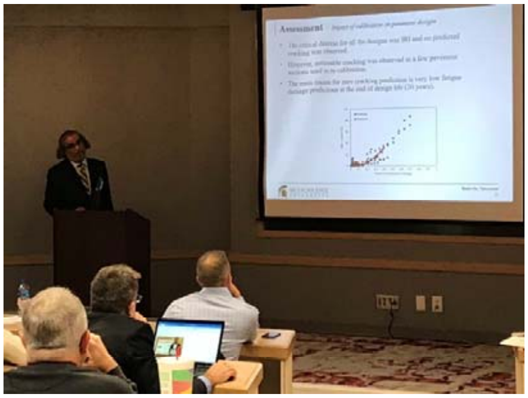
AASHTO PAVEMENT ME NATIONAL USERS GROUP MEETINGS

TECHNICAL REPORT:
THIRD ANNUAL MEETING—NASHVILLE, TN
NOVEMBER 7-8, 2018



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Submission Date:
February 26, 2019

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1. INTRODUCTION

Background

In 2008, the American Association of State Highway and Transportation Officials (AASHTO) published an interim edition of the *Mechanistic-Empirical Pavement Design Guide (MEPDG): A Manual of Practice*. That groundbreaking document presented the first mechanistic-empirical (ME) pavement design procedure based on nationally calibrated pavement performance prediction models (AASHTO 2008). A second edition of the *Manual* containing updated information, additional guidance, and improved nationally calibrated models was published in 2015 (AASHTO 2015).

An accompanying software program, AASHTOWare Pavement ME Design (PMED), was developed and released in 2011. Multiple updates have been made to the software since its initial release, with the latest version (v2.5) made available in July 2018. As part of a previous release (v2.4)[1] in July 2017, the standalone software program Deflection Data Analysis and Backcalculation Tool (BcT, v1.0) was made available to generate backcalculation inputs (using the EVERCALC algorithm) from falling weight deflectometer (FWD) files for use in rehabilitation design. Together, the MEPDG and the AASHTOWare software provide an improved process for conducting pavement analyses and for developing designs based on ME principles.

Implementation of the MEPDG has been proceeding throughout North America since its release. The number of adopting agencies has continued to grow, and many other agencies have made good progress on key parts of the process, including developing appropriate design inputs, establishing material and traffic databases, and training staff or consultants in the proper use of the procedure. Additionally, while the AASHTO *Guide for the Local Calibration of the MEPDG* was published in 2010 (AASHTO 2010), most agencies are actively engaged in calibrating the ME performance models to local conditions, policies, and materials.

Highway Agency Peer Exchange Meetings

In September 2013, the Wisconsin Department of Transportation (WisDOT) initiated an outreach program to conduct an MEPDG implementation peer exchange meeting with SHAs in AASHTO Region 3 (covering Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin). The intent of that peer exchange was to share experiences with five key aspects of MEPDG implementation: calibration, materials testing, traffic data, design acceptance, and deployment (WisDOT 2013). The Wisconsin peer exchange meeting proved successful in providing SHAs with a platform for exchanging and sharing ideas, experiences, tips, and concerns in relation to implementing the MEPDG.

In 2014, the FHWA, in conjunction with AASHTO and others, sponsored four additional peer exchange meetings to foster the sharing of SHA experiences and to facilitate ME implementation effort. These meetings were held at the following locations and dates:

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[1] PMED v2.4 is the formal designation given to the software corresponding to the release of BcT 1.0. The actual downloadable version from the AASHTOWare website is listed as v2.3.1.

- Southeast AASHTO Region 2, Atlanta, Georgia, November 5-6, 2014.
- Southwest AASHTO Region 4, Phoenix, Arizona, January, 20-22, 2015.
- Northwest AASHTO Region 4, Portland, Oregon, April 14-15, 2015.
- Northeast AASHTO Region 1, Albany, New York, May 13-14, 2015.

The results of the four peer exchange meetings were summarized in an FHWA technical report titled *AASHTO MEPDG Regional Peer Exchange Meetings* (Pierce and Smith 2015). This report can be accessed at https://www.fhwa.dot.gov/pavement/dgit/hif15021.pdf.

National Users Group Meetings

To continue the sharing of experiences and the dissemination of information related to ME design, and to facilitate the more rapid adoption of the MEPDG and the AASHTOWare PMED software, Transportation Pooled Fund Study TPF-5(305) (*Regional and National Implementation and Coordination of ME Design*) is now sponsoring four ME implementation meetings to be held annually at the national level. The first of these meetings took place on December 14-15, 2016 in Indianapolis, Indiana, while the second was held on October 11-12, 2017 in Denver, Colorado. The third meeting took place on November 7-8, 2018 in Nashville, Tennessee, and a fourth meeting is scheduled for November 6-7, 2019 in New Orleans, Louisiana.

This report documents the results of the third annual meeting held in Nashville. It includes all pertinent materials and information shared in the meeting and covers the various technical topics presented and discussed by the participants. It also presents key takeaways from the meeting and the proposed next steps for aiding and facilitating the implementation of ME pavement design within highway agencies.

Meeting Goals

The overall goal of the AASHTO Pavement ME National Users Group meetings is to provide SHAs, PHAs, and other stakeholders with a forum for the exchange of information and ideas. Specific objectives include updating participants on enhancements to the ME design procedure and software, providing participants with an opportunity to discuss issues related to the procedure and software, providing demonstration-based training on the latest version of the software, and identifying future training, software, and research needs.

Participants

A total of 97 attendees participated in the third annual Pavement ME Users Group meeting, including representatives from 31 SHAs, three Canadian PHAs, eight consulting firms, nine universities, five industry groups, FHWA, and AASHTO. The meeting was facilitated by Dr. Linda Pierce (NCE) and Mr. Kelly Smith (Applied Pavement Technology, Inc. [APTech]). A complete list of the meeting participants and their contact information is provided in Appendix A.

Agenda

The meeting agenda is provided in Appendix B.

Speakers and Presenters

In addition to introductory and opening remarks by Mr. Chris Wagner (FHWA ME Pooled Fund Manager), and informational messages from Mr. John Donahue (Missouri DOT, Chair of AASHTOWare PMED Task Force and Member of AASHTO Committee on Materials and Pavements [COMP]) and Mr. Felix Doucet (Quebec Ministry of Transportation [MOT], Canadian Liaison to the PMED Task Force), the meeting featured presentations from 19 participants. The presentation materials are provided in chronological order in Appendix C.

2. PRE-MEETING SURVEY

Three weeks before the ME Users Group meeting, SHA/PHA participants were asked to complete a short on-line survey pertaining to their agency's ME design practices. The intent of the survey was to stimulate thoughts in preparation for the meeting and to generate information to help guide the meeting discussions. Responses were received from a total of 26 agencies (23 SHAs, 3 PHAs), with a summary of the results presented in tables 1 through 15 and in figures 1 through 4. (Note: The implementation maps in figures 3 and 4 include the pre-meeting survey results, supplemented by results from the 2016 and 2017 pre-meeting surveys and two previous polls [shown in hatching]—the 2015 ME Peer Exchange survey [Pierce and Smith 2015] and a Transportation Association of Canada [TAC] ME User Group scan). Although the number of respondents in the pre-meeting survey represent about half of the SHAs, it is clear that several agencies have already implemented PMED or are getting close to doing so.

Table 1. Pavement ME implementation status.

Question	Total Responses	Yes	No
1a. Has your agency implemented Pavement ME Design for the design of asphalt pavements and overlays?	26	9	17
1b. If No, does your agency intend to implement it and if so, by what year?	17	3 (2019) 5 (2020) 2 (2021) 1 (2025) 4 (unknown / no set target)	2
2a. Has your agency implemented Pavement ME Design for the design of concrete pavements and overlays?	26	12	14
2b. If No, does your agency intend to implement it and if so, by what year?	14	3 (2019) 3 (2020) 2 (2021) 4 (unknown / no set target)	2

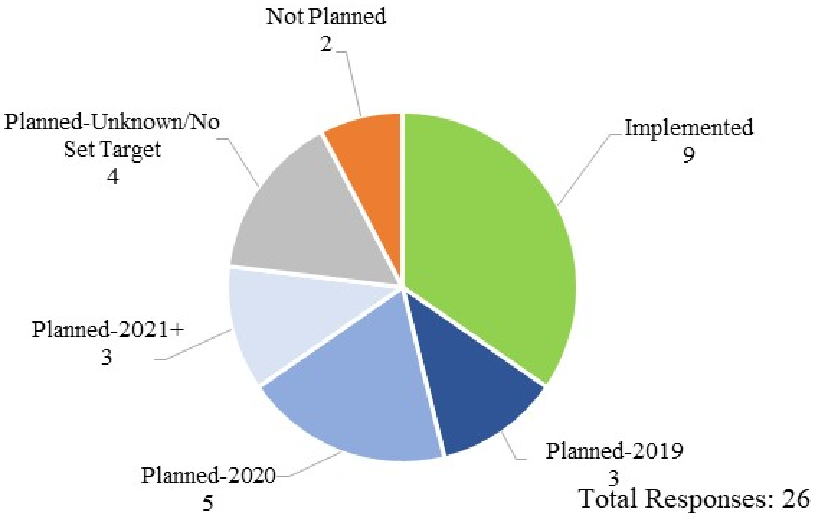


Figure 1. Pavement ME implementation status for asphalt pavements and overlays.

