEPDG software runs since typical values for Iowa and MEPDG default values were used for some input values related to traffic and material properties.

PMIS Performance Data Quality for Verification

A database of historical performance data for the selected sections was prepared from Iowa DOT PMIS. Most of MEPDG performance predictions are recorded in Iowa DOT PMIS. However, the units reported in PMIS for some pavement performance measures (JPCP transverse cracking; alligator and thermal (transverse) cracking of HMA and HMA overlaid pavements) are different from those used in MEPDG (see Table 4). These pavement performance data were not used for verification. These results indicate that the proper conversion methods of pavement distress measurement units from PMIS to MEPDG should be developed for the calibration of MEPDG under Iowa conditions. Even though MEPDG provides rutting predictions for individual pavement layers, Iowa DOT PMIS provides only accumulated (total) rutting observed in HMA surface. This can lead to difficulties in the calibration of individual pavement layer rutting models.

Additionally, some irregularities in distress measures were identified in Iowa DOT PMIS. Occasionally, distress magnitudes appear to decrease with time (see Figure 11) or show erratic patterns (see Figure 12) without explanation.

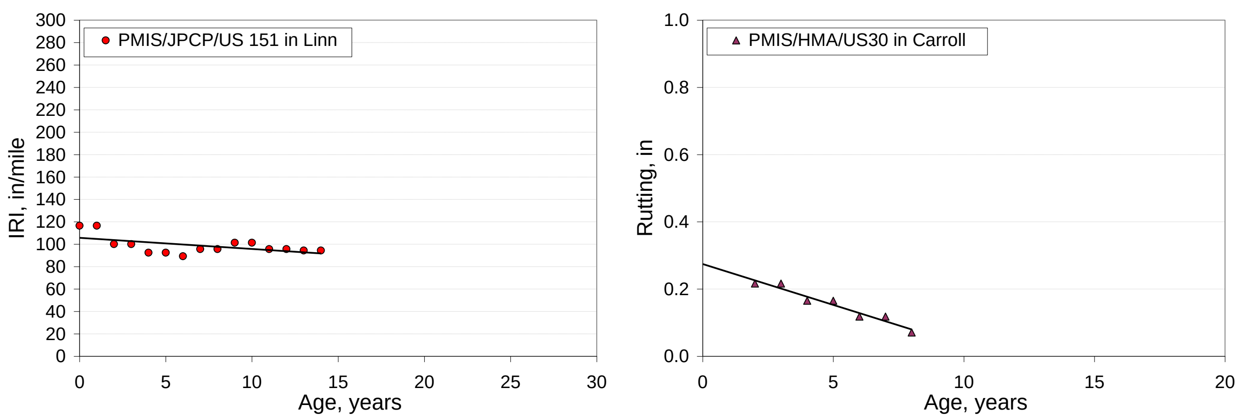


Figure 11. Irregularity in progression of distresses – case 1

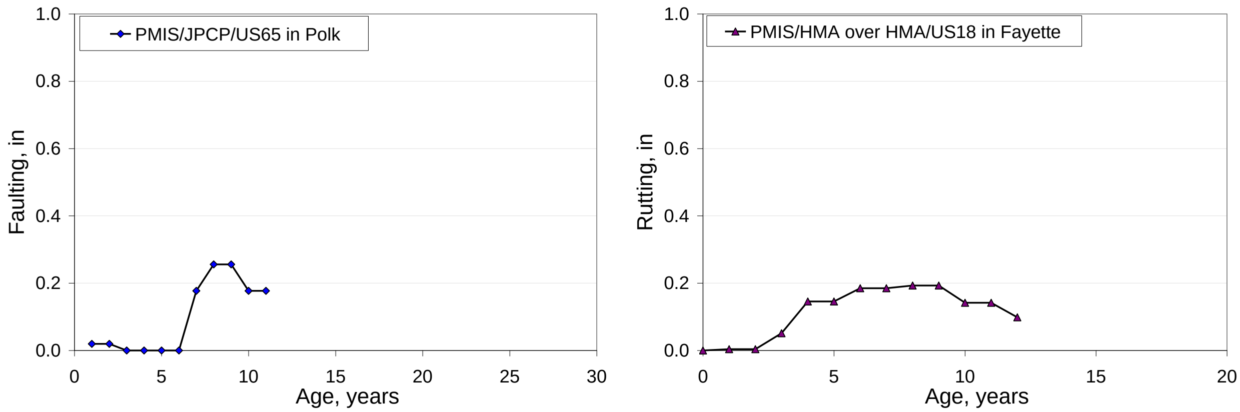


Figure 12. Irregularity in progression of distresses – case 2

Such irregularities in observed distresses were also reported by recent studies by Wisconsin DOT (Kang, 2007) and Washington DOT (Li, 2009b). The Wisconsin study (Kang, 2007) suggested two possible explanations. First, minor maintenance may have been applied to improve pavement performance. Minor maintenance activities are not considered as restoration or reconstruction that can be designed by the MEPDG as well as not recorded in detail by DOT's pavement management system. Second, the irregularity may be due to human factors arising from distress surveys.

NCHRP 1-40 B (2007) recommends that all data should be evaluated for reasonableness check and any irrational trends or outliers in the data be removed before evaluating the accuracy of MEPDG performance predictions. Comparisons of performance measures (MEPDG vs. actual) were conducted for this purpose.

Comparisons of Flexible (HMA) Pavement Performance Measures

Five HMA pavement sections were selected for verification testing of flexible pavement performance predictions. The selected HMA pavement performance predictions are longitudinal cracking, rutting, and IRI. Alligator and thermal (transverse) cracking were not selected for verification testing because of measurement unit differences between MEPDG and Iowa DOT PMIS as discussed previously.

The selected MEPDG pavement performance predictions are compared to actual performance data from PMIS as shown in Figure 13**Error! Reference source not found.**, Figure 14, and Figure 15. As seen in Figure 13 and Figure 15, the MEPDG predicted rutting and IRI trends show a good agreement with the PMIS observations. However, the PMIS rutting data obtained from US 30 in Carroll County and US 61 in Lee County show irrational trends as shown in Figure 14. These data were not used to evaluate the accuracy of MEPDG predictions. In general, the MEPDG rutting predictions underestimate the actual rutting measurements.

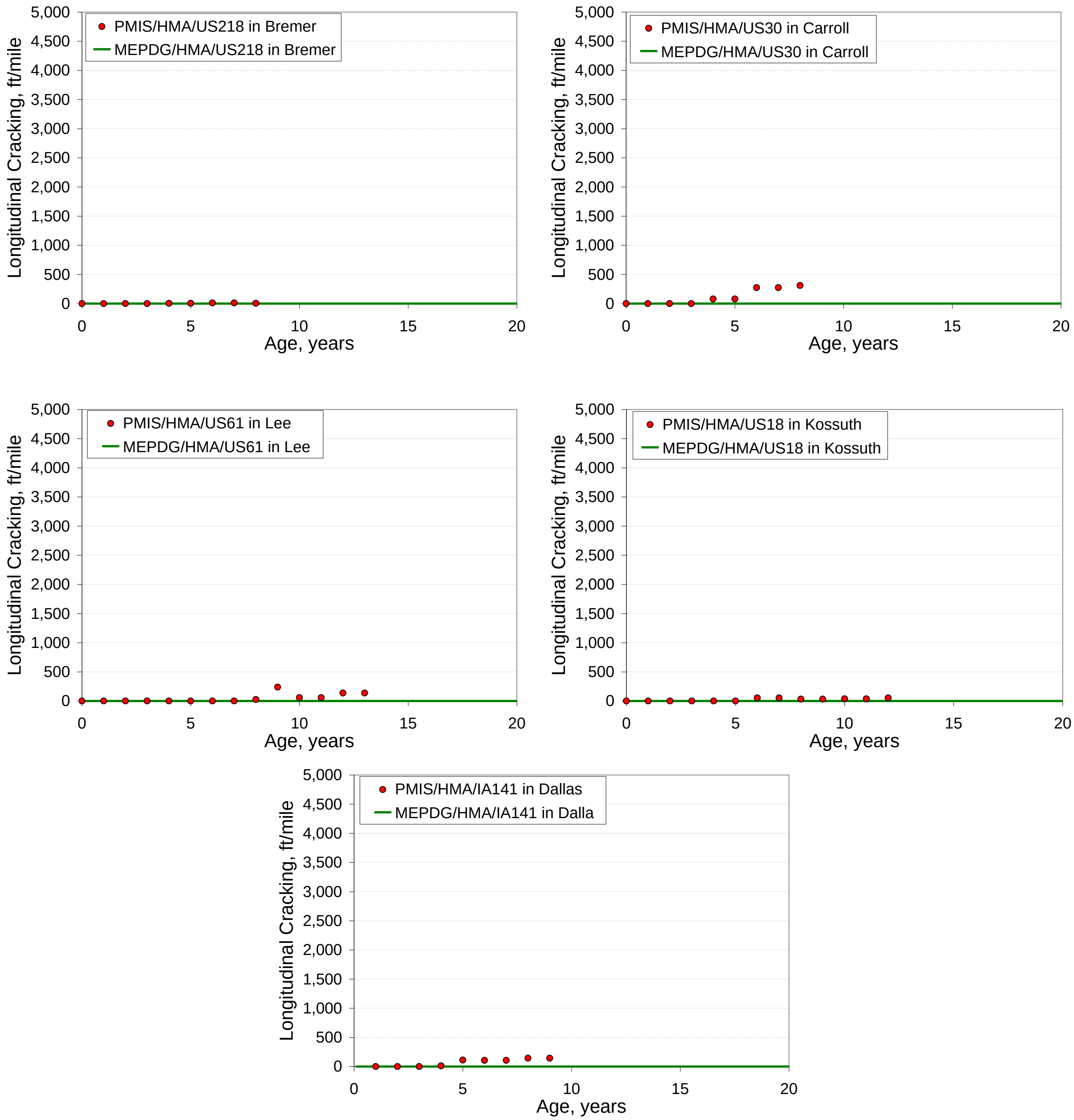


Figure 13. Longitudinal cracking comparisons - predicted vs. actual for HMA pavements in Iowa