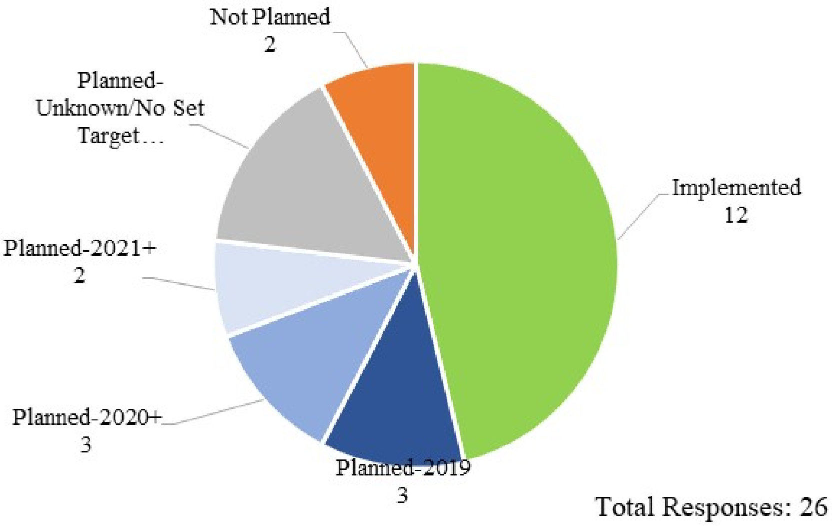


Figure 2. Pavement ME implementation status for concrete pavements and overlays.

Table 2a. Implementation status by asphalt pavement type.

3. For which types of asphalt pavements has your agency implemented or plan to implement Pavement ME Design?	**Total Responses**	**Implemented**	**Planning to Implement**
New Conventional (Thin or Nominal hot-mix asphalt [HMA] on unbound base)	23	9	14
New Deep-Strength (Thick HMA on unbound aggregate base)	21	10	11
New Full-Depth (HMA on stabilized or unstabilized subgrade)	18	7	11
New Semi-Rigid (HMA on stabilized base/subbase)	17	6	11
HMA Overlay on Existing Asphalt Pavement	22	4	18
HMA Overlay on Existing Intact or Fractured Concrete Pavement	19	3	16

Table 2b. Implementation status by concrete pavement type.

4. For which types of concrete pavements has your agency implemented or plan to implement Pavement ME Design?	**Total Responses**	**Implemented**	**Planning to Implement**
New Jointed Plain Concrete (JPC)	23	12	11
New Continuously Reinforced Concrete (CRC)	8	5	3
JPCP Overlay on Existing Pavement	17	5	12
CRCP Overlay on Existing Pavement	4	1	3

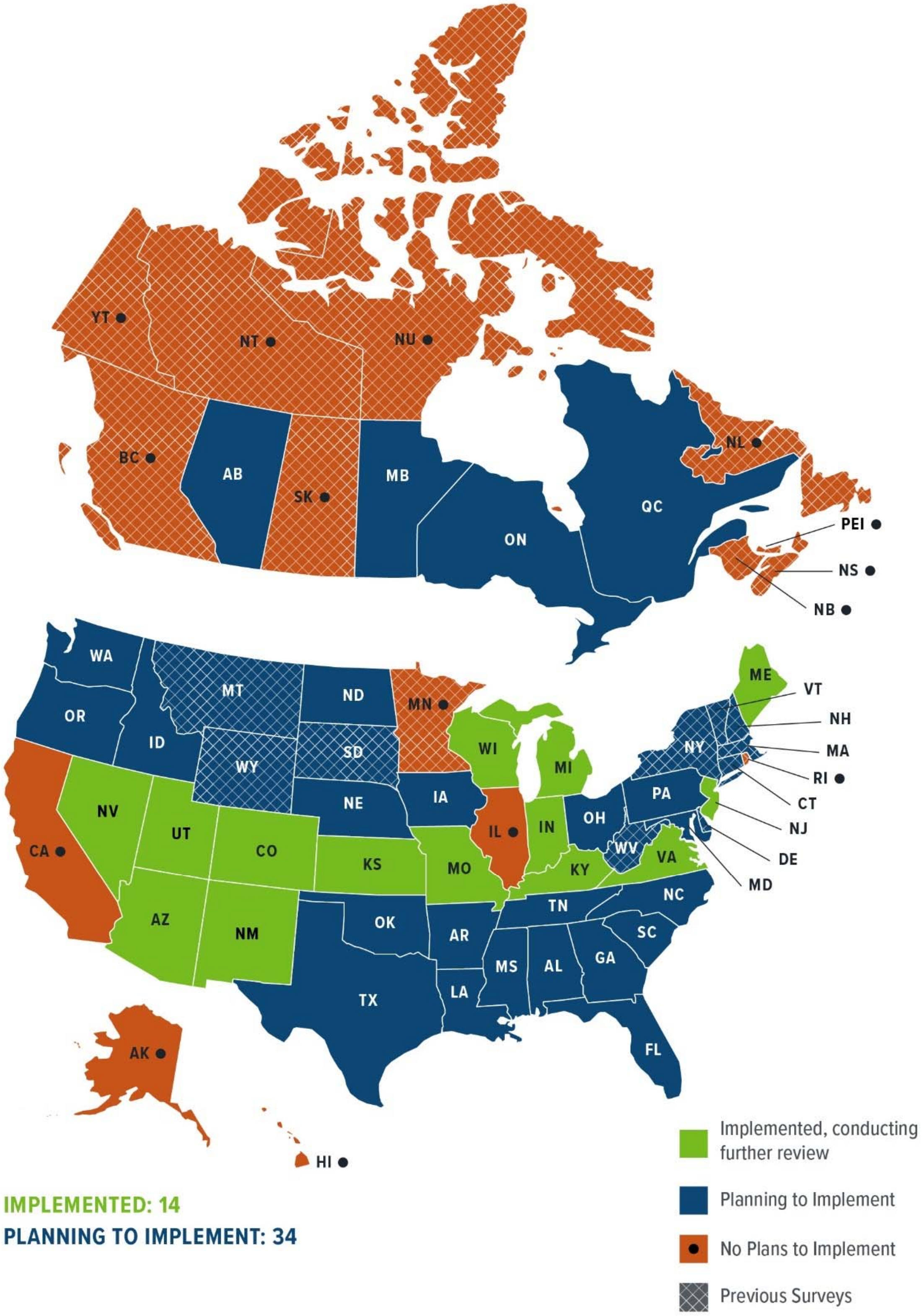


Figure 3. Implementation status by SHA/PHA—asphalt pavements and/or overlays.

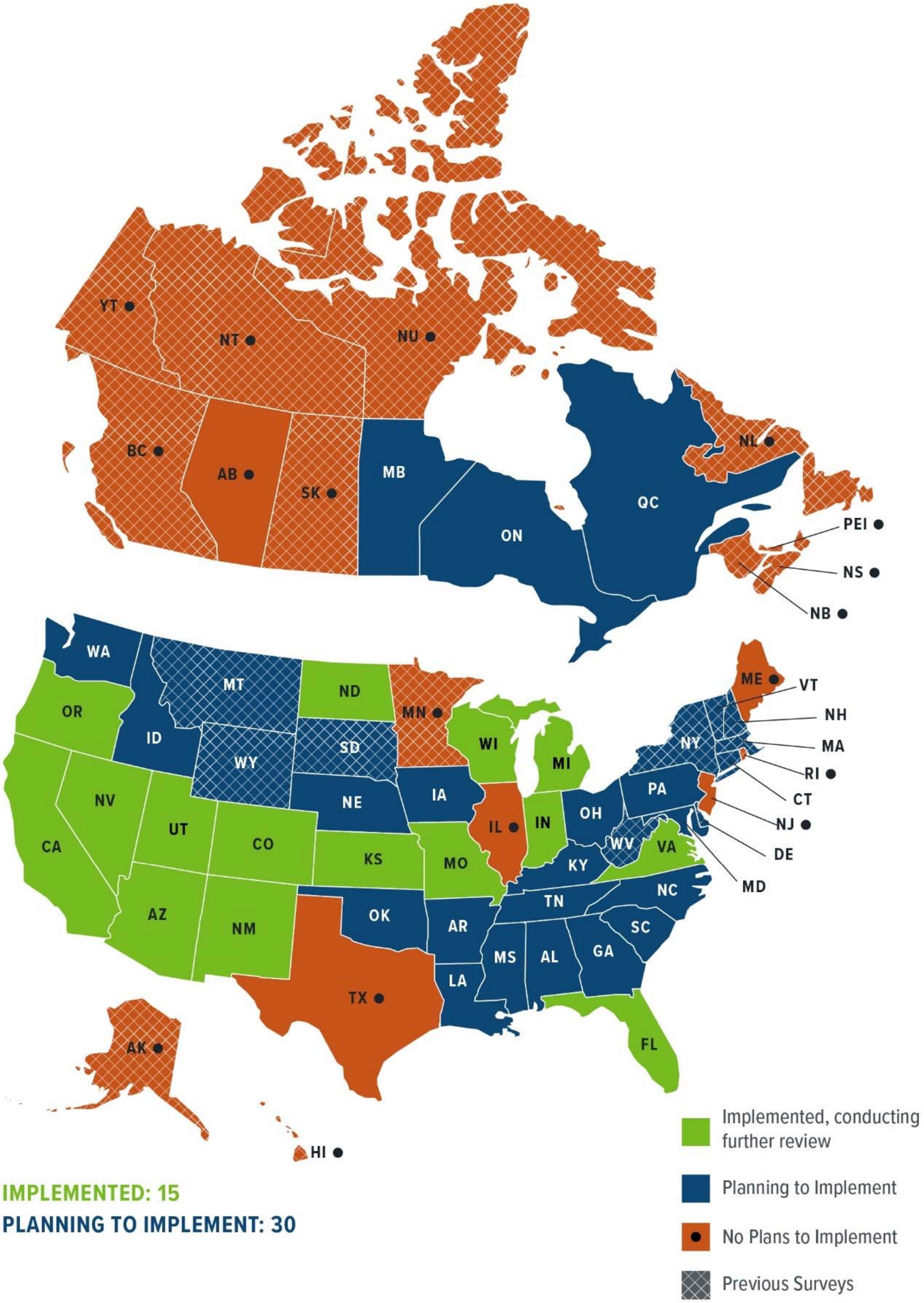


Figure 4. Implementation status by SHA/PHA—concrete pavements and/or overlays.

Table 3. Implementation challenges.

5. What has been the most difficult or challenging technical aspect of implementation (select top two)?	**Total Responses**
Compatibility of performance measures and threshold criteria	5
Designing pavement structures with features that are not included in Pavement ME or that have not been calibrated (e.g., thin portland cement concrete [PCC] overlays, permeable asphalt- or cement-treated bases, geogrids and other reinforcing materials)	8
Availability of data to adequately characterize inputs	6
Characterization of traffic	3
Characterization of climate	0
Characterization of subgrade, subbase, and/or base material properties	2
Characterization of HMA material properties	1
Characterization of PCC material properties	0
Backcalculation analysis for characterizing existing pavement and subgrade properties	1
Sensitivity testing of key design inputs	2
Availability of performance data to adequately perform local calibration and verification	5
Local calibration and verification of performance model coefficients	13
Other:	
➢ Authorities approval to proceed with implementation.	1
➢ Keeping up with the version changes and requirements (re-calibration).	1
➢ Verification that the predicted distresses over time in Pavement ME accurately represent actual pavement distress history based on experience.	1
➢ Understanding (and adequately explaining) resulting design differences between Darwin and Pavement ME (and different versions of Pavement ME) and ensuring that they make sense or whether other actions need to be taken before implementation (ex. frost heave).	1
➢ Complexity (esp. compared to Darwin).	1

Table 4. Hierarchical input levels.

6. What hierarchical input level does your agency use for the following key input parameters (Level 1=site/project specific, Level 2=estimated from correlations or regional-specific, Level 3=global/default)	**Total Responses**	**Level 1**	**Level 2**	**Level 3**
Truck Volume Distribution	25	12	10	3
Lane and Directional Distributions	25	13	8	4
Axle Load Distributions (single, tandem, tridem)	25	4	13	8
Subgrade Resilient Modulus	25	7	15	3
Unbound Base/Subbase Modulus	24	4	19	1
Chemically Stabilized Layer Modulus	24	2	13	9
HMA Dynamic Modulus	24	6	14	4
HMA Creep Compliance and Indirect Tensile Strength	24	5	13	6
HMA Volumetric Properties	23	5	11	1
PCC Elastic Modulus	25	2	17	6
PCC Flexural Strength	25	3	15	7
PCC Coefficient of Thermal Expansion	25	2	18	5
Existing Pavement Moduli	23	9	6	8

Table 5a. Condition threshold levels, Pavement ME Design vs. agency values.

7a. Does your agency use the Pavement ME Design default threshold levels (table 7.1 of 2015 MEPDG Manual of Practice) for distress and smoothness or agency-selected values?	Total Responses	Default Thresholds	Agency Thresholds/Values
Pavement ME Design default values or agency-selected values	25	4	21

Table 5b. Condition threshold levels, agency values.

7b. If agency-selected values, what are the values used for high-type Interstate/Freeway facilities?	Total Responses	Agency Thresholds/Values
HMA smoothness (IRI), in/mi	19	≤100 (0) 101-125 (1) 126-150 (3) 151-175 (7) 176-200 (1) Default (1) TBD or Varies (4) Not applicable (2)
HMA alligator (bottom-up) cracking, % lane area	19	0-5 (2) 6-10 (10) 11-15 (1) 16-20 (1) Default (1) TBD or Varies (4)
HMA total rut depth, in	19	0.00-0.125 (0) 0.126-0.25 (2) 0.26-0.375 (2) 0.376-0.50 (5) 0.51-0.625 (2) 0.626-0.75 (2) >0.75 (1) Default (1) TBD or Varies (4)
HMA transverse thermal cracking, ft/mi	19	≤500 (1) 501-1000 (6) 1001-1500 (6) Default (1) TBD or Varies (3) Not applicable (2)
JPC / CRC smoothness (IRI), in/mi	20	≤100 (0) 101-125 (0) 126-150 (4) 151-175 (6) 176-200 (3) Default (1) TBD or Varies (4) Not applicable (2)
JPC mean joint faulting, in	20	0.00-0.125 (17) 0.126-0.25 (0) TBD or Varies (3)
JPC transverse slab cracking, %	20	1-5 (1) 6-10 (13) 11-15 (2) 16-20 (0) TBD or Varies (4)

Table 6a. Local calibration.

8a. Has your agency conducted a local calibration?	**Total Responses**	**No**	**Yes**
Local Calibration	26	12	14

Table 6b. Local calibration software.

8b. For which software versions has your agency performed a local calibration?	**Total Responses**
Pre-DARWin-ME	1
DARWin-ME	1
v0.6-rigid	0
v0.9	1
v1.0	2
v1.1	1
v1.2	0
v1.3	0
v2.0	1
v2.1	1
v2.2	1
v2.3	2
v2.3.1	1
v2.5	1
v2.5.2	1
v2.x	1
Unknown	3

Table 6c. Use of locally or nationally calibrated models.

8c. Which performance prediction models were analyzed and which type of calibration values (National/Default or Local) are currently being used?	**Total Responses**	**Included in Local Calibration Analysis**	**National**	**Local**	**Not Applicable**
HMA smoothness (IRI)	14	11	4	8	2
HMA longitudinal (top-down) cracking	13	4	5	2	6
HMA alligator (bottom-up) cracking	13	11	5	6	2
HMA transverse thermal cracking	13	7	6	4	3
HMA reflective cracking	12	3	7	1	4
HMA rutting (asphalt layer only)	12	7	3	6	3
HMA rutting (total)	12	11	3	8	1
JPC smoothness (IRI)	14	8	5	7	2
JPC transverse slab cracking	13	9	5	7	1
JPC mean joint faulting	13	9	4	8	1
CRC smoothness (IRI)	10	0	2	0	8
CRC punchouts	11	2	2	2	7

Table 7. Incorporation of Modern-Era Retrospective Analysis for Research and Applications (MERRA).

Question	Total Responses	Yes	No
9a. Has your agency incorporated MERRA weather data into Pavement ME Design?	26	12	14
9b. If Yes, has your agency evaluated or sensitivity-tested the effect of using MERRA data versus ground-based weather data on ME performance predictions?	12	2	10

Table 8a. Traffic database, development.

10a. Has your agency developed a comprehensive traffic database for use in Pavement ME Design?	Total Responses	Yes	No
Comprehensive Traffic Database	26	11	15

Table 8b. Traffic database, traffic input hierarchical levels.

10b. If Yes, does the database include Level 1 project-specific vehicle class distribution inputs and/or Level 2 vehicle class distribution factors (for truck traffic clusters defined by location and highway functional class)?	Total Responses
Level 1 project-specific vehicle class distribution	5
Level 2 vehicle class distribution factors for truck traffic clusters	8

Table 9a. Use of falling weight deflectometer (FWD) backcalculation.

11a. Does your agency use backcalculation of FWD data to characterize the existing pavement and subgrade for rehabilitation design?	Total Responses	Yes	No
FWD Backcalculation Used	26	13[a]	13

[a] Six respondents did not specify which programs/methods they use.

Table 9b. Use of FWD backcalculation, flexible pavement programs/methods.

11b. If Yes, what <u>flexible pavement</u> backcalculation programs/methods are used to establish the necessary Pavement ME Design inputs?	Total Responses
BOUSDEF	0
ELMOD	3
ELSDEF	0
EVERCALC	4
MODULUS	4
WESDEF	0
MODCOMP	0

Table 9c. Use of FWD backcalculation, rigid pavement programs/methods.

11c. If Yes, what rigid pavement backcalculation programs/methods are used to establish the necessary Pavement ME Design inputs?	**Total Responses**
AREA method	0
Best-Fit method	0

Table 9d. Use of FWD backcalculation, composite pavement programs/methods.

11d. If Yes, what composite pavement backcalculation programs/methods are used to establish the necessary Pavement ME Design inputs?	**Total Responses**
Outer AREA method	0
Best-Fit method	0

Table 9e. Use of Pavement ME Backcalculation Tool (EVERCALC).