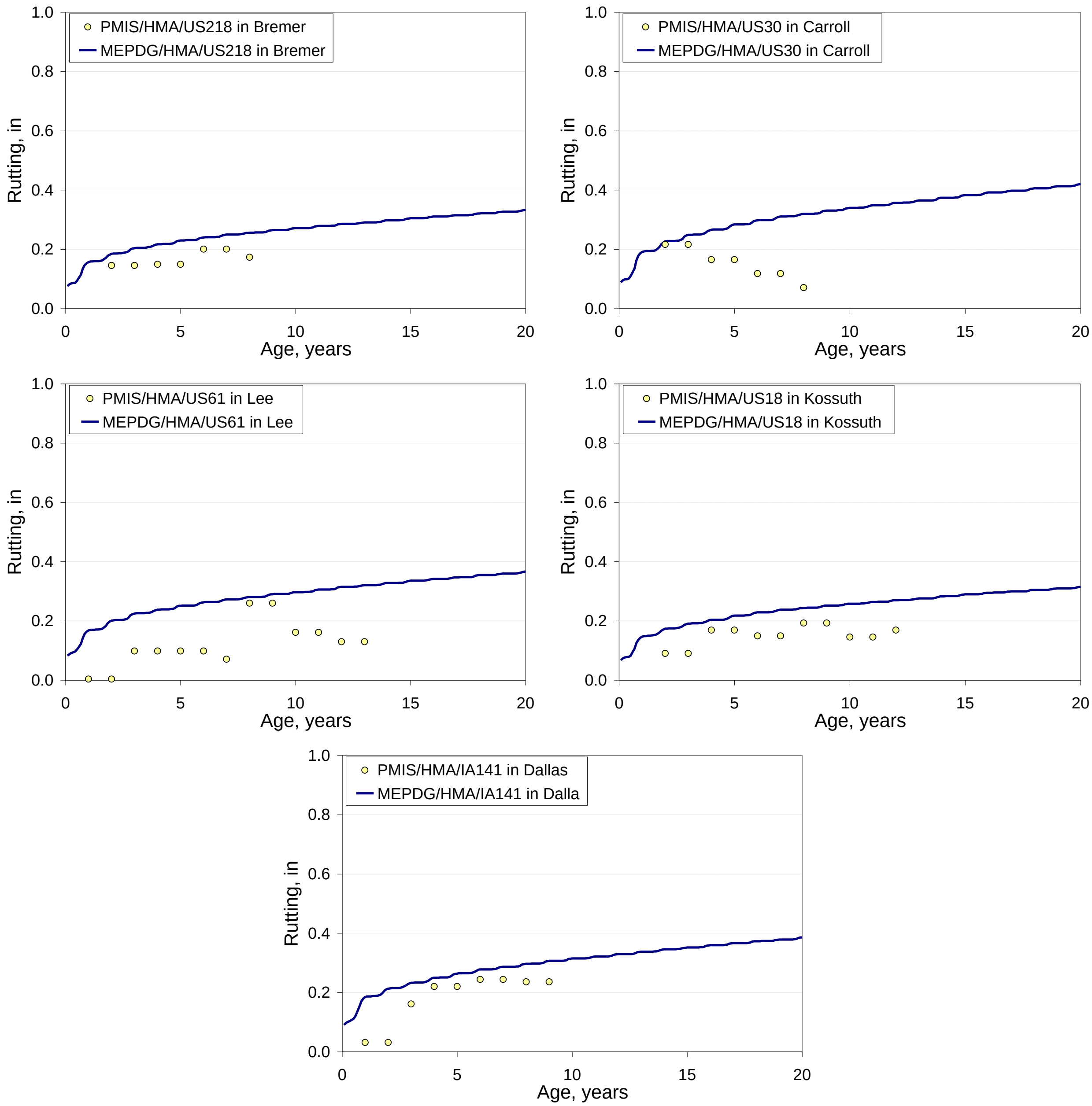


Figure 14. Rutting comparisons - predicted vs. actual for HMA pavements in Iowa

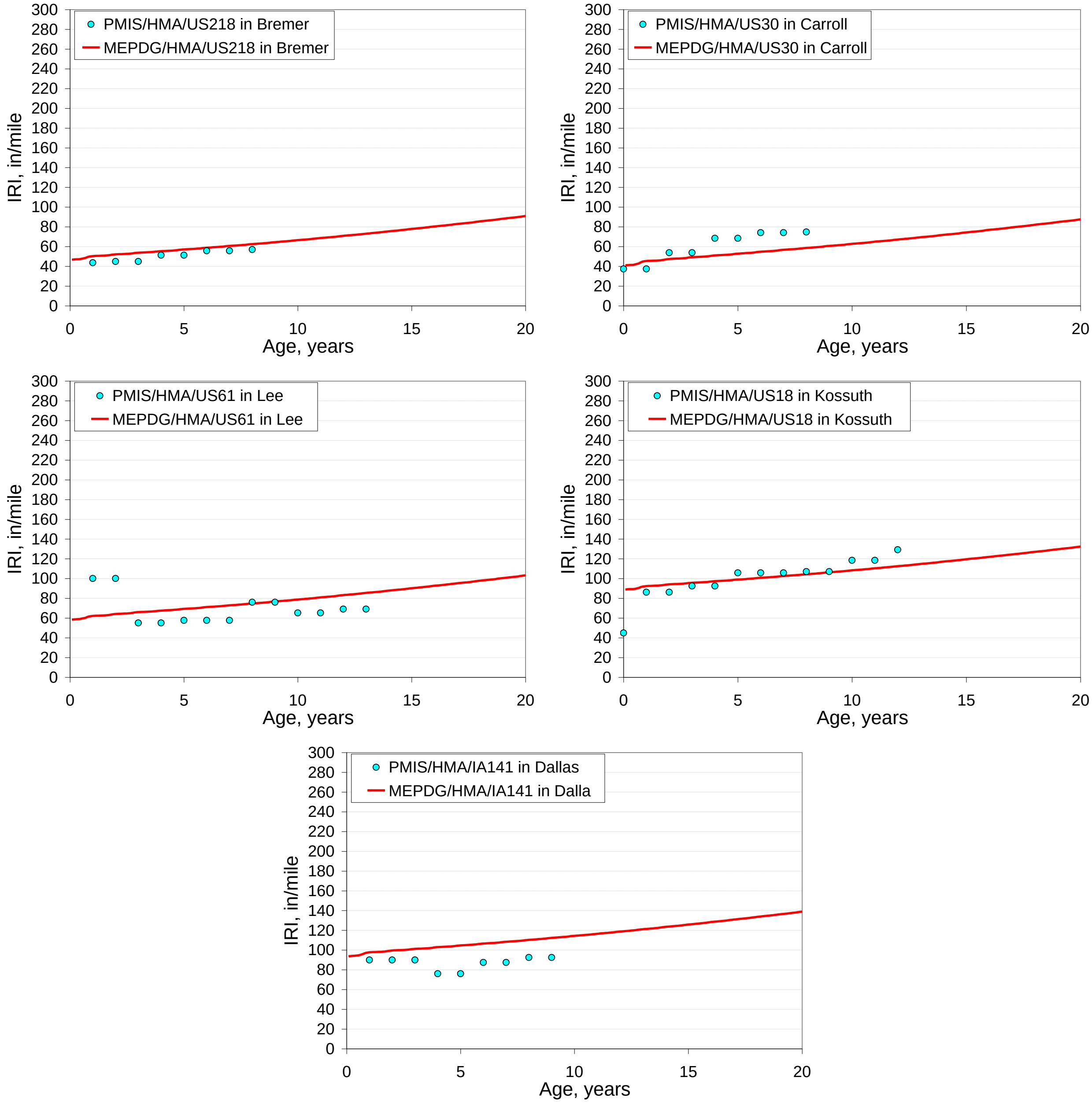


Figure 15. Smoothness (IRI) comparisons - predicted vs. actual for HMA pavements in Iowa

Comparisons of Rigid Pavement (JPCP) Performance Measures

Five JPCP sections were selected for verification testing of rigid pavement performance predictions. The selected JPCP pavement performance predictions are faulting and IRI. Transverse cracking was not one of the selected performance measures for verification testing because of the measurement unit differences discussed previously.

The selected MEPDG pavement performance predictions are compared against actual performance data from PMIS as shown in Figure 16 and Figure 17. Some portions of the faulting data were not used to evaluate accuracy of MEPDG predictions because of erratic trends. IRI predictions in Figure 17 show better agreement with the actual IRI data in US 65 in Polk County and US 75 in Woodbury County compared to other sections which exhibit irrational trends.

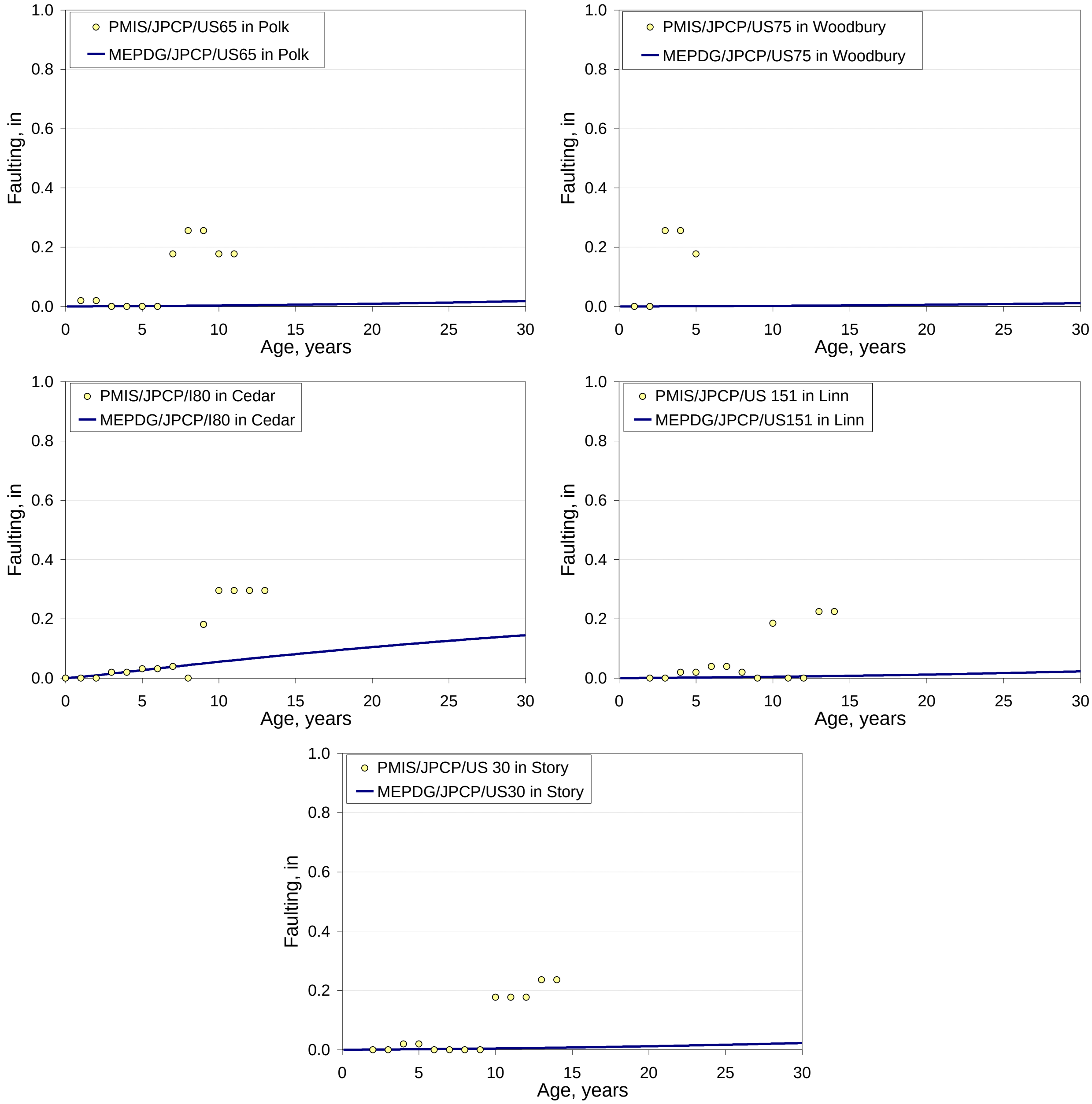


Figure 16. Faulting comparisons - predicted vs. actual for JPCPs in Iowa

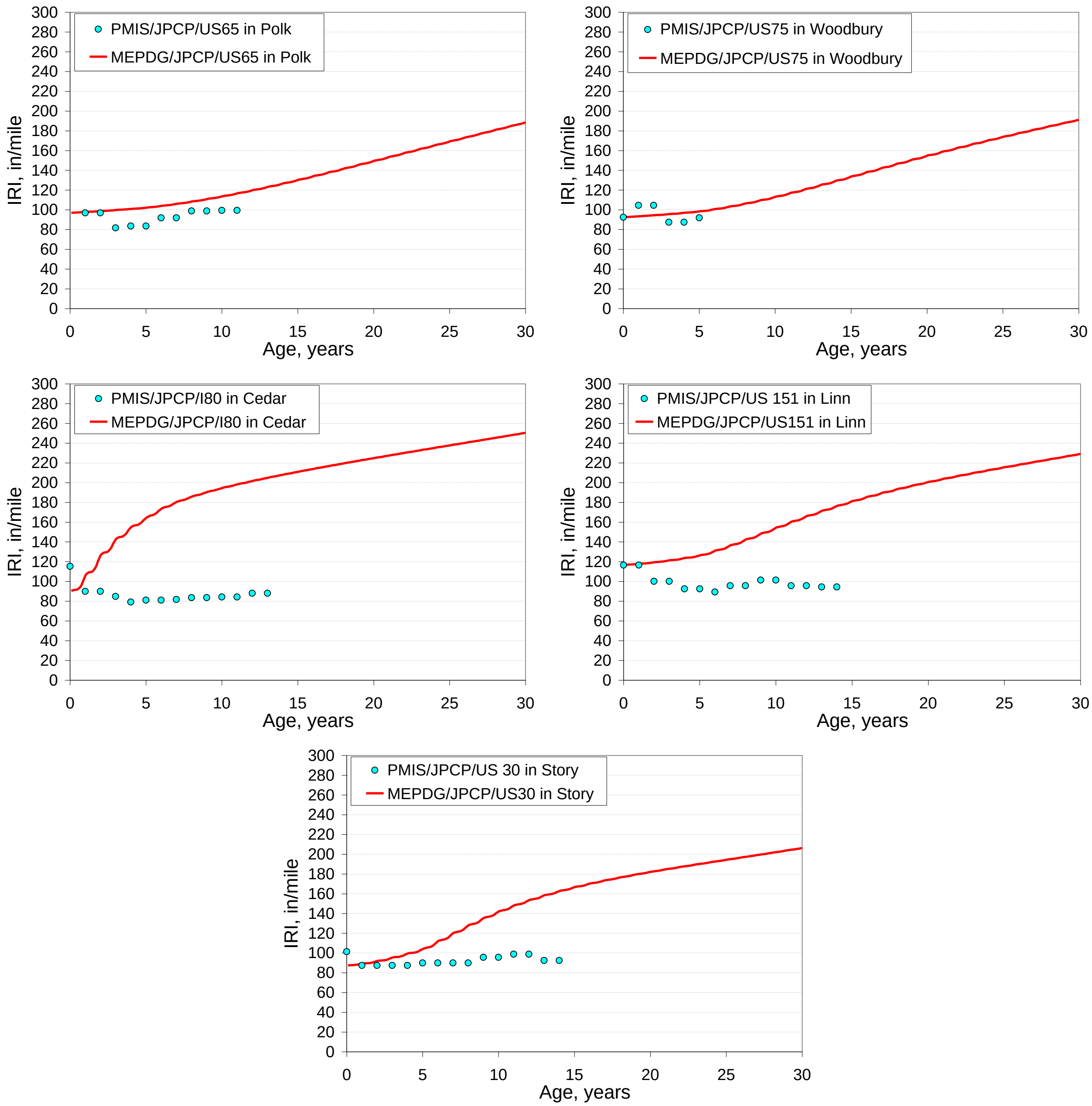


Figure 17. Smoothness (IRI) comparisons - predicted vs. actual for JPCPs in Iowa

Comparisons of Composite Pavement Performance Measures

Three HMA over JPCP sections and three HMA over HMA sections were selected under the category of composite pavements. Similar to HMA pavement performances predictions, the selected composite pavement performance predictions are longitudinal cracking, rutting, and IRI. The comparisons are presented in Figure 18, Figure 19, and Figure 20 for HMA over JPCP sections and in Figure 21, Figure 22, and Figure 23 for HMA over HMA sections. Figure 18 and Figure 21 show that MEPDG cannot provide good predictions for longitudinal cracking in HMA overlaid pavements. Compared to actual observed field rutting predictions, MEPDG overestimates rutting in HMA over JPCP as shown in Figure 19 while underestimates rutting in HMA over HMA as shown in Figure 22. IRI predictions in Figure 20 and Figure 23 illustrate that MEPDG provides good predictions compared to actual IRI data in HMA overlaid pavements.