11e. If Yes, is the Pavement ME Backcalculation Tool (using EVERCALC) being used?	**Yes**	**No**
EVERCALC Used	7	0

Table 10. Materials database/library status.

12. Has your agency developed a materials database or library for quick and reliable establishment of Pavement ME Design inputs?	**Total Responses**	**Yes**	**No**
Subgrade (including chemically stabilized)	26	13	13
Untreated Base/Subbase	26	16	10
Treated Base/Subbase	26	7	19
HMA	26	19	7
PCC	26	16	10

Table 11. Evaluation of unbound materials and subgrade.

13. Has your agency evaluated or sensitivity-tested the impacts of subgrade, subbase, and base layer resilient moduli on the resulting layer thicknesses?	**Total Responses**	**Yes**	**No**
Subgrade (including chemically stabilized)	26	13	13
Untreated Base/Subbase	26	14	12
Treated Base/Subbase	26	9	17

Table 12. HMA material characterization.

14. Which of the following types of asphalt mixes has your agency developed Level 1 or Level 2 inputs for use in Pavement ME Design?	**Total Responses**
Warm-Mix Asphalt (WMA)	9
HMA with Rubber-Modified Binder	2
HMA with Reclaimed Asphalt Pavement (RAP)	13
HMA with Recycled Asphalt Shingles (RAS)	1

Table 13. PCC design features.

15. Which of the following JPC design inputs has your agency evaluated or sensitivity-tested to determine the impacts on PCC thickness?	**Total Responses**
Transverse Joint Spacing	14
Fixed versus Random Transverse Joint Spacing	2
Dowel Bar Size	14
Dowel Bar Spacing / Placement Configuration	6
Dowel Bar Shape	1
Tied versus Untied Shoulders	15
Slab Width	16

Table 14a. Participant suggestions, software improvements.

16. Do you have any suggestions for software improvements?
Calibration tool is needed.
Make calibration easier and decrease odd design results (by improving models & making calibration easier).
Version 2.5 - LCCA analysis-cost analysis.
Conversion to web-based would be good.
Incorporate NEW AASHTO M 322 Binder Grades.
Stop changing without getting verification and feedback from the users.
Make it a user friendly tool.
Traffic Growth Function input now needs selection for each vehicle class. Prefer can select one time for all classes 4-13.
Realistic models that shows logical influence due to its variation as experienced in the field not just good R2 or low standard error.
Move to a web-based version ASAP.
Create a toggle switch between the coefficients for Old Asphalt, Superpave, and polymer-modified asphalt/stone mastic (matrix) asphalt (PMA/SMA).
Make it more user-friendly to use Optimization Rules (ex. vary the dowel diameter for different thicknesses).

Table 14b. Participant suggestions, research needs.

17. Do you have any research needs requests?
Consideration of frost heave and thaw weakening in ME pavement design.
Ongoing calibration, as needed.
More guidance to incorporate or use of unconventional materials (like fibers), FDR, etc.
The Kansas Department of Transportation is having a difficult time trusting pavement distress predictions and thicknesses for both asphalt and concrete pavement that Pavement ME is giving us using our current inputs and calibration coefficients (both local and default). When comparing these predictions to how our pavements have performed over time, there seems to be several issues that have been difficult to pinpoint. We believe more research is needed to compare software pavement distress predictions for all models with the pavement distresses that have actually occurred over time in more situations than just Long-Term Pavement Performance (LTPP) test sections, which are generally only higher traffic loading conditions. Could SHAs submit actual data for inputs for a range of different traffic loading, climate, soil conditions, pavement sections, etc. for more research to improve software pavement distress predictions on a project level? We see continued benefit for SHAs like us that are evaluating the software and going through the local calibration process. Therefore, we believe an extension of this pooled fund to continue with the users group meetings once a year could be beneficial.
Characterization of different Superpave mixes for use in ME (i.e., properties of FAA 45 vs FAA 40).
How to characterize and model SMA, recycled materials in MEPDG? Road map for agencies to implement MEPDG in shortest amount of time.
All models should be evaluated to determine whether the variables included make practical sense, whether any other influencing variables are missing and whether the variables included are actually measured or observed variables.
Defining the relationship between load transfer efficiency with 10-12 dowels, 1.25-1.5 inch diameter dowels, tried/untied shoulders, tubes vs. solid bars looking a load bearing capacity.

Table 14c. Participant suggestions, training needs.

18. Do you have any specific training needs?
How to elaborate an implementation plan.
How to properly design overlays, or designs with existing materials. Particularly, existing pavement. We are having trouble properly assessing the existing pavement and how to handle these design types.
More training on overlay designs and calibration/validation.
Not at this time. Once we are ready to implement, there may be a need to have some in-house training.
Is there user training available for new users? Maybe updates to the webinars as enhancements to the software are not included in those.
Yes, on the technical background of how all the MEPDG models work, what influences those models. In short on the technical essence on the original 1-37A and other relevant studies.
Trouble shooting local calibration could be very helpful. Specifically, how to handle lack of performance data and traffic (WIM) data.
No. First thing is to make the models more meaningful.
Once the decision has been made to implement, training on local calibration will be needed.
Pavement ME Software Training Rehab Design based on FWD Data.

Table 15. Priority rating of integrating NCHRP research into the PMED.

Rank from highest (1) to lowest (8) the importance of integrating the results of the following NCHRP studies into the Pavement ME Design		
Priority Ranking Based on Total Ranking Scores	NCHRP Study	Score
1	NCHRP 1-48, Incorporating Pavement Preservation into the MEPDG (completed). Approach 3—Using Modified Material and Pavement Structural Properties in MEPDG Models to Account for Preservation)	68
2	NCHRP 9-51, Material Properties of Cold In-Place Recycled (CIR) and Full-Depth Reclamation (FDR) Asphalt Concrete for Pavement Design (completed)	78
3	NCHRP 1-53, Proposed Enhancements to Pavement ME Design: Improved Consideration of the Influence of Subgrade and Unbound Layers on Pavement Performance (near completion).	85
4	NCHRP 4-36, Characterization of Cementitiously Stabilized Layers for Use in Pavement Design and Analysis (completed).	87
5	NCHRP 9-44, Developing a Plan for Validating an Endurance Limit for HMA Pavements (completed), and NCHRP 9-44A, Validating an Endurance Limit for HMA Pavements: Laboratory Experiment and Algorithm Development (completed).	105
6	NCHRP 1-50, Quantifying the Influence of Geosynthetics on Pavement Performance (completed).	114
7	NCHRP 1-51, A Model for Incorporating Slab/Underlying Layer Interaction into the MEPDG Concrete Pavement Analysis Procedures (completed).	123
8	NCHRP 1-54, Guidelines for Limiting Damage to Flexible and Composite Pavements Due to the Presence of Water (near completion).	129

3. INTRODUCTORY SESSION

Mr. Chris Wagner (FHWA) opened the third annual ME Users Group meeting by welcoming both new and returning participants, recognizing their valued efforts in implementing ME design principles, and discussing the fundamental importance of the meeting. He gave special recognition to one of the meeting attendees, Mr. Gary Sharpe, who served on the original NCHRP panel for the MEPDG over 20 years ago. He encouraged participants to continue to be proactive in their implementation efforts and to make the most of the Users Group meeting through learning, sharing, and communicating with peers.

Mr. John Donahue (Missouri DOT) provided a high-level overview of the latest efforts of the AASHTOWare PMED Task Force. He touched upon the 2017 rollout of the Backcalculation Tool (BcT) and the forthcoming (2019) Calibration Tool, and noted the key enhancements to the 2018 software release (v2.5), including incorporation of recalibrated asphalt performance prediction models and MERRA2 data (for asphalt models only; concrete models will be based on North American Regional Reanalysis [NARR] climate data until recalibration), integration of the MEPDG MOP, and the development of Application Program Interfaces (APIs) for asphalt modulus and thermal cracking. Mr. Donahue reported that the current focus is on incorporation of the HMA top-down fatigue cracking model and conversion to a web-based application of PMED. Although there have been challenges with the top-down cracking model, it is expected to be incorporated in v2.6 in 2019. The web-based technology is an even greater challenge and may take 2 to 3 more years to complete. Mr. Donahue mentioned a few other updates on the to-do list (e.g., slab/base interface, geosynthetics), but noted that not everything can be done at once because funding is largely dependent on software fees. He emphasized the importance of getting input from the users regarding improvements to be made.

Mr. Felix Doucet (Quebec MOT) updated the participants on the implementation activities of the Transportation Association of Canada (TAC) Pavement ME Design User Group. He described the 10-year history of the group—pooled fund group of 25 to 35 active members, representing highway agencies, academia, consultants, and industry—and shared some of the group's mandates, such as collaboration with the AASHTOWare PMED Task Force, development of the 2014 Canadian User Guide (*Canadian Guide: Default Parameters for AASHTOWare Pavement ME Design* [TAC 2014]), and interaction with other pavement and materials groups in Canada. Mr. Doucet reported on the Canadian PMED trials, which have included sensitivity analysis of selected design inputs (e.g., HMA air voids and binder content, climate, soils) and testing software updates (e.g., NARR vs MERRA), and the panel discussions that have been conducted over the years, including a 2018 meeting that focused on evaluating how well other design software meshes with PMED. Mr. Doucet noted that the User Group is trying to become a subcommittee and that they are running new trials (with assistance from ARA). He also noted that they have begun making site visits to projects to confirm or understand the difference between predicted and measured performance levels. A copy of Mr. Doucet's presentation is featured as presentation 1 in Appendix C.

4. AGENCY IMPLEMENTATION STATUS

Session 2 of the meeting focused on agency reporting of MEPDG implementation status. Dr. Pierce began the session by presenting the HMA and PCC implementation maps developed from the 2016 and 2017 Users Group meetings. These maps showed only a slight change in the number of agencies that have implemented the PMED, but a notable increase in the agencies that are planning to implement PMED for new asphalt pavements and overlays. Dr. Pierce pointed out that the maps would be updated based on the results of the 2018 meeting, and these updated maps are presented in figures 3 and 4.

Following Dr. Pierce's presentation, meeting participants were asked to provide a brief update on their agency's implementation status. A summary of the implementation efforts and progress reported in the second Users Group meeting was provided as a handout, and participants were instructed to use their respective summary as a guide for their update. In addition, participants were asked to touch upon specific implementation challenges and solutions, and whether local calibrations have been performed and if calibrated models are currently being used.

Table 16 summarizes the information reported by each SHA/PHA. A summary of key aspects of MEPDG implementation and use by each agency is provided in table 17.

Table 16. MEPDG implementation status of participating SHAs/PHAs.

Agency	Status/Update
Alabama DOT	• Still in process of implementation with new software version. • Completed traffic study. • Completed material characterization of subgrade soils. • Participating in NCAT Asphalt Mixture Performance Tester pooled fund study. • Semi-implemented training course for consultants. • Conducting sensitivity analysis of subgrade soils and models. • Developing materials libraries and databases. • Adding additional calibration sites and extending data collection effort.
Alberta MOT	• Currently conducting parallel designs with AASHTO 1993 and PMED v2.3. • Conducted PMED designs since April 2016. The designs are outsourced; they require consultants to do one ME design as a design check, and have done about 120 designs so far. • Local calibration has not been conducted; they are waiting for v2.5 before doing a calibration. They believe v2.5 is more conservative than v2.3. • Traffic data from seven WIM sites. • Some materials characterization; biggest hurdle is unbound base.
Arizona DOT	• User guide has been prepared, and is available upon request. • Traffic study completed. Identified three traffic clusters and eight truck traffic distributions. Installed 10 additional WIM sites. • Materials characterization completed around 2000. • Conducting and comparing parallel designs using AASHTO 1993, Arizona DOT Structural Overlay Design for Arizona (SODA) procedure, and PMED (2012-present). • Implemented PMED for asphalt pavement rehabilitation. • Evaluating v2.5.
Arkansas DOT	• No update; not present at meeting. For latest info, see 1st Annual Meeting technical report.
California DOT	• No update; not present at meeting. For latest info, see 2nd Annual Meeting technical report.

Table 16. MEPDG implementation status of participating SHAs/PHAs (continued).

Agency	**Status/Update**
Colorado DOT	• Full PMED implementation on July 1, 2014. • Conducted local calibration in 2010-2011. • Performed AASHTO 1993 and PMED parallel designs 2012-2014. • Developed individual rutting models for HMA mixes with different binders (Marshall, Superpave, and PMA). • Completed modulus characterization for cold in-place recycling (CIPR) and doing the same for full-depth reclamation (FDR). • Sensitivity study for SMA is ongoing. • Completed database, dynamic modulus sensitivity testing on 105 asphalt mixes (statewide and regional modulus values). • Evaluating PCC widened-lane issue (8-inch thickness for high traffic using 12.5-ft lane is not reasonable). • Currently not using BCOA; they have their own spreadsheet tool for this. • Updated to PMED v2.3 for 2019. Contracted with ARA to validate v2.5 with MERRA. • CDOT Pavement Design Manual (https://www.codot.gov/business/designsupport/materials-and-geotechnical/manuals/pdm) has ME design procedures for HMA, PCC, and overlays.
FHWA Federal Lands	• Most roads are low volume. • Currently using AASHTO 1993. However, ad hoc use of PMED with agency designs. • Not planning a robust calibration effort at this time. • Focusing on getting better traffic data.
Florida DOT	• Implemented PMED for concrete designs only. Currently using v2.3. Will validate/recalibrate once the national models have been recalibrated to include MERRA data. • PMED for HMA designs not implemented; waiting for the release of the top-down cracking model. AASHTO 1993 still being used for HMA. • Design phase for concrete pavement test road (2018-2019), construction anticipated 2020. • Software available to all DOT staff. • Design manual available at: http://www.fdot.gov/roadway/pm/Publications/RPDM201801.pdf.
Georgia DOT	• Still in process of implementation. With big changeover in staff, stopped doing parallel designs. • Conducted some CTE testing. • University of Georgia conducting study for training and software. Past research by the university on PMA and SMA mixtures resulted in expanded HMA database in 2016. • Assessment of LTPP distress types, modified to Georgia DOT. • Working to utilize level 2 inputs as much as possible. • PMED v2.3.1 is running properly now (previously had IT issues). • Plan to calibrate PMED after the release of v2.5. • Expanding WIM data.
Idaho Transportation Department (TD)	• No update; not present at meeting. For latest info, see 2nd Annual Meeting technical report.
Illinois DOT	• Developed their own ME design procedure in the 1980's and updated it in the early 2000's. • No plans to implement Pavement ME in the next 5 years. • Purchased PMED license in 2018 for evaluation purposes.
Indiana DOT	• Full implementation in 2009 (first section designed and built that year). • Currently perform ME designs (using PMED v2.3) on approximately 500 miles of pavement/year. • ME design procedure is featured in INDOT Design Manual, Chapter 304, Comprehensive Pavement Analyses (https://www.in.gov/indot/design_manual/files/Ch304_2013.pdf). • Developed materials database in 2000. • Developed traffic database and conducted sensitivity study in 2004. Currently updating traffic inputs. • Local calibration performed using data from 103 calibration sections and using accelerated pavement testing (APT) for local calibration effort. • Refining and recalibrating the models based on performance of as-built (2009) pavement sections. • Evaluating issues with overlay design and potential use of geosynthetics. • Encountered lengthy run times using v2.5.

Table 16. MEPDG implementation status of participating SHAs/PHAs (continued).

Agency	Status/Update
Iowa DOT	• Have been attempting to implement PMED for many years; work still in progress. • Third recalibration is currently being conducted. • Addressed PCC widened-lane issue (moved from 14 ft to 12 ft, due to longitudinal cracking). • Evaluating NARR vs. MERRA (need information on global bias).
Kansas DOT	• Implemented for both asphalt and concrete designs; however, not fully trusting of results. Hence, conducting parallel designs using AASHTO 1993 and PMED. • Conducted local calibration using Level 3 data. • Kansas State University is conducting research on concrete pavements. The pavement management system (PMS) database has no slab cracking information for JPCP, so selected PCC sites must be identified and surveyed for cracking. • Need to conduct improved HMA material characterization; not sure if they have any bottom-up cracking (cores needed to verify). • Need to verify calibration efforts, but have limited staff. • Kansas State University is doing a research project on subgrade resilient modulus and HMA overlays (completed calibration of HMA overlay on concrete and now calibrating HMA overlay on asphalt). • Conducting additional testing on cement-treated bases. • Evaluating where to put research efforts and the level of effort needed (lab testing and field studies).
Kentucky Transportation Cabinet	• Developed and implemented online ME design catalog for asphalt pavements, based on hundreds of runs using PMED v2.3. See: https://transportation.ky.gov/Highway-Design/Pages/Pavement-Design.aspx. • Currently not pursuing PMED implementation for concrete pavement. They don't have a sufficient number of PCC sites and the potential savings using PMED is not there. • Have not conducted local calibration; however, validation effort has confirmed v2.3 and v2.5. • Conducted limited dynamic modulus testing. • Traffic studies not yet performed.
Louisiana DOTD	• Conducted local calibration for v2.2/2.3. • Conducting parallel designs using AASHTO 1993 and PMED. • Plan to implement v2.5 in 2019.
Maine DOT	• Had been using PMED with global calibration factors. However, because v2.5 gave drastic shift in cracking predictions, they are now conducting parallel designs using AASHTO 1993 and PMED. • Looking for internal ME champion and working with universities to help move forward. • Good progress on climate database and traffic data from WIM sites. • Working on characterizing unbound base materials (including resilient modulus testing). • Evaluating results of accelerated pavement testing level 1 inputs to level 3 inputs. • Conducting PG binder testing and asphalt mix characterization. • Focusing on extracting historical data for calibration effort. • Focusing on characterization of recycled materials. • Using global calibration coefficients. • Adding 5 to 6 projects to local calibration sites..
Manitoba Infrastructure	• Using AASHTO 1993 exclusively. Previously conducted parallel designs using AASHTO 1993 and PMED, however encountered various issues with PMED (concern with MERRA data quality, high longitudinal cracking prediction, insensitivity to base/subgrade, IT firewall problems). • PMED local calibration assisted in revision of AASHTO 1993 unbound layer coefficients. • Developed database for pavement materials. • Level 1 inputs for base and subgrade materials and level 3 for subbase. • Traffic data available from 7 WIM sites. Developed Level 1 traffic inputs. • Level 1 asphalt binder and mix characterization completed (for penetration-grade binder).
Maryland SHA	• AASHTO 1993 is primary design method, and can be supplemented by PMED, but not required. • Local calibration on hold until release of v2.5. Had planned to do a calibration but ran out of funding. • Completed materials characterization and traffic study. • Need more WIM sites for better traffic characterization. • University of Maryland conducted asphalt concrete (AC)/unbound base sensitivity analysis (E* not changing significantly with time) and study on comparing AASHTO 1993 designs and ME designs). • Design parameters are available in the MDSHA Pavement Design Guide (http://www.sha.maryland.gov/OMT/pdguide0616.pdf).