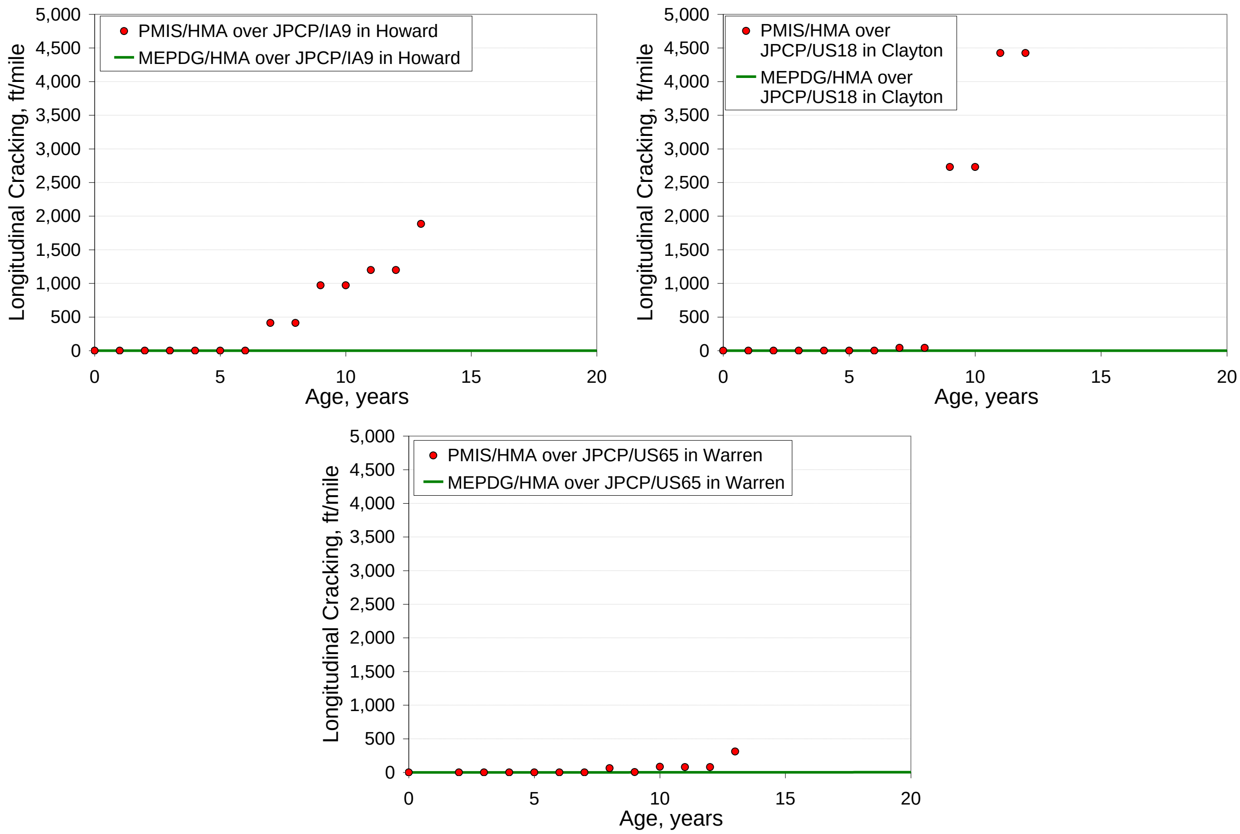


Figure 18. Longitudinal cracking comparisons - predicted vs. actual for HMA over JPCPs in Iowa

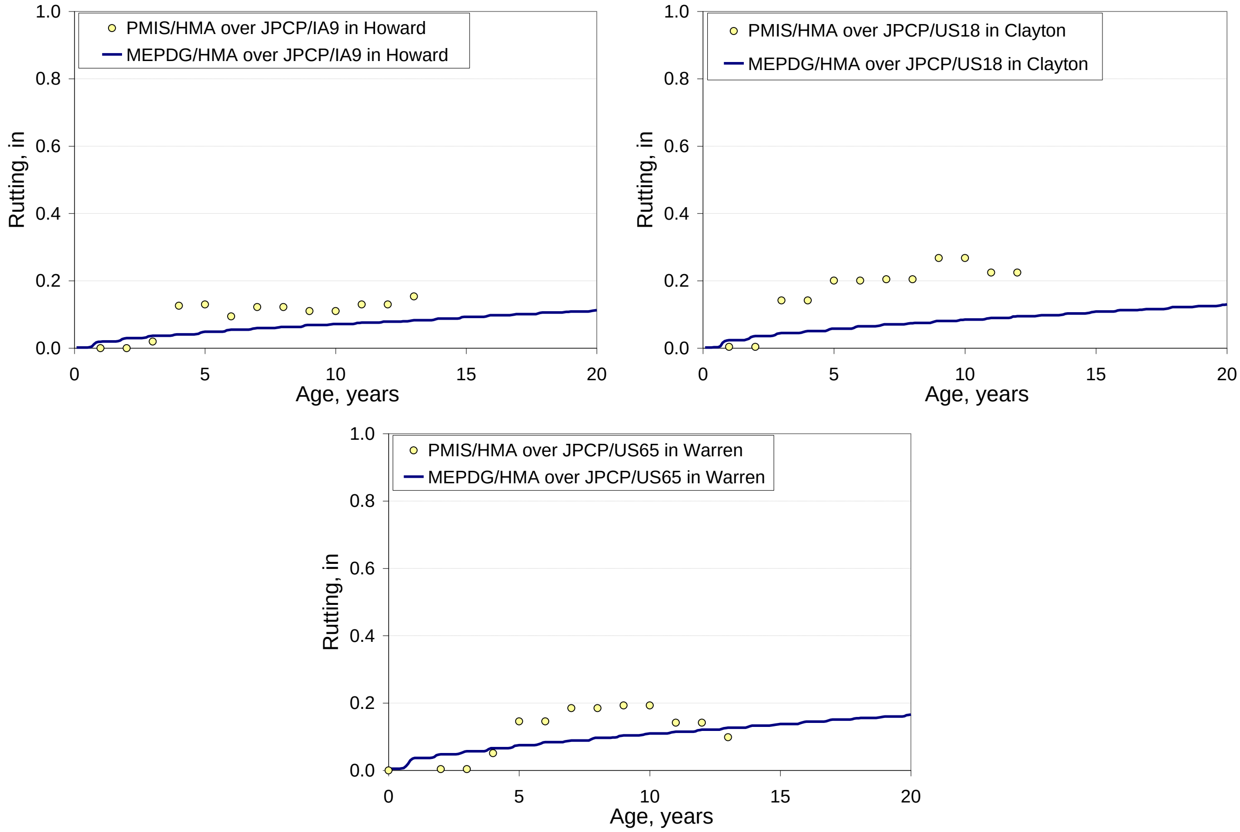


Figure 19. Rutting comparisons - predicted vs. actual for HMA over JPCPs in Iowa

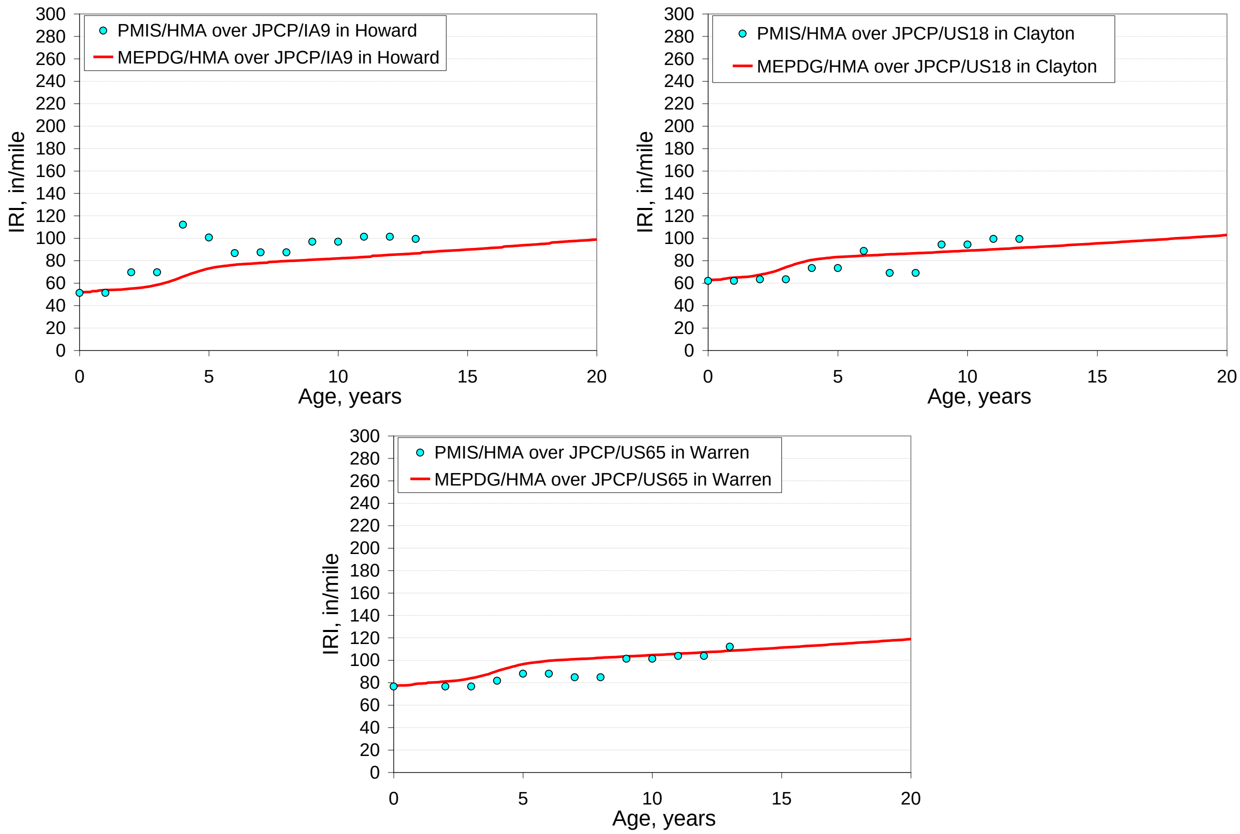


Figure 20. Smoothness (IRI) comparisons - predicted vs. actual for HMA over JPCPs in Iowa

HMA over HMA pavement

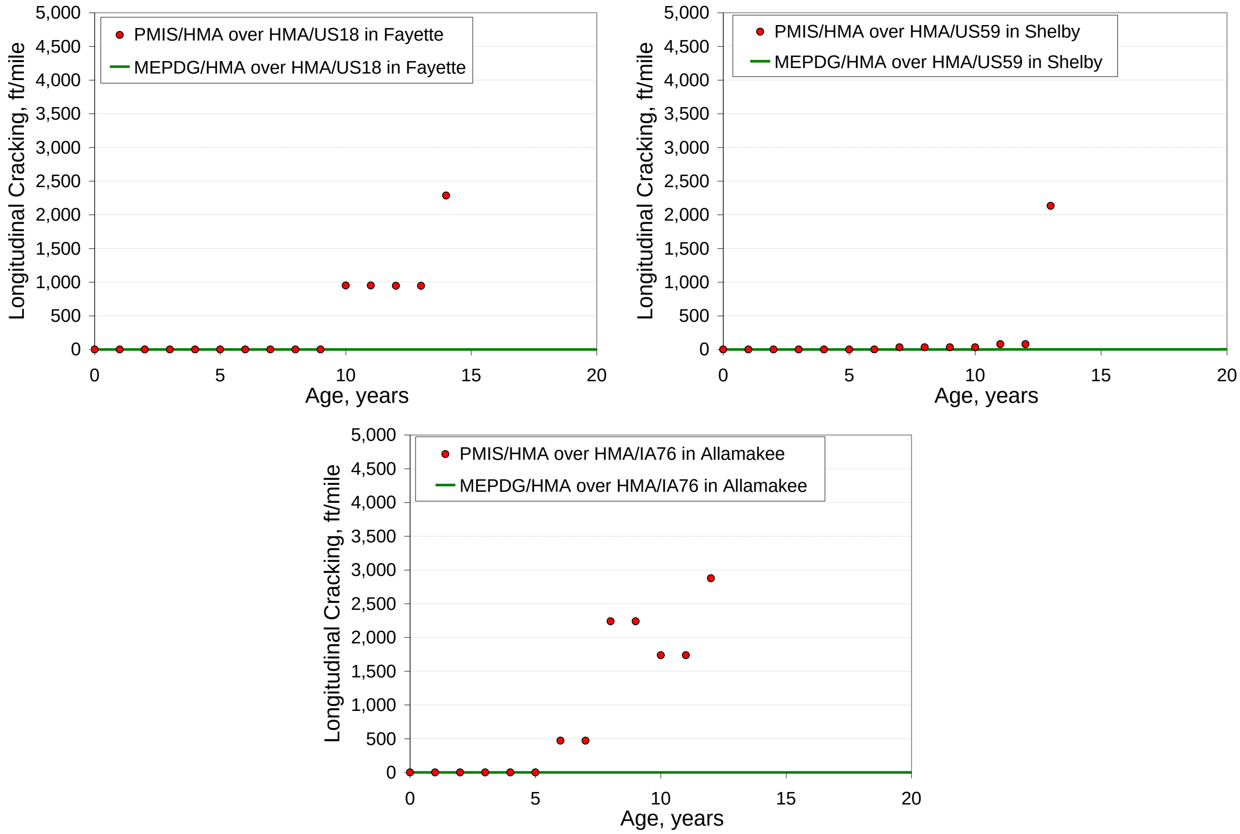


Figure 21. Longitudinal cracking comparisons - predicted vs. actual for HMA over HMA pavements in Iowa

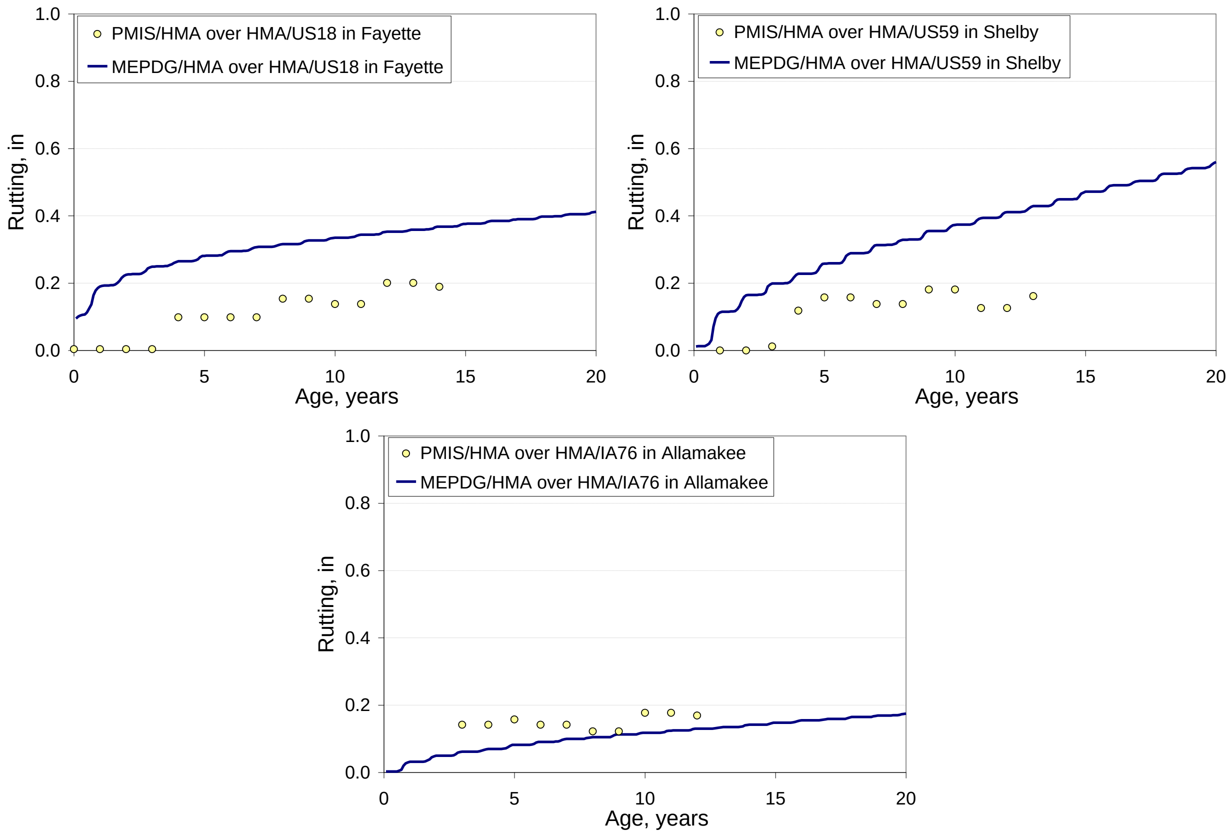


Figure 22. Rutting comparisons - predicted vs. actual for HMA over HMA pavements in Iowa

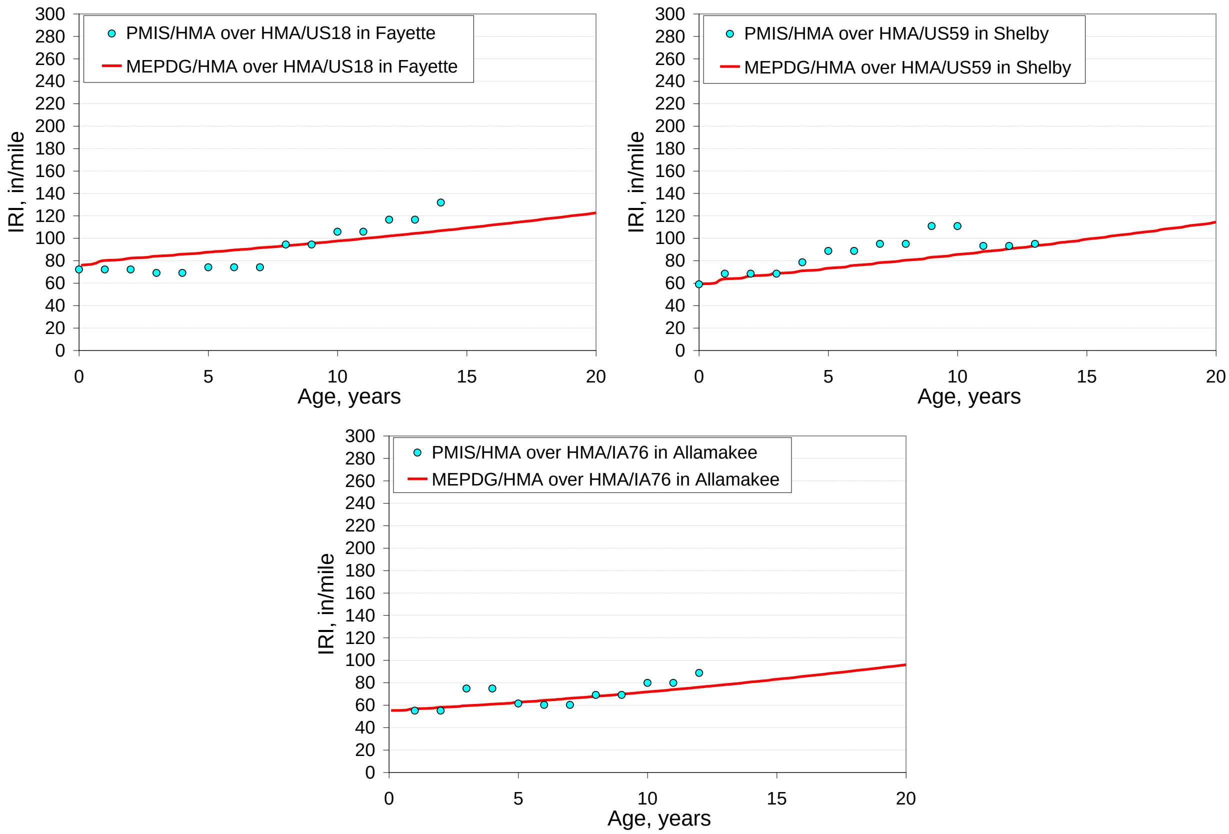


Figure 23. Smoothness (IRI) comparisons - predicted vs. actual for HMA over HMA pavements in Iowa

Accuracy of Performance Predictions

The MEPDG performance predictions evaluated for accuracy in this study includes rutting, faulting and IRI. Longitudinal cracking was not evaluated because it was later recommended by the NCHRP 1-40B study (Muthadi, 2007; Von Quintus and Moulthrop, 2007) that the longitudinal cracking model be dropped from the local calibration guide development due to lack of accuracy in the predictions.

Based on the recommendations of NCHRP 1-40B study, previous researchers (Muthadi, 2007) employed a null hypothesis test (a paired t-test) to check the accuracy of the MEPDG performance prediction models with national calibration factors. Current study also adopted a null hypothesis test (a paired t-test) to assess if there is any bias (systematic difference) and residual error between the measured and predicted distress values. The hypothesis here is that no significant differences exist between the measured and predicted values. A p-value greater than 0.05 (alpha) signifies that no significant difference exists between the measured and predicted values and, hence, the hypothesis is accepted.

The null hypothesis test results for each pavement type are presented in Figure 24 to Figure 27.

As shown in these figures, it can be observed that all of p-values except IRI of HMA over JPCPs are less than 0.05 (alpha) signifying that systematic difference (bias) exists between the measured and predicted values. Only IRI values for HMA over JPCPs do not have any bias. Even though p-values for IRI of HMA and HMA over HMA pavements are less than 0.05 (alpha), the values of IRI at these pavements as shown in Figure 24 and Figure 27are close to line of equality (45 degree line) signifying good agreement between the actual values and predictions. These results indicate that bias needs to be eliminated by recalibrating the MEPDG performance models to local conditions and materials.

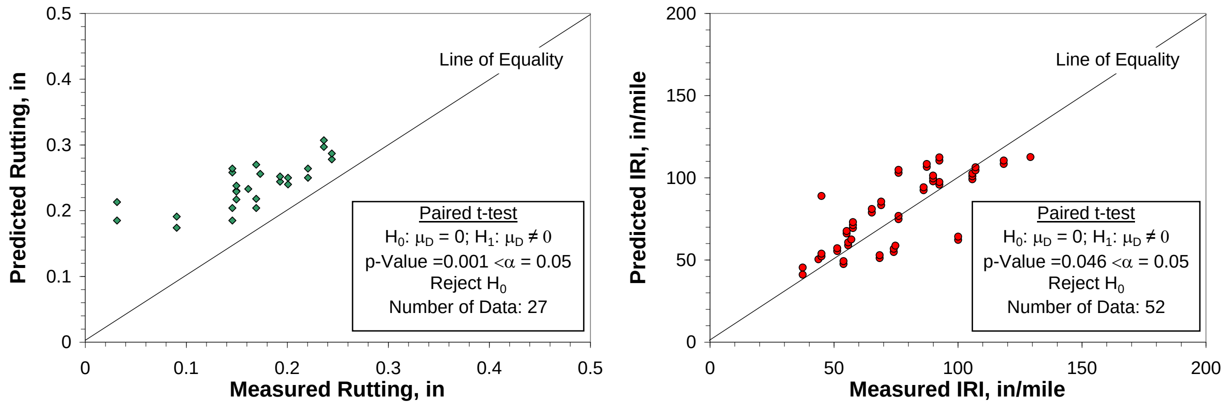


Figure 24. Verification testing results for rutting and IRI (HMA pavements in Iowa)

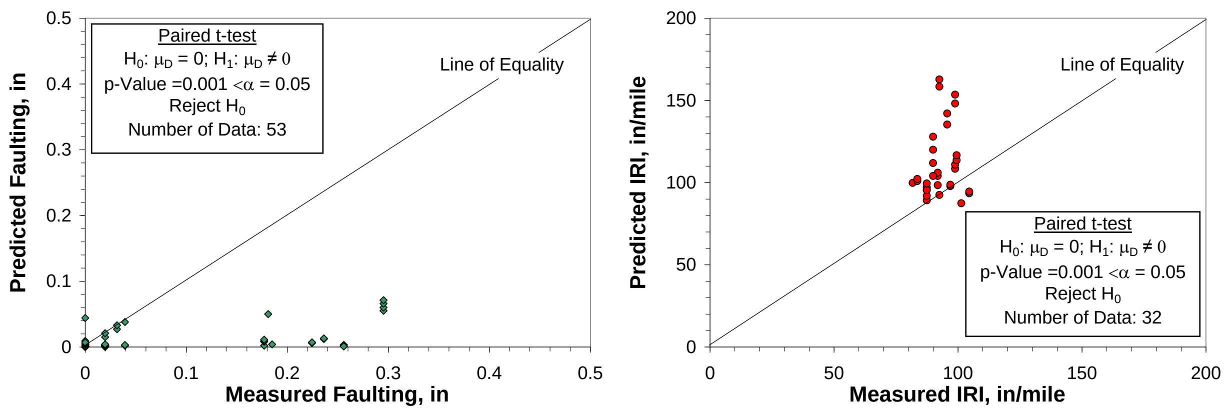


Figure 25. Verification testing results for faulting and IRI - JPCPs in Iowa

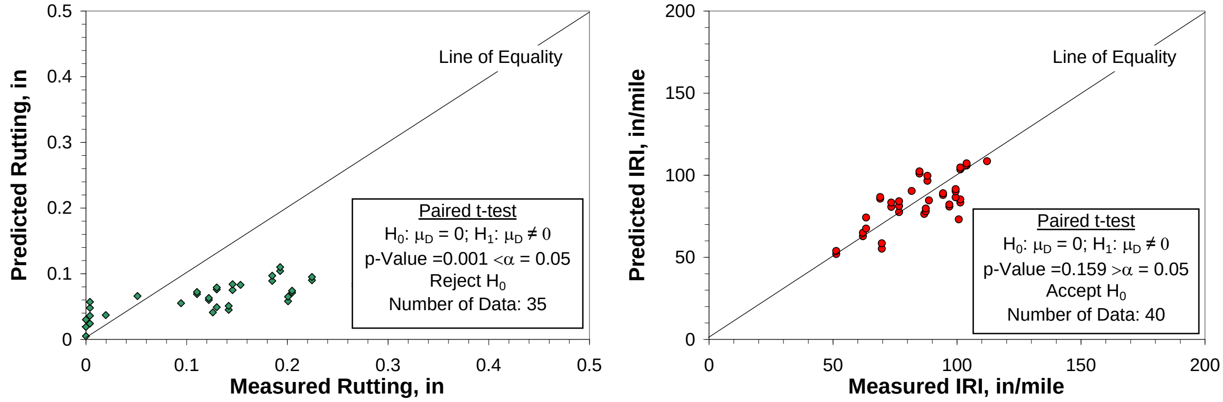


Figure 26. Verification testing results for rutting and IRI - HMA over JPCPs in Iowa

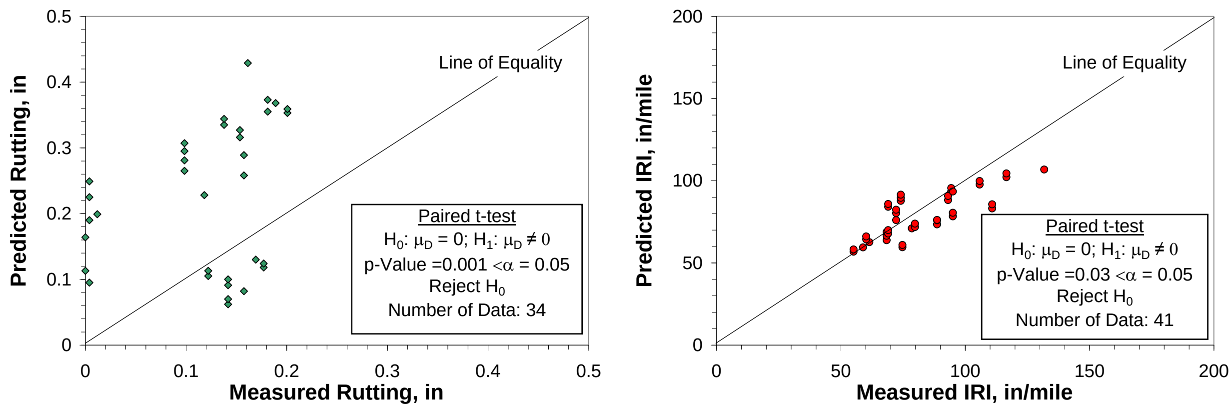


Figure 27. Verification testing results for rutting and IRI - HMA over HMA pavements in Iowa

SUMMARY

The objective of this research is to evaluate the accuracy of the nationally calibrated Mechanistic-Empirical Pavement Design Guide (MEPDG) prediction models for Iowa conditions. Comprehensive literature review was conducted to identify the MEPDG input parameters and the verification process. Sensitivity of MEPDG input parameters to predictions was studied using different versions of MEPDG software. Based on literature review results and sensitivity study, the detail verification procedures are developed. The 16 of pavements sections around state, not used for national calibration in NCHRP 1-47A, were selected. The database of MEPDG input requiring parameters and the actual pavement performance measures for the selected pavements was prepared for verification. The accuracy of the MEPDG for Iowa conditions was statistically evaluated. Based on this, the following findings and recommendations were made to improve the accuracy of MEPDG under Iowa conditions.

Findings and Conclusions

- The MEPDG-predicted IRI values are in good agreement with the actual IRI values from Iowa DOT PMIS for flexible and HMA overlaid pavements.
- Similar to MEPDG verification results reported by leading states including Montana, North Carolina, Washington, and Texas, bias (systematic difference) was found for MEPDG rutting and faulting models for Iowa highway conditions and materials.
- Bias (systematic difference) found in MEPDG rutting and faulting models can be eliminated by recalibrating the MEPDG performance models to Iowa highway conditions and materials.
- The HMA alligator and thermal (transverse) cracking and the JPCP transverse cracking in Iowa DOT PMIS are differently measured compared to MEPDG measurement metrics.
- The HMA longitudinal cracking model included in the MEPDG need to be refined to improve the accuracy of predictions.
- Irregularity trends in some of the distress measures recorded in Iowa DOT PMIS for certain pavement sections are observed. These may need to be removed from for verification and MEPDG local calibration.
- MEPDG provides individual pavement layer rutting predictions while Iowa DOT PMIS provides only accumulated (total) surface rutting observed in the pavement. This can lead to difficulties in the calibration of MEPDG rutting models for component pavement layers.
- The latest version (1.0) of MEPDG software seems to provide more reasonable predictions compared to the earlier versions.

Recommendations

- Recalibrating the MEPDG performance models to Iowa conditions is recommended to improve the accuracy of predictions.
- Increased number of pavement sections with more reliable data from the Iowa DOT PMIS should be included for calibration.
- Before performing calibration, it should be ensured that pavement distress measurement units between PMIS and MEPDG match.
- All the actual performance data should be subjected to reasonableness check and any presence of irrational trends or outliers in the data should be removed before performing calibration.
- Local calibration of HMA longitudinal cracking model included in the MEPDG should not be performed before it is refined further and released by the MEPDG research team.