Table 16. MEPDG implementation status of participating SHAs/PHAs (continued).

Agency	Status/Update
Michigan DOT	• Fully implemented for new HMA and new PCC design in 2014. Currently on hiatus since 2015. • Recalibrated using v2.2/2.3. Will take v2.3 to management for approval, then work on v2.5. • Traffic characterization and climate characterization projects complete. • HMA characterization database completed for Level 1 inputs. • MDOT User Guide for ME Pavement Design is a good platform for user and is available at: (https://www.michigan.gov/documents/mdot/MDOT_Mechanistic_Empirical_Pavement_Design_User_Guide_483676_7.pdf). • Conducting JPCP, HMA full-depth, and recycled material designs, with AASHTO 1993 as initial and PMED as final (use PMED results, if within ±1 in of the AASHTO 1993 design). • Challenges with obtaining additional pavement performance data. • Working on efforts to include rehabilitation designs. • Evaluating changes in software. They find it difficult to keep up with what has changed. Calibration is costly, especially when having to do it multiple times. Looking forward to automated calibration. • Additional analysis is needed on JPCP. Because of limited concrete sections and historical performance data, it is hard to identify the breaks in the performance curves. • Use WIM and Level 2 cluster data based on WIM for traffic. Next research coming out in 2018 to update clustering.
Mississippi DOT	• Ongoing asphalt pavement field study (completion expected in 2018). No PCC study due to funding limitations. • Need to develop input forms. • Evaluating FWD results. • Assessing impact of construction and materials variability. • Characterizing unbound materials. • In the process of local calibration.
Missouri DOT	• Implementation in 2004 (national models). • Local calibration in 2009. Conducting second calibration effort, which will be completed soon. • Hoping to incorporate MERRA in near future. • Conducting recycled HMA characterization. • Currently focusing on AC/AC overlays (complete evaluation early 2018). • Evaluating what threshold criteria to use; trying to strike balance between threshold and thickness. • Concerned with the quality of condition data.
Nebraska DOT	• Currently using AASHTO 1993. • Conducting verification using LTPP. • Adding more calibration sites
Nevada DOT	• Full implementation in July 2015 using v2.3.1. Currently migrating to v2.5.2 for HMA. Adopted national calibration factors for JPC, but further work on JPC is not a focus. • AASHTO 1993 and PMED parallel designs. • Added two additional WIM sites. • Will locally calibrate models as their included in the PMED. Have locally calibrated the asphalt rutting and bottom-up fatigue cracking models. Default calibration factors are used for IRI. • Adopted national calibration values for JPCP. • CTE testing on four aggregate sources. • AI Report ER235 on performance differences (no lab testing) between PMA binders and neat binders (Calibration Factors for Polymer-Modified Asphalts Using M-E Based Design Methods https://mxo.asphaltinstitute.org/webapps/displayItem.htm?acctItemId=244). • Evaluating uncommon materials (CIR, open-graded wearing surface, and stress-absorbing interlayers) and how to incorporate them into the design process. • Conducting research on unbound materials and impacts of swelling soils. • Developing robust catalog for PMA mixes, which are used on all highway systems.
New Jersey DOT	• Using PMED v2.5, focusing on new and rehabilitated asphalt pavements. • Use AASHTO 1993 as a cross check, but do not change the PMED results. • Materials characterization completed for Level 1 inputs. • Traffic user's manual development completed for level 1 inputs. • Training for designers is on-going.

Table 16. MEPDG implementation status of participating SHAs/PHAs (continued).

Agency	Status/Update
New Mexico DOT	• PMED v2.5 calibrated and implemented. Primarily used for rehab design on a limited basis. • Completed materials database (asphalt, concrete, and unbound materials). • Need study for incorporating recycled materials. They are big into recycling, but not sure how to model these materials in ME. • Need additional WIM sites. • Due for a recalibration. • Designed first CRCP project using PMED, construction 2018-2019.
North Carolina DOT	• Implemented PMED for new HMA designs on major projects (2011-2015). Currently using AASHTO 1993 with PMED shadow designs using global coefficients. Moving to re-implement PMED. • Local calibration was conducted, but it was not perfect. They had concerns with the effort (including effects of aggregate base issues) and there has been numerous model and software updates since the original calibration. • Completed characterization of concrete materials (thermal properties dependent on fine-aggregate characteristics). • Completed WIM study despite lack of WIM sites.
North Dakota DOT	• PMED implemented for concrete pavement design (primarily using national default values). Using North Dakota DOT-determined values for CTE. • Conducting parallel designs with AASHTO 1993 and PMED; need to populate database more for comparison purposes. • Local calibration conducted for concrete pavements in 2013-2014. Recalibration for flexible pavements planned for when v2.5 comes out. • Need to evaluate WIM data. • Conducting materials characterization study and working on a materials catalog.
Ohio DOT	• No update; not present at meeting. For latest info, see 1st Annual Meeting technical report.
Oklahoma DOT	• Using PMED v2.5. • Conducting parallel designs using AASHTO 1993 and PMED for concrete pavements. • Using AASHTO 1993 for asphalt pavements.
Ontario MOT	• Conducting parallel designs with AASHTO 1993 and PMED (PMED as design/performance check). • Flexible models calibrated last year; need to recalibrate (they are doing a resurvey on fatigue cracking). • Completed local calibration for concrete pavements. • Web-based traffic information system good source for traffic characterization; updated database in 2017. • Climate characterization based on 34 weather stations; completed comparison with NARR and MERRA. • Level 3 materials inputs based on contract specifications. Resilient modulus testing has been completed on some soils; but need to include more soil types. • Tested with PMED v2.5. • Need to provide staff training (how to use new interface, MERRA, and new calibration factors) and update User Manual.
Oregon DOT	• PMED implemented for concrete pavements only. • Have not completed local calibration (only half-way done). • Pavement design guide available at: https://www.oregon.gov/ODOT/Construction/Documents/pavement_design_guide.pdf.
Pennsylvania DOT	• Using AASHTO 1993 and PMED parallel designs for truck traffic > 500 trucks/day. • Working on PMED v2.5.3 and have noticed increased predictions in transverse cracking. • 12 WIM sites for traffic data. • Collecting samples for materials characterization of SMA and 9.5-mm, PG 76-22. • LTPP in-place concrete is JRCP; however, new designs are JPCP. As a result, they are having issues with calibrating JPCP due to limited historical performance data. • For PCC, evaluating long-life design (mix optimization), CTE effects, and performance on asphalt- and cement-treated bases (ATB and CTB). • Using LTPP and Superpave In-Situ Stress/Strain Investigation (SISSI) sites for local calibration. • Received ARA training in ME theory and PMED applications. • Questioning the parallel design approach and not fully comfortable with PMED software. • Frost-heave is having significant effect on thickness and they are having difficulties with which resilient modulus sequences to use.

Table 16. MEPDG implementation status of participating SHAs/PHAs (continued).

Agency	Status/Update
Quebec MOT	• Continuing evaluation of the software through special projects. • Conducting sensitivity analysis with TAC design trials. • Conducting PMED beta testing for SI versions. • Revise implementation plan with availability of recalibrated asphalt models and calibration tool.
South Carolina DOT	• PMED not yet implemented. They are comparing results to their 1974 interim design guide, as well as PerRoad and other methods. • Conducting local calibration, however having issues with distress data (limited time-series data, data accuracy issues, and few PCC sites). Two new LCMS survey vehicles will help. • Considering regional calibration effort with Virginia and North Carolina DOTs. • Considering use of global calibration coefficients and comparing results to AASHTO 1972. • Dynamic modulus, sensitivity testing, and CTE studies completed. • University of South Carolina conducting subgrade characterization and design catalog work. • Need more WIM sites.
Tennessee DOT	• Have been working on PMED for many years; plan to implement in Fall 2019. • Traffic data/inputs being worked on with assistance from University of Tennessee-Chattanooga. • Completed materials library. • Performed verification with v2.3 and calibration is next.
Texas DOT	• No update; not present at meeting. For latest info, see 2nd Annual Meeting technical report.
Utah DOT	• Conducting pavement designs using PMED since 2011; required all Federal Aid - Local pavement designs in 2015. • Using Level 1 traffic inputs. • Completed resilient modulus testing of soils and unbound aggregate materials. • Completed CTE testing. • Calibration and validation was conducted using both LTPP and SHA pavement sections. • Pavement Design Manual of Instruction available at: https://www.udot.utah.gov/main/uconowner.gf?n=20339215312776663. • Challenges modeling pavement structures (materials - e.g., SMA) outside the norm. • Implemented BcT backcalculation tool, 6 ft x 6 ft BCOA designs, and Map-ME.
Virginia DOT	• Implemented PMED (v2.2.6) for new HMA and PCC on January 1, 2018. Currently beta testing v2.5 to assess differences with v2.2.6. • Work on PMED for rehab design begun in 2018. • Initial local calibration for HMA and CRCP in 2015. • Use level 1 for bound materials. • Mix selection guidelines developed. Need to differentiate inputs for neat HMA, PMA, and SMA. • Need training on basics of PMED.
Washington State DOT	• Original calibration effort in 2002 using v1.0. • Developed design catalog based on PMED v1.0, AASHTO 1993, and pavement performance data. • Traffic data (Level 1) study completed in 2007. • Evaluating BcT backcalculation tool. • Waiting for the release of v2.6 before implementing. • Involved in the NCHRP 1-52 and 1-53 model upgrades via panel participation.
Wisconsin DOT	• Full implementation of PMED in 2014 for new and reconstruction design of HMA and PCC pavements. • Currently using v2.1. Planning on verification/recalibration with v2.5 in the near future (2019). • Traffic analysis study completed, use site specific data. • Completed HMA materials characterization. • Local calibration completed in 2010. • Not currently conducting rehab designs, but may re-consider this after the v2.5 calibration. • Developed an original pavement design manual and subsequently updated and streamlined it. Manual is continually being updated.

Table 17. Summary of key aspects of MEPDG implementation and use.

Agency	HMA Characterization	PCC Characterization	Unbound Base/Subbase and Subgrade Soil Characterization	Local Calibration	Parallel Design	Implementation	User Guide
Alabama DOT	Developing database	Developing database	Subgrade soils	Adding more calibration sites	—	In progress	—
Alberta MOT	Some testing	—	Some testing	Not yet	Yes	In progress	—
Arizona DOT	Yes	Yes	Yes	2010-2012	2012-current	Yes, PMED used solely for asphalt rehab	Yes
Arkansas DOT	No update; not present at meeting. For latest info, see 1st Annual Meeting technical report.						
California DOT	No update; not present at meeting. For latest info, see 2nd Annual Meeting technical report.						
Colorado DOT	Yes, including CIPR dynamic modulus	—	—	2010-2011	2012-2014	Yes, 2014	Yes
FHWA Federal Lands Highways	—	—	—	—	Yes	—	—
Florida DOT	N/A	Developing concrete pavement test road	—	Ongoing (3rd calibration)	—	Yes, PCC only	Yes
Georgia DOT	Some HMA	Some CTE	—	Planned with v2.5	—	In progress	—
Idaho TD	No update; not present at meeting. For latest info, see 2nd Annual Meeting technical report.						
Illinois DOT	—	—	—	Purchased v2.5 in 2018 for evaluation purposes only	—	—	—
Indiana DOT	Yes	Yes	Yes	2009	—	Yes, 2009	Yes
Iowa DOT	—	—	—	Ongoing (3rd calibration)	—	In progress	—
Kansas DOT	Ongoing	Ongoing	Ongoing	Calibration using Level 3 inputs	Yes	Yes	—
Kentucky Transportation Cabinet	Limited dynamic modulus testing	No	—	Verification using v2.3 and v2.5	—	Yes, HMA only (online Design Catalog)	Yes
Louisiana DOTD	—	—	—	Calibration using v2.2/2.3	Yes	Expected 2019	—
Maine DOT	Yes	No	Yes, working on subbase data	—	—	Yes, HMA only	—
Manitoba Infrastructure	Yes	—	Level 1 for base and subgrade, Level 3 for subbase	Yes	Yes, previously (now using AASHTO 1993 solely)	In progress	—
Maryland SHA	Yes	—	Yes	On hold until release of v2.5	Yes	In progress	Yes
Michigan DOT	Yes, Level 1	—	—	Yes, v2.2/2.3	Yes	Yes, 2014 (currently on hiatus since 2015)	Yes
Mississippi DOT	Ongoing	—	Ongoing	In progress	—	—	—
Missouri DOT	Conducting recycled HMA characterization	—	—	Ongoing (2nd calibration)	—	Yes, 2004 (national models)	—
Nebraska DOT	—	—	—	Adding more calibration sites	—	—	—

Table 17. Summary of key aspects of MEPDG implementation and use (continued).

Agency	HMA Characterization	PCC Characterization	Unbound Base/Subbase and Subgrade Soil Characterization	Local Calibration	Parallel Design	Implementation	User Guide
Nevada DOT	Yes	CTE testing on four aggregate sources	On-going	HMA only; national calibration values for PCC	Yes	Yes, 2015	Draft guide for HMA pavement
New Jersey DOT	Level 1	—	—	—	Yes, AASHTO 1993 used as cross check only	Yes, HMA only	Traffic user's manual
New Mexico DOT	Yes	Yes	Yes	HMA only	Yes	Yes	—
North Carolina DOT	Yes	Almost completed	Yes	Yes, but need to recalibrate	Yes, use AASHTO 1993 with PMED shadow design	Yes, 2011-2015 (currently using AASHTO 1993, but will re-implement PMED in future)	—
North Dakota DOT	Yes	Yes	Yes	2013/14 (PCC), HMA recalibration when v2.5 is released	Yes	Yes, PCC (primarily default values, NDDOT CTE values)	—
Ohio DOT	No update; not present at meeting. For latest info, see 1st Annual Meeting technical report.						
Oklahoma DOT	—	—	—	—	Yes, PCC only	In progress	—
Ontario MOT	Level 3	Level 3	Level 3; some subgrade characterization	Ongoing (PCC and HMA models calibrated; HMA recalibration needed)	Yes	High-profile projects only	Yes
Oregon DOT	—	—	—	In progress	—	Yes, PCC only	Yes
Pennsylvania DOT	Yes, includes WMA, SMA, and RAP	Yes	Yes	—	Yes, for truck traffic > 500 veh/day	In progress	—
Quebec MOT	Yes	Yes	—	In progress	—	In progress	—
South Carolina DOT	Yes	Yes	—	Ongoing	—	In progress	—
Tennessee DOT	Yes	Yes	Yes	Verification using v2.3 (calibration next)	—	Expected 2019	—
Texas DOT	No update; not present at meeting. For latest info, see 2nd Annual Meeting technical report.						
Utah DOT	—	Yes	Yes	Yes	Yes, since 2011	Yes, 2011	Yes
Virginia DOT	Level 1	—	—	2015	—	Yes, 2018	Yes
Washington State DOT	—	—	—	2002	—	In progress (design catalog in 2013)	—
Wisconsin DOT	Yes	Level 3	Level 3	2010 using v2.1 (plan to recalibrate with v2.5 in 2019)	—	Yes, 2014 (new and reconstruction); rehab potentially in 2019	Yes (updating)

5. ME RESEARCH

Session 3 of the meeting consisted of brief updates on current FHWA and NCHRP ME research activities. Summaries of the information presented and subsequent discussions are provided below. Copies of the presentations are featured as presentations 2 and 3 in Appendix C.

1. ***FHWA Research Summary*** **(Mr. Tom Yu, FHWA)**—Mr. Yu provided an overview of FHWA's development of the ME-based Pavement Design Catalog. He prefaced his talk by noting that the complexity of the ME design procedure gives the perception that pavements can be designed to a very specific level of performance, but that in reality, there is a great amount of variability in the ME performance models which can prevent this. He also pointed out that the design process uses a pavement structure in an idealized condition, whereas a pavement structure actually declines over time from an idealized state to a deteriorated state as a result of traffic and environmental loadings (e.g., subgrade soil can become decompacted and destabilized, base layers can become contaminated). Mr. Yu stressed the importance of a good foundation and noted how it is often overlooked or not considered in the design process, with the thinking that increased pavement layer thickness will take care of any foundation issues.

   Mr. Yu referenced Germany's emphasis on good foundation design and provided example illustrations from the German Design Catalog. He discussed other keys to achieving well performing pavements (e.g., adequate structural section, durable materials, quality construction) and noted that they are covered in the ME Design Catalog. The catalog, which is expected to be released in March 2019, also features detailed guidelines and design tables that can be used for performing design checks.

   In closing, Mr. Yu made special mention of Transportation Pooled Fund (TPF) 1469 (*Road Foundation Contamination and Drainage: In-Service Evaluation and Best-Practice Recommendations*), which is currently an open solicitation (agencies are asked to sign up) focused on road foundation contamination and drainage in both asphalt and concrete pavements.

2. ***NCHRP Research Summary*** **(Dr. Linda Pierce, NCE)**—Dr. Pierce provided a brief overview of past, current, and future NCHRP research efforts pertaining to the MEPDG and *PMED* software. Table 18 lists the relevant NCHRP projects and their timeline.

Table 18. Timeline of NCHRP research projects related to MEPDG and the PMED software.