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APPENDIX A: MEPDG INPUT DATABASE

Table A.1. MEPDG input parameters for HMA pavement systems

Type	Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
General Information	Design life (years)	20	20	20	20	20
	Base / Subgrade construction month	1998/Aug	1998/Aug	1993/Aug	1994/Aug	1997/Aug
	Pavement construction month	1998/Sept	1998/Sept	1993/Sept	1994/Sept	1997/Sept
	Traffic open month	1998/Oct	1998/Oct	1993/Oct	1994/Oct	1997/Oct
	Type of design (Flexible, CRCP, JPCP)	Flexible	Flexible	Flexible	Flexible	Flexible
	Restoration (JPCP)	Not required	Not required	Not required	Not required	Not required
	Overlay (AC, PCC)	Not required	Not required	Not required	Not required	Not required
Site / Project Identification	Location	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
	Project I.D	NHS-218-8(40)--19-09	NHSN-30-2(79)--2R-14	DE-RP-61-1(65)--33-56	NHS-18-3(69)--19-55	NHSN-141-6(43)--2R-25
	Section I.D	ACC-1	ACC-2	ACC-3	ACC-4	ACC-5
	Date	Analysis date	Analysis date	Analysis date	Analysis date	Analysis date
	Station/ mile post format	Mile Post	Mile Post	Mile Post	Mile Post	Mile Post
	Station/mile post begin	198.95	69.94	25.40	119.61	137.60
	Station/ mile post end	202.57	80.46	30.32	130.08	139.27
	Traffic direction	1	1	1	1	2
Analysis Parameter Flexible Pavement	Initial IRI (in/ mile)	43.7	37.4	55.1	86.2	90.0
	Terminal IRI (in /mile) limit	172 (Default)	172 (Default)	172 (Default)	172 (Default)	172 (Default)
	AC longitudinal cracking (ft/ mi) limit	1000 (Default)	1000 (Default)	1000 (Default)	1000 (Default)	1000 (Default)
	AC alligator cracking (%)limit	25 (Default)	25 (Default)	25 (Default)	25 (Default)	25 (Default)
	AC transverse cracking (ft/mi) limit	1000 (Default)	1000 (Default)	1000 (Default)	1000 (Default)	1000 (Default)
	Permanent deformation - Total (in) limit	0.75 (Default)	0.75 (Default)	0.75 (Default)	0.75 (Default)	0.75 (Default)

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type		Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Analysis Parameter		Permanent deformation - AC only (in) limit	0.25 (Default)	0.25 (Default)	0.25 (Default)	0.25 (Default)	0.25 (Default)
Traffic Input	General	Two-way average annual daily truck traffic (AADTT)	349	562	697	208	647
		Number of lanes in design direction	2 (Default)	2 (Default)	2 (Default)	2 (Default)	2 (Default)
		Percent of trucks in design direction	50 (Default)	50 (Default)	50 (Default)	50 (Default)	50 (Default)
		Percent of trucks in design lane	50 (Default)	50 (Default)	50 (Default)	50 (Default)	50 (Default)
		Operational Speed (mph)	60 (Default)	60 (Default)	60 (Default)	60 (Default)	60 (Default)
	Traffic Volume Adjustment Factors	Monthly adjustment factor	Default MAF (all : 1.0)	Default MAF (all : 1.0)	Default MAF (all : 1.0)	Default MAF (all : 1.0)	Default MAF (all : 1.0)
		Vehicle class distribution	TTC=1 (Default)	TTC=1 (Default)	TTC=1 (Default)	TTC=1 (Default)	TTC=1 (Default)
		Hourly truck distribution	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)
		Traffic growth factor	Compound growth /4% (Default)	Compound growth /4% (Default)	Compound growth /4% (Default)	Compound growth /4% (Default)	Compound growth /4% (Default)
	Axle Load Distribution Factors	Axle load distribution	Default	Default	Default	Default	Default
		Axle types	Single	Single	Single	Single	Single

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type		Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Traffic Input	General Traffic Inputs	Mean wheel location (in)	18 (Default)	18 (Default)	18 (Default)	18 (Default)	18 (Default)
		Traffic wander standard deviation(in)	10(Default)	10(Default)	10(Default)	10(Default)	10(Default)
		Design lane width (ft)	12(Default)	12(Default)	12(Default)	12(Default)	12(Default)
		Number axle/truck	Default	Default	Default	Default	Default
		Axle configuration: average axle width (ft)	8.5(Default)	8.5(Default)	8.5(Default)	8.5(Default)	8.5(Default)
		Axle configuration: dual tire spacing (in)	12(Default)	12(Default)	12(Default)	12(Default)	12(Default)
		Axle configuration: tire pressure for single & dual tire (psi)	120(Default)	120(Default)	120(Default)	120(Default)	120(Default)
		Axle configuration: axle spacing for tandem, tridem, and quad axle (in)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)
		Wheelbase: average axle spacing (ft)	12/15/18 (Default)	12/15/18 (Default)	12/15/18 (Default)	12/15/18 (Default)	12/15/18 (Default)
		Wheelbase: percent of trucks	33/33/34 (Default)	33/33/34 (Default)	33/33/34 (Default)	33/33/34 (Default)	33/33/34 (Default)
Climate Input		Climate data file	US218 in Bremer.icm (42.7008_-92.58345_1000)	US30 in Carroll.icm (42.0785_-94.8885_1000)	US61 in Lee.icm (40.7033_-91.2386_700)	US18 in Kossuth.icm (43.0817_-94.2383_1000)	IA141 in Dallas.icm (41.8199_-93.9118_1000)
		Depth of water table	15 ft	15 ft	15 ft	15 ft	15 ft
Structure Input		Surface short-wave absorptivity	0.85 (Default)	0.85 (Default)	0.85 (Default)	0.85 (Default)	0.85 (Default)
	Layer	Type	ACC/ACC/GSB/Subgrade	ACC/ACC/ACC/Subgrade	ACC/ACC/GSB/Subgrade	ACC/ACC/GSB/Subgrade	ACC/ACC/GSB/Subgrade
		Material	ACC/ BAC by 1999, TBB by 2006 /Agg/Soil	ACC/ACC/BAC/Soil	ACC/TBB/Agg/Soil	ACC/BAC/Agg/Soil	ACC/TBB/Agg/Soil

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type		Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Structure Input	Layer	Thickness	3”/8.5”/10.3” /Semi-infinite (last layer)	1.5”/1.5”/8.7” Semi-infinite (last layer)	4”/ 9”/10” Semi-infinite (last layer)	3”/8”/6” Semi-infinite (last layer)	3”/8.9”/7.5” Semi-infinite (last layer)
		Interface	1 (Default)	1 (Default)	1 (Default)	1 (Default)	1 (Default)
	HMA Design Properties	HMA E*predictive model	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A
		HMA rutting model	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A
		Fatigue endurance limit	Unchecked	Unchecked	Unchecked	Unchecked	Unchecked
Material Input	Asphalt Surface	Material	ACC	ACC	ACC	ACC	ACC
		Thickness	3”	1.5”	4”	3”	3”
		Asphalt mixer: gradation ($R_{3/4}$, $R_{3/8}$, $R_{\#4}$, $P_{\#200}$)	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4
		Asphalt binder: PG grade	PG58-28	PG58-28	PG58-28	PG58-28	PG58-28
		Asphalt binder: viscosity grade	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt binder: pentration grade	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt general: reference temp	70°F	70°F	70°F	70°F	70°F
		Asphalt general: volumetric properties (V_{beff})	11	11	11	11	11
		Asphalt general: volumetric properties (V_a)	7	7	7	7	7
		Asphalt general: volumetric properties (total unit weight)	143	143	143	143	143

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type		Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Material Input	Asphalt Surface	Asphalt general: Poisson's ratio	0.35	0.35	0.35	0.35	0.35
		Asphalt general: thermal properties (thermal conductivity asphalt)	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)
		Asphalt general: thermal properties (heat capacity asphalt)	0.23(Default)	0.23(Default)	0.23(Default)	0.23(Default)	0.23(Default)
	Asphalt Base	Material	BAC or TBB	ACC/BAC	TBB	BAC	TBB
		Thickness	8.5"	1.5"/8.7"	9"	8"	8.9"
		Asphalt mixer: gradation ($R_{3/4}$, $R_{3/8}$, $R_{\#4}$, $P_{\#200}$)	NMS ¾ " gradation - Cuml.% retain. ¾" : 0 - Cuml.% retain.3/8" : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3	NMS ¾ " gradation - Cuml.% retain. ¾" : 0 - Cuml.% retain.3/8" : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3	NMS ¾ " gradation - Cuml.% retain. ¾" : 0 - Cuml.% retain.3/8" : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3	NMS ¾ " gradation - Cuml.% retain. ¾" : 0 - Cuml.% retain.3/8" : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3	NMS ¾ " gradation - Cuml.% retain. ¾" : 0 - Cuml.% retain.3/8" : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3
		Asphalt binder: PG grade	PG58-28	PG58-28	PG58-28	PG58-28	PG58-28
		Asphalt binder: viscosity grade	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt binder: pentration grade	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt general: reference temp, °F	70	70	70	70	70
		Asphalt general: volumetric properties (V_{beff})	12	12	12	12	12
		Asphalt general: volumetric properties (V_a)	8	8	8	8	8

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type		Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Material Input	Asphalt Base	Asphalt general: volumetric properties (total unit weight)	143	143	143	143	143
		Asphalt general: Poisson's ratio	0.35	0.35	0.35	0.35	0.35
		Asphalt general: thermal properties (thermal conductivity asphalt)	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)
		Asphalt general: thermal properties (heat capacity asphalt)	0.23(Default)	0.23(Default)	0.23(Default)	0.23(Default)	0.23(Default)
	Granular Base	Material	Aggregate (A-1-a)	Not required (No aggr. base)	Aggregate (A-1-a)	Aggregate (A-1-a)	Aggregate (A-1-a)
		Thickness	10.3"	Not required (No aggr. base)	10"	6"	7.5"
		Strength properties: Poisson ratio	0.35 (Default)	Not required (No aggr. base)	0.35 (Default)	0.35 (Default)	0.35 (Default)
		Strength properties: coefficient of lateral pressure	0.5 (Default)	Not required (No aggr. base)	0.5 (Default)	0.5 (Default)	0.5 (Default)
		Strength properties: analysis type (using ICM, user input modulus)	user input modulus – representative value	Not required (No aggr. base)	user input modulus – representative value	user input modulus – representative value	user input modulus – representative value
		Material properties: Modulus	35,063 (Task 5)	Not required (No aggr. base)	35,063 (Task 5)	35,063 (Task 5)	35,063 (Task 5)
		Material properties: CBR	Not required if modulus is chosen	Not required (No aggr. base)	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: R-Value	Not required if modulus is chosen	Not required (No aggr. base)	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: layer coefficient	Not required if modulus is chosen	Not required (No aggr. base)	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type		Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Material Input	Granular Base	Material properties: DCP	Not required if modulus is chosen	Not required (No aggr. base)	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: based on PI and gradation	Not required if modulus is chosen	Not required (No aggr. base)	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		ICM: gradation	Not required if user input modulus is chosen	Not required (No aggr. base)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: liquid limit and plasticity index	Not required if user input modulus is chosen	Not required (No aggr. base)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: compacted or uncompacted	Not required if user input modulus is chosen	Not required (No aggr. base)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: user index (max. dry unit weight)	Not required if user input modulus is chosen	Not required (No aggr. base)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: user index (specific gravity)	Not required if user input modulus is chosen	Not required (No aggr. base)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: user index (sat. hydraulic conductivity)	Not required if user input modulus is chosen	Not required (No aggr. base)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: user index (opt. gravimetric water content)	Not required if user input modulus is chosen	Not required (No aggr. base)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type		Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Material Input	Subgrade	Material	Soil (A-6)	Soil (A-6)	Soil (A-6)	Soil (A-6)	Soil (A-6)
		Thickness	Semi-infinite (last layer)	Semi-infinite (last layer)	Semi-infinite (last layer)	Semi-infinite (last layer)	Semi-infinite (last layer)
		Strength properties: Poisson ratio	0.35 (Default)	0.35 (Default)	0.35 (Default)	0.35 (Default)	0.35 (Default)
		Strength properties: coefficient of lateral pressure	0.5 (Default)	0.5 (Default)	0.5 (Default)	0.5 (Default)	0.5 (Default)
		Strength properties: analysis type (using ICM, user input modulus)	using ICM	using ICM	using ICM	using ICM	using ICM
		Material properties: Modulus	9,946 (Task 5)	9,946 (Task 5)	9,946 (Task 5)	9,946 (Task 5)	9,946 (Task 5)
		Material properties: CBR	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: R-Value	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: layer coefficient	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: DCP	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: based on PI and gradation	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type		Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Material Input	Subgrade	ICM: gradation	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)
		ICM: plasticity index (%)/ liquid limit (%)/compacted layer	19.1/34.8 (Task 5)	19.1/34.8 (Task 5)	19.1/34.8 (Task 5)	19.1/34.8 (Task 5)	19.1/34.8 (Task 5)
		ICM: compacted or uncompacted	Compacted	Compacted	Compacted	Compacted	Compacted
		ICM: user index (max. dry unit weight)	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (specific gravity)	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (sat. hydraulic conductivity)	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (opt. gravimetric water content)	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation

Table A.1. MEPDG input parameters for HMA pavement systems (continued)

Type	Input Parameter	US218 in Bremer	US30 in Carroll	US61 in Lee	US18 in Kossuth	IA141 in Dallas
Thermal cracking (ACC surface)	Average tensile strength at 14 ^{O}F	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Creep compliance – low, mid, high temp at different loading time (1, 2, 5, 10, 20, 50, and 100 sec)	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Compute mix coefficient of thermal contraction (VMA)	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Compute mix coefficient of thermal contraction (aggregate coefficient of thermal contraction)	5e-006 (Default)	5e-006 (Default)	5e-006 (Default)	5e-006 (Default)	5e-006 (Default)
	Input mix coefficient of thermal contraction	Not required if computing option is chosen	Not required if computing option is chosen	Not required if computing option is chosen	Not required if computing option is chosen	Not required if computing option is chosen

Table A.2. MEPDG input parameters for JPC pavement systems

Type	Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
General Information	Design life (years)	30	30	30	30	30
	Base / Subgrade construction month	Not required	Not required	Not required	Not required	Not required
	Pavement construction month	1994 /Sept	2001/Sept	1991/Sept	1992/Sept	1992/Sept
	Traffic open month	1994/Oct	2001/Oct	1991/Oct	1992/Oct	1992/Oct
	Type of design (Flexible, CRCP, JPCP)	JPCP	JPCP	JPCP	JPCP	JPCP
	Restoration (JPCP)	Not required	Not required	Not required	Not required	Not required
	Overlay (AC, PCC)	Not required	Not required	Not required	Not required	Not required
Site / Project Identification	Location	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
	Project I.D	NHS-500-1(3)--19-77	NHSX-75-1(75)--19-97	IR-80-7(57)265	F-RP-151-3(79)	F-30-5(80)--20-85
	Section I.D	PCC-1	PCC-2	PCC-3	PCC-4	PCC-5
	Date	Analysis date	Analysis date	Analysis date	Analysis date	Analysis date
	Station/ mile post format	Mile Post	Mile Post	Mile Post	Mile Post	Mile Post
	Station/mile post begin	082.40	096.53	275.34	040.04	151.92
	Station/ mile post end	083.10	099. 93	278.10	045.14	156.80
	Traffic direction	1	1	1	2	2
Analysis Parameter	Initial IRI (in/ mile)	96.9	92.5	90.0	116.6	87.4
Rigid Pavement	Terminal IRI (in /mile) limit	172 (Default)	172 (Default)	172 (Default)	172 (Default)	172 (Default)
	Transverse cracking (JPCP) (% slabs cracked) limit	15 (Default)	15 (Default)	15 (Default)	15 (Default)	15 (Default)
	Mean joint faulting (JPCP) (in) limit	0.12 (Default)	0.12 (Default)	0.12 (Default)	0.12 (Default)	0.12 (Default)

Table A.2. MEPDG input parameters for JPC pavement systems (continued)

Type		Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
Traffic Input	General	Two-way average annual daily truck traffic (AADTT)	472	330	7525	496	889
		Number of lanes in design direction	2 (Default)	2 (Default)	2 (Default)	2 (Default)	2 (Default)
		Percent of trucks in design direction	50 (Default)	50 (Default)	50 (Default)	50 (Default)	50 (Default)
		Percent of trucks in design lane	50 (Default)	50 (Default)	50 (Default)	50 (Default)	50 (Default)
		Operational Speed (mph)	60 (Default)	60 (Default)	60 (Default)	60 (Default)	60 (Default)
	Traffic Volume Adjustment Factors	Monthly adjustment factor	Default MAF (all : 1.0)	Default MAF (all : 1.0)	Default MAF (all : 1.0)	Default MAF (all : 1.0)	Default MAF (all : 1.0)
		Vehicle class distribution	TTC=1 (Default)	TTC=1 (Default)	TTC=1 (Default)	TTC=1 (Default)	TTC=1 (Default)
		Hourly truck distribution	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)
		Traffic growth factor	Compound growth /4% (Default)	Compound growth /4% (Default)	Compound growth /4% (Default)	Compound growth /4% (Default)	Compound growth /4% (Default)
	Axle Load Distribution Factors	Axle load distribution	Default	Default	Default	Default	Default
		Axle types	Single	Single	Single	Single	Single

Table A.2. MEPDG input parameters for JPC pavement systems (continued)

Type		Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
Traffic Input	General Traffic Inputs	Mean wheel location (in)	18 (Default)	18 (Default)	18 (Default)	18 (Default)	18 (Default)
		Traffic wander standard deviation(in)	10(Default)	10(Default)	10(Default)	10(Default)	10(Default)
		Design lane width (ft)	12(Default)	12(Default)	12(Default)	12(Default)	12(Default)
		Number axle/truck	Default	Default	Default	Default	Default
		Axle configuration: average axle width (ft)	8.5(Default)	8.5(Default)	8.5(Default)	8.5(Default)	8.5(Default)
		Axle configuration: dual tire spacing (in)	12(Default)	12(Default)	12(Default)	12(Default)	12(Default)
		Axle configuration: tire pressure for single & dual tire (psi)	120(Default)	120(Default)	120(Default)	120(Default)	120(Default)
		Axle configuration: axle spacing for tandem, tridem, and quad axle (in)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)
		Wheelbase: average axle spacing (ft)	12/15/18 (Default)	12/15/18 (Default)	12/15/18 (Default)	12/15/18 (Default)	12/15/18 (Default)
		Wheelbase: percent of trucks	33/33/34 (Default)	33/33/34 (Default)	33/33/34 (Default)	33/33/34 (Default)	33/33/34 (Default)
Climate Input		Climate data file	US65 in Polk.icm (41.645_-93.5106_1000)	US75 in Woodbury.icm (42.5571_-96.3377_1200)	I80 in Cedar.icm (41.6355_-90.8987_800)	US151 in Linn.icm (42.0526_-91.4761_800)	US30 in Story.icm (42.0086_-93.5555_1000)
		Depth of water table	15 ft	15 ft	15 ft	15 ft	15 ft
Structure Input		Surface short-wave absorptivity	0.85 (Default)	0.85 (Default)	0.85 (Default)	0.85 (Default)	0.85 (Default)
	Layer	Type	JPCP/GSB/Subgrade	JPCP/GSB/Subgrade	JPCP/GSB/Subgrade	JPCP/GSB/Subgrade	JPCP/GSB/Subgrade
		Material	PCC/Agg/Soil	PCC/Agg/Soil	PCC/Agg/Soil	PCC/Agg/Soil	PCC/Agg/Soil

Table A.2. MEPDG input parameters for JPC pavement systems (continued)

Type		Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
Structure Input	Layer	Thickness	11”/10”/Semi-infinite (last layer)	10”/20”/Semi-infinite (last layer)	12”/9”/Semi-infinite (last layer)	9.5”/10”/Semi-infinite (last layer)	10”/10”/Semi-infinite (last layer)
	PCC Design Features	Permanent curl/warp effective temperature difference (F)	-10 (Default)	-10 (Default)	-10 (Default)	-10 (Default)	-10 (Default)
		Joint spacing (JPCP), ft	20 (RPCC and Curling projects)	20 (RPCC and Curling projects)	20 (RPCC and Curling projects)	20 (RPCC and Curling projects)	20 (RPCC and Curling projects)
		Sealant type (JPCP)	Liquid	Liquid	Liquid	Liquid	Liquid
		Random joint spacing	Unchecked	Unchecked	Unchecked	Unchecked	Unchecked
		Doweled transverse joints: dowel bar diameter (JPCP), in.	1.5 (Curling projects)	1.5 (Curling projects)	1.5 (Curling projects)	1.5 (Curling projects)	1.5 (Curling projects)
		Doweled transverse joints: dowel bar spacing (JPCP),in	12 (Curling projects)	12 (Curling projects)	12 (Curling projects)	12 (Curling projects)	12 (Curling projects)
		Edge support: tied PCC shoulder – long term LTE (JPCP)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)
		Edge Support: widened slab –slab width (JPCP)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)
		Erodibility index	Erosion resistance (3)	Erosion resistance (3)	Erosion resistance (3)	Erosion resistance (3)	Erosion resistance (3)
		PCC-Base interface (JPCP)	Full friction contact	Full friction contact	Full friction contact	Full friction contact	Full friction contact
		Los of full friction (JPCP), age in months	60 (Default)	60 (Default)	60 (Default)	60 (Default)	60 (Default)

Table A.2. MEPDG input parameters for JPC pavement systems (continued)

Type		Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
Material Input	PCC Surface	Material	JPCP	JPCP	JPCP	JPCP	JPCP
		Thickness	11”	10”	12”	9.5”	10”
		General properties : unit weight , pcf	142.7 (Task 6)	142.7 (Task 6)	142.7 (Task 6)	142.7 (Task 6)	142.7 (Task 6)
		General properties : Poisson’s ratio	0.2 (Default)	0.2 (Default)	0.2 (Default)	0.2 (Default)	0.2 (Default)
		Thermal properties: coeff. of thermal expansion, per F× 10^-6	5.69 (Task 6-limesstone)	5.69 (Task 6-limesstone)	5.69 (Task 6-limesstone)	5.69 (Task 6-limesstone)	5.69 (Task 6-limesstone)
		Thermal properties: thermal conductivity, Btu/hr•ft•F°	0.77 (Task 6)	0.77 (Task 6)	0.77 (Task 6)	0.77 (Task 6)	0.77 (Task 6)
		Thermal properties: heat capacity, Btu/lb•F°	0.28 (Default)	0.28 (Default)	0.28 (Default)	0.28 (Default)	0.28 (Default)
		Mix design properties : cement type	Type I (Curling project)	Type I (Curling project)	Type I (Curling project)	Type I (Curling project)	Type I (Curling project)
		Mix design properties: cementitious material content, pcy	538 (Task 4-MMO-L project)	538 (Task 4-MMO-L project)	538 (Task 4-MMO-L project)	538 (Task 4-MMO-L project)	538 (Task 4-MMO-L project)
		Mix design properties: W/C ratio	0.405(Task 4 – Iowa DOT QMC)	0.405(Task 4 – Iowa DOT QMC)	0.405(Task 4 – Iowa DOT QMC)	0.405(Task 4 – Iowa DOT QMC)	0.405(Task 4 – Iowa DOT QMC)
		Mix design properties: aggregate type	Limestone (Default)	Limestone (Default)	Limestone (Default)	Limestone (Default)	Limestone (Default)
		Mix design properties: zero stress temp.	Derived	Derived	Derived	Derived	Derived
		Shrinkage properties: ultimate shrinkage at 40 %, micro-strain	454 (Task 4)	454 (Task 4)	454 (Task 4)	454 (Task 4)	454 (Task 4)
		Shrinkage properties: reversible shrinkage, %	50 (Default)	50 (Default)	50 (Default)	50 (Default)	50 (Default)

Table A.2. MEPDG input parameters for JPC pavement systems (continued)

Type		Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
Material Input	PCC Surface	Shrinkage properties: time to develop 50 % of ultimate shrinkage (JPCP)	35 (Default)	35 (Default)	35 (Default)	35 (Default)	35 (Default)
		Shrinkage properties: curing method	Curing compound (Default)	Curing compound (Default)	Curing compound (Default)	Curing compound (Default)	Curing compound (Default)
		Strength properties: PCC Modulus of Rupture, psi	646 (Task 4)	646 (Task 4)	646 (Task 4)	646 (Task 4)	646 (Task 4)
		Strength properties: PCC compressive strength, psi	4,397 (Task 4)	4,397 psi (Task 4)	4,397 (Task 4)	4,397 (Task 4)	4,397 (Task 4)
		Strength properties: PCC elastic modulus, psi	Derived	Derived	Derived	Derived	Derived
	Granular Base	Material	Aggregate (A-1-a)	Aggregate (A-1-a)	Aggregate (A-1-a)	Aggregate (A-1-a)	Aggregate (A-1-a)
		Thickness	10”	20”	9”	10”	10”
		Strength properties: Poisson ratio	0.35 (Default)	0.35 (Default)	0.35 (Default)	0.35 (Default)	0.35 (Default)
		Strength properties: coefficient of lateral pressure	0.5 (Default)	0.5 (Default)	0.5 (Default)	0.5 (Default)	0.5 (Default)
		Strength properties: analysis type (using ICM, user input modulus)	User input modulus – representative value	User input modulus – representative value	User input modulus – representative value	User input modulus – representative value	User input modulus – representative value
		Material properties: Modulus	35,063 (Task 5)	35,063 (Task 5)	35,063 (Task 5)	35,063 (Task 5)	35,063 (Task 5)
		Material properties: CBR	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: R-Value	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: layer coefficient	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen

Table A.2. MEPDG input parameters for JPC pavement systems (continued)

Type		Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
Material Input	Granular Base	Material properties: DCP	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: based on PI and gradation	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		ICM: gradation	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: liquid limit and plasticity index	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: compacted or uncompacted	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: user index (max. dry unit weight)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: user index (specific gravity)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: user index (sat. hydraulic conductivity)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen
		ICM: user index (opt. gravimetric water content)	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen	Not required if user input modulus is chosen

Table A.2. MEPDG input parameters for JPC pavement systems (continued)

Type		Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
Material Input	Subgrade	Material	Soil (A-6)	Soil (A-6)	Soil (A-6)	Soil (A-6)	Soil (A-6)
		Thickness	Semi-infinite (last layer)	Semi-infinite (last layer)	Semi-infinite (last layer)	Semi-infinite (last layer)	Semi-infinite (last layer)
		Strength properties: Poisson ratio	0.35 (Default)	0.35 (Default)	0.35 (Default)	0.35 (Default)	0.35 (Default)
		Strength properties: coefficient of lateral pressure	0.5 (Default)	0.5 (Default)	0.5 (Default)	0.5 (Default)	0.5 (Default)
		Strength properties: analysis type (using ICM, user input modulus)	using ICM	using ICM	using ICM	using ICM	using ICM
		Material properties: Modulus	9,946 (Task 5)	9,946 (Task 5)	9,946 (Task 5)	9,946 (Task 5)	9,946 (Task 5)
		Material properties: CBR	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: R-Value	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: layer coefficient	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: DCP	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: based on PI and gradation	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen

Table A.2. MEPDG input parameters for JPC pavement systems (continued)

Type		Input Parameter	US65 in Polk	US75 in Woodbury	I80 in Cedar	US 151 in Linn	US 30 in Story
Material Input	Subgrade	ICM: gradation	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)
		ICM: plasticity index (%)/ liquid limit (%)/compacted layer	19.1/34.8 (Task 5)	19.1/34.8 (Task 5)	19.1/34.8 (Task 5)	19.1/34.8 (Task 5)	19.1/34.8 (Task 5)
		ICM: compacted or uncompacted	Compacted	Compacted	Compacted	Compacted	Compacted
		ICM: user index (max. dry unit weight)	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (specific gravity)	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (sat. hydraulic conductivity)	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (opt. gravimetric water content)	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation	Derived from gradation

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems

Type	Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
General Information	Design life (years)	20	20	20
	Base / Subgrade construction month	1991/Aug	1993/Aug	1994/Aug
	Pavement construction month (existing structure construction year)	1991/Sept (1977)	1993/Sept (1970)	1994/Sept (1964)
	Traffic open month	1991/Oct	1993/Oct	1994/Oct
	Type of design (Flexible, CRCP, JPCP)	Not required	Not required	Not required
	Restoration (JPCP)	Not required	Not required	Not required
	Overlay (ACC, PCC)	ACC over ACC	ACC over ACC	ACC over ACC
Site / Project Identification	Location	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
	Project I.D (existing structure project I.D)	FN-18-8(29)--20-33 (FN-18-8(14)--21-33)	STP-59-4(24)--2C-83 (F-59-4(2)--20-83)	STP-76-2(19)--2C-03 (FN-347)
	Section I.D	ACC over ACC-1	ACC over ACC-2	ACC over ACC-3
	Date	Analysis date	Analysis date	Analysis date
	Station/ mile post format	Mile Post	Mile Post	Mile Post
	Station/mile post begin	273.05	069.73	019.78
	Station/ mile post end	274. 96	070.63	024.82
	Traffic direction	1	1	1
Analysis Parameter	Initial IRI (in/ mile)	72.2	58.9	55.1
Flexible Pavement	Terminal IRI (in /mile) limit	172 (Default)	172 (Default)	172 (Default)
	AC longitudinal cracking (ft/ mi) limit (Flexible)	1000 (Default)	1000 (Default)	1000 (Default)
	AC alligator cracking (%)limit (Flexible)	25 (Default)	25 (Default)	25 (Default)
	AC transverse cracking (ft/mi) limit (Flexible)	1000 (Default)	1000 (Default)	1000 (Default)
	Chemically stabilized layer fatigue fracture, %	25(Default)	25(Default)	25(Default)
	Permanent deformation - Total (in) limit (Flexible)	0.75 (Default)	0.75 (Default)	0.75 (Default)
	Permanent deformation - AC only (in) limit (Flexible)	0.25 (Default)	0.25 (Default)	0.25 (Default)

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Traffic Input	General	Two-way average annual daily truck traffic (AADTT)	2150	3430	1340
		Number of lanes in design direction	2 (Default)	2 (Default)	2 (Default)
		Percent of trucks in design direction	50 (Default)	50 (Default)	50 (Default)
		Percent of trucks in design lane	50 (Default)	50 (Default)	50 (Default)
		Operational Speed (mph)	60 (Default)	60 (Default)	60 (Default)
	Traffic Volume Adjustment Factors	Monthly adjustment factor	Default MAF (all : 1.0)	Default MAF (all : 1.0)	Default MAF (all : 1.0)
		Vehicle class distribution	TTC=1 (Default)	TTC=1 (Default)	TTC=1 (Default)
		Hourly truck distribution	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)
		Traffic growth factor	Compound growth /4% (Default)	Compound growth /4% (Default)	Compound growth /4% (Default)
	Axle Load Distribution Factors	Axle load distribution	Default	Default	Default
		Axle types	Single	Single	Single
Traffic Input	General Traffic Inputs	Mean wheel location (in)	18 (Default)	18 (Default)	18 (Default)
		Traffic wander standard deviation(in)	10(Default)	10(Default)	10(Default)
		Design lane width (ft)	12(Default)	12(Default)	12(Default)
		Number axle/truck	Default	Default	Default
		Axle configuration: average axle width (ft)	8.5(Default)	8.5(Default)	8.5(Default)
		Axle configuration: dual tire spacing (in)	12(Default)	12(Default)	12(Default)
		Axle configuration: tire pressure for single & dual tire (psi)	120(Default)	120(Default)	120(Default)

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Traffic Input	General Traffic Inputs	Axle configuration: axle spacing for tandem, tridem, and quad axle (in)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)
		Wheelbase: average axle spacing (ft)	12/15/18 (Default)	12/15/18 (Default)	12/15/18 (Default)
		Wheelbase: percent of trucks	33/33/34 (Default)	33/33/34 (Default)	33/33/34 (Default)
Climate Input		Climate data file	US18 in Fayette.icm (43.0588_-91.6134_900)	US59 in Shelby.icm (41.5696_-95.3335_1100)	IA76 in Allamakee.icm (43.2111_-91.4319_800)
		Depth of water table	15 ft	15 ft	15 ft
Structure Input		Surface short-wave absorptivity	0.85 (Default)	0.85 (Default)	0.85 (Default)
	Layer	Type (Overlaid structure)	ACC	ACC/ACC	ACC/ACC
		Material (Overlaid structure)	ACC	ACC/BAC	ACC/BAC
		Thickness, in.	4”	2”/2”	2”/2”
		Interface	1 (Default)	1 (Default)	1 (Default)
		Type (Existing structure)	ACC/ACC/SAS/Subgrade	ACC/ACC/SLS/Subgrade	ACC/ACC/SAS/Subgrade
		Material (Existing structure)	ACC/ATB/Soil-Agg/Soil	ACC/ACC/Soil-Lime/Soil	BAC/ATB/ Soil-Agg /Soil
		Thickness, in.	3”/8”/6”/Semi-infinite (last layer)	1”/3.5”/6”/Semi-infinite (last layer)	3”/7”/6”/ Semi-infinite (last layer)
		Interface	1 (Default)	1 (Default)	1 (Default)
	Flexible Rehabilitation	Rehabilitation level	Level 3	Level 3	Level 3
		Milled thickness, in	0	0	1
		Geotextile present on exiting layer	Unchecked	Unchecked	Unchecked
		Pavement Rating	Fair (Default)	Fair (Default)	Fair (Default)
		Total rutting	0	0.2	0.1
	HMA Design Properties	HMA E*predictive model	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A
		HMA rutting model	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A
		Fatigue endurance limit	Unchecked	Unchecked	Unchecked
		Reflection cracking analysis	Checked	Checked	Checked

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Material Input	Asphalt Surface (overlay)	Material	ACC	ACC	ACC
		Thickness, in.	4”	2”	2”
		Asphalt mixer: gradation ($R_{3/4}$, $R_{3/8}$, $R_{\#4}$, $P_{\#200}$),%	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4
		Asphalt binder: PG grade	PG58-28	PG58-28	PG58-28
		Asphalt binder: viscosity grade	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt binder: pentration grade	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt general: reference temp, °F	70	70	70
		Asphalt general: volumetric properties (V_{beff}),%	11	11	11
		Asphalt general: volumetric properties (V_a),%	7	7	7
		Asphalt general: volumetric properties (total unit weight),%	143	143	143
		Asphalt general: Poisson’s ratio	0.35	0.35	0.35
		Asphalt general: thermal properties (thermal conductivity asphalt), Btu/hr•ft•F°	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)
		Asphalt general: thermal properties (heat capacity asphalt), Btu/lb•F°	0.23(Default)	0.23(Default)	0.23(Default)

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Material Input	Asphalt Base (overlay)	Material	Not required (No overlaid ACC base)	BAC	BAC
		Thickness, in.	Not required (No overlaid ACC base)	2”	2”
		Asphalt mixer: gradation ($R_{3/4}$, $R_{3/8}$, $R_{\#4}$, $P_{\#200}$),%	Not required (No overlaid ACC base)	NMS ¾ ” gradation - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3	NMS ¾ ” gradation - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3
		Asphalt binder: PG grade	Not required (No overlaid ACC base)	PG58-28	PG58-28
		Asphalt binder: viscosity grade	Not required (No overlaid ACC base)	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt binder: pentration grade	Not required (No overlaid ACC base)	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt general: reference temp, °F	Not required (No overlaid ACC base)	70°F	70°F
		Asphalt general: volumetric properties (V_{beff}),%	Not required (No overlaid ACC base)	12	12
		Asphalt general: volumetric properties (V_a),%	Not required (No overlaid ACC base)	8	8
		Asphalt general: volumetric properties (total unit weight),%	Not required (No overlaid ACC base)	143	143
		Asphalt general: Poisson’s ratio	Not required (No overlaid ACC base)	0.35	0.35
		Asphalt general: thermal properties (thermal conductivity asphalt), Btu/hr•ft•F°	Not required (No overlaid ACC base)	1.21(Task 6)	1.21(Task 6)
		Asphalt general: thermal properties (heat capacity asphalt), Btu/lb•F°	Not required (No overlaid ACC base)	0.23(Default)	0.23(Default)

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Material Input	Asphalt Surface (existing)	Material	ACC	ACC	BAC
		Thickness, in.	3”	1”	3”
		Asphalt mixer: gradation ($R_{3/4,}$ $R_{3/8}$, $R_{\#4}$, $P_{\#200}$),%	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4
		Asphalt binder: PG grade	Not required if viscosity grade is chosen	Not required if viscosity grade is chosen	Not required if viscosity grade is chosen
		Asphalt binder: viscosity grade	AC-10	AC-10	AC-10
		Asphalt binder: pentration grade	Not required if viscosity grade is chosen	Not required if viscosity grade is chosen	Not required if viscosity grade is chosen
		Asphalt general: reference temp, °F	70	70	70
		Asphalt general: volumetric properties (V_{beff}),%	11	11	11
		Asphalt general: volumetric properties (V_a),%	7	7	7
		Asphalt general: volumetric properties (total unit weight),%	143	143	143
		Asphalt general: Poisson’s ratio	0.35	0.35	0.35
		Asphalt general: thermal properties (thermal conductivity asphalt), Btu/hr•ft•F°	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)
		Asphalt general: thermal properties (heat capacity asphalt), Btu/lb•F°	0.23(Default)	0.23(Default)	0.23(Default)

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Material Input	Asphalt Base (existing)	Material	ATB	ACC	ATB
		Thickness, in.	8”	3.5”	7”
		Asphalt mixer: gradation ($R_{3/4,}$ $R_{3/8}$, $R_{\#4}$, $P_{\#200}$),%	NMS ¾ ” gradation - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3	NMS ¾ ” gradation - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3	NMS ¾ ” gradation - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3
		Asphalt binder: PG grade	Not required if viscosity grade is chosen	Not required if viscosity grade is chosen	Not required if viscosity grade is chosen
		Asphalt binder: viscosity grade	AC-10	AC-10	AC-10
		Asphalt binder: pentration grade	Not required if viscosity grade is chosen	Not required if viscosity grade is chosen	Not required if viscosity grade is chosen
		Asphalt general: reference temp, °F	70°F	70°F	70°F
		Asphalt general: volumetric properties (V_{beff}),%	12	12	12
		Asphalt general: volumetric properties (V_a),%	8	8	8
		Asphalt general: volumetric properties (total unit weight),%	143	143	143
		Asphalt general: Poisson’s ratio	0.35	0.35	0.35
		Asphalt general: thermal properties (thermal conductivity asphalt), Btu/hr•ft•F°	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)
		Asphalt general: thermal properties (heat capacity asphalt), Btu/lb•F°	0.23(Default)	0.23(Default)	0.23(Default)

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Material Input	Stabilized layer (existing)	Material	Not required (no stabilized layer)	Soil-Lime	Not required (no stabilized layer)
		Thickness, in.	Not required (no stabilized layer)	6”	Not required (no stabilized layer)
		Unit weight, pcf	Not required (no stabilized layer)	150 (Default)	Not required (no stabilized layer)
		Poisson ratio	Not required (no stabilized layer)	0.2 (Default)	Not required (no stabilized layer)
		Elastic/resilient modulus, psi	Not required (no stabilized layer)	2,000,000 (Default)	Not required (no stabilized layer)
		Minimum elastic/resilient modulus, psi	Not required (no stabilized layer)	100,000 (Default)	Not required (no stabilized layer)
		Modulus of rupture, psi	Not required (no stabilized layer)	650 (Default)	Not required (no stabilized layer)
		Thermal conductivity, Btu/hr•ft•F°	Not required (no stabilized layer)	1.25 (Default)	Not required (no stabilized layer)
		Heat capacity, Btu/lb•F°	Not required (no stabilized layer)	0.28 (Default)	Not required (no stabilized layer)

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Material Input	Granular Base (existing)	Material	Soil-Agg (A-2-5)	Not required (no aggr. base)	Soil-Agg (A-2-5)
		Thickness, in.	6”	Not required (no aggr. base)	6”
		Strength properties: Poisson ratio	0.35 (Default)	Not required (no aggr. base)	0.35 (Default)
		Strength properties: coefficient of lateral pressure	0.5 (Default)	Not required (no aggr. base)	0.5 (Default)
		Strength properties: analysis type (using ICM, user input modulus)	user input modulus – representative value	Not required (no aggr. base)	user input modulus – representative value
		Material properties: Modulus, psi	17,000(Default)	Not required (no aggr. base)	17,000(Default)
		Material properties: CBR,%	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		Material properties: R-Value	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		Material properties: layer coefficient	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		Material properties: DCP, in/blow	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		Material properties: based on PI and gradation	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		ICM: gradation, %	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		ICM: liquid limit and plasticity index ,%	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		ICM: compacted or uncompacted	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		ICM: user index (max. dry unit weight)	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		ICM: user index (specific gravity)	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		ICM: user index (sat. hydraulic conductivity)	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen
		ICM: user index (opt. gravimetric water content)	Not required if modulus is chosen	Not required (no aggr. base)	Not required if modulus is chosen

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type		Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Material Input	Subgrade	Material	Soil (A-6)	Soil (A-6)	Soil (A-6)
		Thickness, in.	Semi-infinite (last layer)	Semi-infinite (last layer)	Semi-infinite (last layer)
		Strength properties: Poisson ratio	0.35 (Default)	0.35 (Default)	0.35 (Default)
		Strength properties: coefficient of lateral pressure	0.5 (Default)	0.5 (Default)	0.5 (Default)
		Strength properties: analysis type (using ICM, user input modulus)	using ICM	using ICM	using ICM
		Material properties: Modulus, psi	9,946 (Task 5)	9,946 (Task 5)	9,946 (Task 5)
		Material properties: CBR,%	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: R-Value	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: layer coefficient	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: DCP, in/blow	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: based on PI and gradation	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		ICM: gradation, %	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)
		ICM: liquid limit and plasticity index ,%	19.1/34.8(Task 5)	19.1/34.8(Task 5)	19.1/34.8(Task 5)
		ICM: compacted or uncompacted	Compacted	Compacted	Compacted
		ICM: user index (max. dry unit weight)	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (specific gravity)	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (sat. hydraulic conductivity)	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (opt. gravimetric water content)	Derived from gradation	Derived from gradation	Derived from gradation

Table A.3. MEPDG input parameters for HMA overlaid HMA pavement systems(continued)

Type	Input Parameter	US 18 in Fayette	US 59 in Shelby	IA 76 in Allamakee
Thermal cracking (ACC surface)	Average tensile strength at 14 ^{O}F	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Creep compliance – low, mid, high temp at different loading time (1, 2, 5, 10, 20, 50, and 100 sec)	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Compute mix coefficient of thermal contraction (VMA)	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Compute mix coefficient of thermal contraction (aggregate coefficient of thermal contraction)	5e-006 (Default)	5e-006 (Default)	5e-006 (Default)
	Input mix coefficient of thermal contraction	Not required if computing option is chosen	Not required if computing option is chosen	Not required if computing option is chosen

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems

Type	Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
General Information	Design life (years)	20	20	20
	Base / Subgrade construction month	1992/Aug	1992/Aug	1991/Aug
	Pavement construction month (existing structure construction year)	1992/Sept (1973)	1992/Sept (1967, 2006 resurfacing)	1991/Sept (1972, 1952,1929)
	Traffic open month	1992/Oct	1992/Oct	1991/Oct
	Type of design (Flexible, CRCP, JPCP)	Not required	Not required	Not required
	Restoration (JPCP)	Not required	Not required	Not required
	Overlay (ACC, PCC)	ACC over PCC	ACC over PCC	ACC over PCC
Site / Project Identification	Location	IA 9 in Howard	US18 in Clayton	US 65 in Warren
	Project I.D (existing structure project I.D)	FN-9-7(24)--21-45 (FN-9-7(2)--21-45)	FN-18-9(59)--21-22 (F-18-9(2)--20-22, NHSN-018-9(83)--2R-22 -resurfacing project I.D)	F-65-3(24)--20-91(FN-69-3(8)--21-91)
	Section I.D	ACC over PCC-1	ACC over PCC-2	ACC over PCC-3
	Date	Analysis date	Analysis date	Analysis date
	Station/ mile post format	Mile Post	Mile Post	Mile Post
	Station/mile post begin	240.44	289.85	059.74
	Station/ mile post end	241.48	295.74	069.16
	Traffic direction	1	1	1
Analysis Parameter	Initial IRI (in/ mile)	51.3	62.1	76.7
Rigid pavement	Transverse cracking (JPCP) (% slabs cracked) limit	15 (Default)	15 (Default)	15 (Default)
	Mean joint faulting (JPCP) (in) limit	0.12 (Default)	0.12 (Default)	0.12 (Default)

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems (continued)

Type		Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
Analysis Parameter	Flexible pavement	Terminal IRI (in /mile) limit	172 (Default)	172 (Default)	172 (Default)
		AC longitudinal cracking (ft/ mi) limit	1000 (Default)	1000 (Default)	1000 (Default)
		AC alligator cracking (%)limit	25 (Default)	25 (Default)	25 (Default)
		AC transverse cracking (ft/mi) limit	1000 (Default)	1000 (Default)	1000 (Default)
		Chemically stabilized layer fatigue fracture, %	25(Default)	25(Default)	25(Default)
		Permanent deformation - Total (in) limit	0.75 (Default)	0.75 (Default)	0.75 (Default)
		Permanent deformation - AC only (in) limit	0.25 (Default)	0.25 (Default)	0.25 (Default)
Traffic Input	General	Two-way average annual daily truck traffic (AADTT)	510	555	736
		Number of lanes in design direction	2 (Default)	2 (Default)	2 (Default)
		Percent of trucks in design direction	50 (Default)	50 (Default)	50 (Default)
		Percent of trucks in design lane	50 (Default)	50 (Default)	50 (Default)
		Operational Speed (mph)	60 (Default)	60 (Default)	60 (Default)
	Traffic Volume Adjustment Factors	Monthly adjustment factor	Default MAF (all : 1.0)	Default MAF (all : 1.0)	Default MAF (all : 1.0)
		Vehicle class distribution	TTC=1 (Default)	TTC=1 (Default)	TTC=1 (Default)
		Hourly truck distribution	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)	Mid to 5am: 2.3 6am to 9am: 5.0 10am to 3pm:5.9 4pm to 7pm: 4.6 8pm to 11pm:3.1 (Default)
		Traffic growth factor	Compound growth /4% (Default)	Compound growth /4% (Default)	Compound growth /4% (Default)

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems (continued)

Type		Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
Traffic Input	Axle Load Distribution Factors	Axle load distribution	Default	Default	Default
	General Traffic Inputs	Axle types	Single	Single	Single
		Mean wheel location (in)	18 (Default)	18 (Default)	18 (Default)
		Traffic wander standard deviation(in)	10(Default)	10(Default)	10(Default)
		Design lane width (ft)	12(Default)	12(Default)	12(Default)
		Number axle/truck	Default	Default	Default
		Axle configuration: average axle width (ft)	8.5(Default)	8.5(Default)	8.5(Default)
		Axle configuration: dual tire spacing (in)	12(Default)	12(Default)	12(Default)
		Axle configuration: tire pressure for single & dual tire (psi)	120(Default)	120(Default)	120(Default)
	General Traffic Inputs	Axle configuration: axle spacing for tandem, tridem, and quad axle (in)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)	51.6/49.2/49.2 (Default)
		Wheelbase: average axle spacing (ft)	12/15/18 (Default)	12/15/18 (Default)	12/15/18 (Default)
		Wheelbase: percent of trucks	33/33/34 (Default)	33/33/34 (Default)	33/33/34 (Default)
Climate Input		Climate data file	IA9 in Howard.icm (43.3728_-92.0828_800)	US18 in Clayton.icm (43.0091_-91.3265_800)	US65 in Warren.icm (41.5138_-93.5753_900)
		Depth of water table	15 ft	15 ft	15 ft

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems (continued)

Type		Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
Structure Input		Surface short-wave absorptivity	0.85 (Default)	0.85 (Default)	0.85 (Default)
	Layer	Type (Overlaid structure)	ACC	ACC	ACC
		Material (Overlaid structure)	ACC	ACC	ACC
		Thickness, in.	4”	3”	4”
		Type (Existing structure)	JPCP/Subgrade	JPCP/Subgrade	JPCP/ACC/Subgrade
		Material (Existing structure)	PCC/Soil	PCC/Soil	PCC/ATB/Soil
		Thickness, in.	8”/Semi-infinite (last layer)	10”/Semi-infinite (last layer)	9”/4”/Semi-infinite (last layer)
	Flexible Rehabilitation	Geotextile present on exiting layer	Unchecked	Unchecked	Unchecked
	HMA Design Properties	HMA E*predictive model	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A
		HMA rutting model	NCHRP 1-37A	NCHRP 1-37A	NCHRP 1-37A
		Fatigue endurance limit	Unchecked	Unchecked	Unchecked
		Reflection cracking analysis	Checked	Checked	Checked
	PCC Design Features	Permanent curl/warp effective temperature difference (F)	-10 (Default)	-10 (Default)	-10 (Default)
		Joint spacing (JPCP), ft	20 (RPCC and Curling projects)	20 (RPCC and Curling projects)	20 (RPCC and Curling projects)
		Sealant type (JPCP)	Liquid	Liquid	Liquid
		Random joint spacing	Unchecked	Unchecked	Unchecked
		Doweled transverse joints: dowel bar diameter (JPCP), in.	1.5 (Curling project)	1.5 (Curling projects)	1.5 (Curling projects)
		Doweled transverse joints: dowel bar spacing (JPCP),in	12 (Curling projects)	12 (Curling projects)	12 (Curling projects)
		Edge support: tied PCC shoulder – long term LTE (JPCP)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)
		Edge Support: widened slab –slab width (JPCP)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)	Unchecked (RPCC and Curling projects)
		Erodibility index	Erosion resistance (3)	Erosion resistance (3)	Erosion resistance (3)
		PCC-Base interface (JPCP)	Full friction contact	Full friction contact	Full friction contact
		Los of full friction (JPCP), age in months	60 (Default)	60 (Default)	60 (Default)

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems (continued)

Type		Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
Material Input	Asphalt Surface (overlay)	Material	ACC	ACC	ACC
		Thickness, in.	4”	3”	4”
		Asphalt mixer: gradation ($R_{3/4}$, $R_{3/8}$, $R_{\#4}$, $P_{\#200}$),%	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4	NMS ½” - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 15 - Cuml.% retain.#4 : 41 - % passing #200 : 4
		Asphalt binder: PG grade	PG58-28	PG58-28	PG58-28
		Asphalt binder: viscosity grade	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt binder: pentration grade	Not required if PG grade is chosen	Not required if PG grade is chosen	Not required if PG grade is chosen
		Asphalt general: reference temp, °F	70	70	70
		Asphalt general: volumetric properties (V_{beff}),%	11	11	11
		Asphalt general: volumetric properties (V_a),%	7	7	7
		Asphalt general: volumetric properties (total unit weight),%	143	143	143
		Asphalt general: Poisson’s ratio	0.35	0.35	0.35
		Asphalt general: thermal properties (thermal conductivity asphalt), Btu/hr•ft•F°	1.21(Task 6)	1.21(Task 6)	1.21(Task 6)
		Asphalt general: thermal properties (heat capacity asphalt), Btu/lb•F°	0.23(Default)	0.23(Default)	0.23(Default)
	PCC Surface (existing)	Material	JPCP	JPCP	JPCP
		Thickness, in.	8”	10”	9”

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems (continued)

Type		Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
Material Input	PCC Surface (existing)	General properties : unit weight , pcf	142.7 (Task 6)	142.7 (Task 6)	142.7 (Task 6)
		General properties : Poisson's ratio	0.2 (Default)	0.2 (Default)	0.2 (Default)
		Thermal properties: coeff. of thermal expansion, per F× 10^-6	5.69 (Task 6-limesstone)	5.69 (Task 6-limesstone)	5.69 (Task 6-limesstone)
		Thermal properties: thermal conductivity, Btu/hr•ft•F°	0.77 (Task 6)	0.77 (Task 6)	0.77 (Task 6)
		Thermal properties: heat capacity, Btu/lb•F°	0.28 (Default)	0.28 (Default)	0.28 (Default)
		Mix design properties : cement type	Type I (Curling project)	Type I (Curling project)	Type I (Curling project)
		Mix design properties: cementitious material content, pcy	538 (Task 4-MMO-L project)	538 (Task 4-MMO-L project)	538 (Task 4-MMO-L project)
		Mix design properties: W/C ratio	0.405(Task 4 – Iowa DOT QMC)	0.405(Task 4 – Iowa DOT QMC)	0.405(Task 4 – Iowa DOT QMC)
		Mix design properties: aggregate type	Limestone (Default)	Limestone (Default)	Limestone (Default)
		Mix design properties: zero stress temp.	Derived	Derived	Derived
		Shrinkage properties: ultimate shrinkage at 40 %, micro-strain	454 (Task 4)	454 (Task 4)	454 (Task 4)
		Shrinkage properties: reversible shrinkage, %	50 (Default)	50 (Default)	50 (Default)
		Shrinkage properties: time to develop 50 % of ultimate shrinkage (JPCP)	35 (Default)	35 (Default)	35 (Default)
		Shrinkage properties: curing method	Curing compound (Default)	Curing compound (Default)	Curing compound (Default)
		Strength properties: PCC Modulus of Rupture, psi	646 (Task 4)	646 (Task 4)	646 (Task 4)
		Strength properties: PCC compressive strength, psi	4,397 (Task 4)	4,397 psi (Task 4)	4,397 (Task 4)
		Strength properties: PCC elastic modulus, psi	Derived	Derived	Derived

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems (continued)

Type		Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
Material Input	Asphalt Base (existing)	Material	Not required (no asphalt base)	Not required (no asphalt base)	ATB
		Thickness, in.	Not required (no asphalt base)	Not required (no asphalt base)	4”
		Asphalt mixer: gradation ($R_{3/4}$, $R_{3/8}$, $R_{\#4}$, $P_{\#200}$),%	Not required (no asphalt base)	Not required (no asphalt base)	NMS ¾ ” gradation - Cuml.% retain. ¾” : 0 - Cuml.% retain.3/8” : 25 - Cuml.% retain.#4 : 56 - % passing #200 : 3
		Asphalt binder: PG grade	Not required (no asphalt base)	Not required (no asphalt base)	Not required if viscosity grade is chosen
		Asphalt binder: viscosity grade	Not required (no asphalt base)	Not required (no asphalt base)	AC-10
		Asphalt binder: pentration grade	Not required (no asphalt base)	Not required (no asphalt base)	Not required if viscosity grade is chosen
		Asphalt general: reference temp, °F	Not required (no asphalt base)	Not required (no asphalt base)	70°F
		Asphalt general: volumetric properties (V_{beff}),%	Not required (no asphalt base)	Not required (no asphalt base)	12
		Asphalt general: volumetric properties (V_a),%	Not required (no asphalt base)	Not required (no asphalt base)	8
		Asphalt general: volumetric properties (total unit weight),%	Not required (no asphalt base)	Not required (no asphalt base)	143
		Asphalt general: Poisson’s ratio	Not required (no asphalt base)	Not required (no asphalt base)	0.35
		Asphalt general: thermal properties (thermal conductivity asphalt), Btu/hr•ft•F°	Not required (no asphalt base)	Not required (no asphalt base)	1.21(Task 6)
		Asphalt general: thermal properties (heat capacity asphalt), Btu/lb•F°	Not required (no asphalt base)	Not required (no asphalt base)	0.23(Default)

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems (continued)

Type		Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
Material Input	Subgrade	Material	Soil (A-6)	Soil (A-6)	Soil (A-6)
		Thickness, in.	Semi-infinite (last layer)	Semi-infinite (last layer)	Semi-infinite (last layer)
		Strength properties: Poisson ratio	0.35 (Default)	0.35 (Default)	0.35 (Default)
		Strength properties: coefficient of lateral pressure	0.5 (Default)	0.5 (Default)	0.5 (Default)
		Strength properties: analysis type (using ICM, user input modulus)	using ICM	using ICM	using ICM
		Material properties: Modulus, psi	9,946 (Task 5)	9,946 (Task 5)	9,946 (Task 5)
		Material properties: CBR,%	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: R-Value	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: layer coefficient	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: DCP, in/blow	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		Material properties: based on PI and gradation	Not required if modulus is chosen	Not required if modulus is chosen	Not required if modulus is chosen
		ICM: gradation, %	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)	Mean/ Select soil gradation (Task 5)
		ICM: liquid limit and plasticity index ,%	19.1/34.8(Task 5)	19.1/34.8(Task 5)	19.1/34.8(Task 5)
		ICM: compacted or uncompacted	Compacted	Compacted	Compacted
		ICM: user index (max. dry unit weight)	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (specific gravity)	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (sat. hydraulic conductivity)	Derived from gradation	Derived from gradation	Derived from gradation
		ICM: user index (opt. gravimetric water content)	Derived from gradation	Derived from gradation	Derived from gradation

Table A.4. MEPDG input parameters for HMA overlaid JPC pavement systems (continued)

Type	Input Parameter	IA 9 in Howard	US18 in Clayton	US 65 in Warren
Thermal cracking (ACC surface)	Average tensile strength at 14 ^{O}F	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Creep compliance – low, mid, high temp at different loading time (1, 2, 5, 10, 20, 50, and 100 sec)	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Compute mix coefficient of thermal contraction (VMA)	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties	Calculated value from asphalt surface material properties
	Compute mix coefficient of thermal contraction (aggregate coefficient of thermal contraction)	5e-006 (Default)	5e-006 (Default)	5e-006 (Default)
	Input mix coefficient of thermal contraction	Not required if computing option is chosen	Not required if computing option is chosen	Not required if computing option is chosen
Rigid Rehabilitation	Before restoration, percent slabs with transverse cracks plus previously replaced/repaired slab	20 (Default)	20 (Default)	20 (Default)
	After restoration, total percent of slab with repairs after restoration	20 (Default)	20 (Default)	20 (Default)
	Modulus of subgrade reaction (psi / in)	Unchecked	Unchecked	Unchecked
	Month modulus of subgrade reaction was measured	Unchecked	Unchecked	Unchecked