NCHRP Project	**Title**	**Year Completed**	**Included in *PMED***
1-37A	Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures: Phase II	2004	–
9-30	Experimental Plan for Calibration and Validation of HMA Performance Models for Mix and Structural Design	2004	No
1-39	Traffic Data Collection, Analysis, and Forecasting for Mechanistic Pavement Design	2004	Indirectly
1-40	Facilitating the Implementation of the Guide for the Design of New and Rehabilitated Pavement Structures	2006	No
1-40A	Independent Review of the Recommended Mechanistic-Empirical Design Guide and Software	2006	–
9-23A	Implementing a National Catalog of Subgrade Soil-Water Characteristic Curve (SWCC) Default Inputs for Use with the MEPDG	2007	No
1-42A	Models for Predicting Top-Down Cracking of Hot-Mix Asphalt Layers	2009	No (see 1-52)
1-40B	User Manual and Local Calibration Guide for the Mechanistic-Empirical Pavement Design Guide and Software	2009	–
1-40D(01)	Technical Assistance to NCHRP and NCHRP Project 1-40A: Versions 0.9 and 1.0 of the M-E Pavement Design Software	2009	–
1-41	Models for Predicting Reflection Cracking of Hot-Mix Asphalt Overlays	2010	Yes
1-40D(02)	Technical Assistance to NCHRP and NCHRP Project 1-40A: Versions 0.9 and 1.0 of the M-E Pavement Design Software	2011	–
1-47	Sensitivity Evaluation of MEPDG Performance Prediction	2011	No
9-23B	Integrating the National Database of Subgrade Soil-Water Characteristic Curves and Soil Index Properties With the MEPDG	2012	No
9-30A	Calibration of Rutting Models for HMA Structural and Mix Design	2012	Yes
4-36	Characterization of Cementitiously Stabilized Layers for Use in Pavement Design and Analysis	2013	FY 2017
1-48	Incorporating Pavement Preservation into the MEPDG	2013	FY 2018[1]
20-05, Topic 44-06	Implementation of the AASHTO Mechanistic-Empirical Pavement Design Guide and Software	2014	No

[1] Limited treatment types.

Table 18. Timeline of NCHRP research projects related to MEPDG and the PMED software (continued).

NCHRP Project	**Title**	**Year Completed**	**Included in *PMED***
1-51	A Model for Incorporating Slab/Underlying Layer Interaction into the MEPDG Concrete Pavement Analysis Procedures	2016	FY 2018[2]
1-52	Top-Down Cracking Model for Asphalt Pavements	2017	FY 2018[2]
9-51	Material Properties of Cold In-Place Recycled and Full-Depth Reclamation Asphalt Concrete for Pavement Design	2017	Software addendum to be added
1-50	Quantifying the Influence of Geosynthetics on Pavement Performance	2017	FY 2018[2]
1-53	Improved Consideration of the Influence of Subgrade and Unbound Layers on Pavement Performance	2018	FY 2020 (plan)
1-59	Including the Effects of Shrink/Swell and Frost Heave in ME Pavement Design	2021	TBD
20-50(21)	Enhancements of Climatic Inputs and Related Models for Pavement ME Using LTPP Climate Tool (MERRA-2)	2021	TBD

[2] Limited treatment types.

6. AASHTOWARE PMED SOFTWARE UPDATE

Session 4 of the meeting consisted of an AASHTO briefing on purchasing and licensing of the AASHTO *PMED* software, followed by a presentation from the software developer (ARA) regarding the latest enhancements to the program. Summaries of the information presented and surrounding discussions are provided below. Copies of the presentations are featured as presentations 4 and 5 in Appendix C.

1. ***Software Announcements and News* (Ms. Vicki Schofield, AASHTOWare)**—This presentation directed users to the AASHTOWare PMED website (http://www.aashtoware.org/Pavement/) and ARA support site (www.me-design.com) for information on purchasing, installing and using the PMED software, and accessing other helpful information. It also touched upon enhancements to the July 2018 release of PMED v2.5 (e.g., integration of MEPDG Manual of Practice, incorporation of the globally recalibrated flexible and semi-rigid performance models, inclusion of the Maintenance Strategy Tool) and expected enhancements to the July 2019 software release (e.g., incorporation of the NCHRP 1-52 top-down asphalt pavement cracking model, integration with the Calibration Tool).

   Ms. Schofield gave a quick breakdown of the current (October 2018) number of SHA (38) and PHA (4) license-holders, as well as the types of licenses held by other organizations (50 no-cost educational, 76 private sector companies, and 14 universities). Among SHAs and PHAs, the numbers of licenses are comparable to 2017; however, for other organizations, the numbers have increased considerably. Ms. Schofield asked participants about their interest in being able to run two versions of the software (e.g., v2.3 and v2.5). Several expressed an interest and the matter will now be addressed by the AASHTOWare PMED Task Force.

   Ms. Schofield spoke briefly about the BcT, pointing out that the tool can be licensed separately from PMED and used as a stand-alone, single-user application. Asked about the ability to get BcT installations for multiple users within an agency, Mr. Chad Becker (ARA) reported it can't currently be done since the tool only has a workstation license. Ms. Schofield indicated that AASHTO will look into possible solutions.

   A major focus of the presentation was AASHTO's move toward a web-based version of PMED. A beta version of this technology for JPCP design was successfully completed in 2017. Development of the full web-based program will begin in FY 2019. Ms. Schofield described the challenges of going to a web-based program and stated that there would be a 10 percent increase in the licensing fee over the next few years to cover development costs. The issues of file-sharing (at least one SHA has IT regulations that disallows file sharing sites) and multi-version use were raised about the new technology. Ms. Schofield indicated these matters are being fully considered by the PMED Task Force and they will be addressed.

2. ***Software Updates and Enhancements* (Mr. Chad Becker, ARA)**—The focus of this presentation was on the enhancements and updates made to the current version of PMED (v2.5, released in July 2018) and those anticipated for the next software release (v2.6, scheduled for July 2019). The presentation also touched on the programming challenges

associated with developing a web-based program and previewed some of the long-term planned enhancements.

Key enhancements and new features of each software version are summarized below.

PMED v2.5 (current patch release 2.5.3)

- Integration of the AASHTO *MEPDG Manual of Practice*. The software includes a link to a PDF of the manual.
- Globally recalibrated flexible and semi-rigid performance models for both new and rehabilitated pavements using MERRA 2 climatic data. MERRA 2 is the default, but the user has the option of specifying Ground-Based Weather Station (GBWS) or NARR climatic data.
- Maintenance Strategy Tool allows the user to incorporate a single future preventive maintenance treatment into the flexible or rigid pavement design. The tool resets performance parameters to reflect the changes in conditions associated with limited planned non-structural preservation treatments (e.g., cold milling, microsurfacing, thin HMA overlays, diamond grinding).
- Report customization allows the user to select which performance measures and criteria to include in the design analysis.
- Level 1 and 2 indirect tensile strength input capabilities.

PMED v2.6 (July 2019)

- Incorporation of the rePave Pavement Scoping Tool developed by NCE (Newt Jackson) under SHRP2 Project R23.
- Inclusion of the top-down asphalt pavement cracking model developed by Dr. Bob Lytton (Texas A&M University) under NCHRP Project 1-52.
- Integration with web-based, semi-automated Calibration Tool ("Calibrator"), which will allow users to upload their own calibration projects and use them in conjunction with the primary calibration data set (LTPP) to calibrate the PMED models (see chapter 10, Calibration Tool presentation).

PMED v3.0 (FY 2022)

- Evolution of v2.6 into a Web Technology Application (WTA), involving:
  - Transliteration of analysis executables (from Fortran and C++ code to C#).
  - Analysis library domain enrichment.
  - Domain and behavior enrichment.
  - Adapting and developing a modular reporting subsystem and uniform data persistence model.
  - Core platform integration and creation of new web-based user interface.
  - Alpha and beta testing.
- Future enhancements (following release of v3.0 and at the discretion of AASHTO and the PMED Task Force), including products from NCHRP 1-50, 1-51, 4-36, and 9-51 (see table 15).

Regarding future enhancements, Ms. Marta Juhasz (Alberta MOT) made the point that most agencies want to have the top-down cracking model, but will be reluctant if it requires a recalibration. Mr. Affan Habib (Virginia DOT) recommended against incorporating the NCHRP 9-51 CIR model, as personal experience with its use gave poor results.

Mr. Becker and Mr. Donahue reported that the Task Force has a very comprehensive process for determining if and how research is integrated into the software. They carefully consider what the effects might be (are they reasonable or not) before making a decision and also engage in a dialog with the Principal Investigator of the research to identify the reasons for the effects.

7. AGENCY IMPLEMENTATION EXPERIENCES

Session 5 of the meeting featured three presentations on agency implementation experiences and one university presentation on the new reflection cracking model for asphalt pavement design. Summaries of the information presented and subsequent discussions are provided below. Copies of the presentations are featured as presentations 6 through 9 in Appendix C.

1. ***Georgia's Implementation Efforts on Climate Research*** **(Mr. Stephen Durham, University of Georgia)**—The focus of Mr. Durham's presentation was on the results of a study comparing PMED performance predictions using GBWS, NARR, MERRA1, and MERRA2 climatic data. The study used base-case HMA and PCC pavement designs for 15 virtual weather station-based projects and compared the distress (rutting, alligator cracking, and thermal cracking for HMA; joint faulting and transverse cracking for PCC) and smoothness (IRI) predictions generated by each climate data source, as illustrated in figure 5. The results showed significant discrepancies in predictions in many cases, with noticeably greater scatter associated with MERRA2.

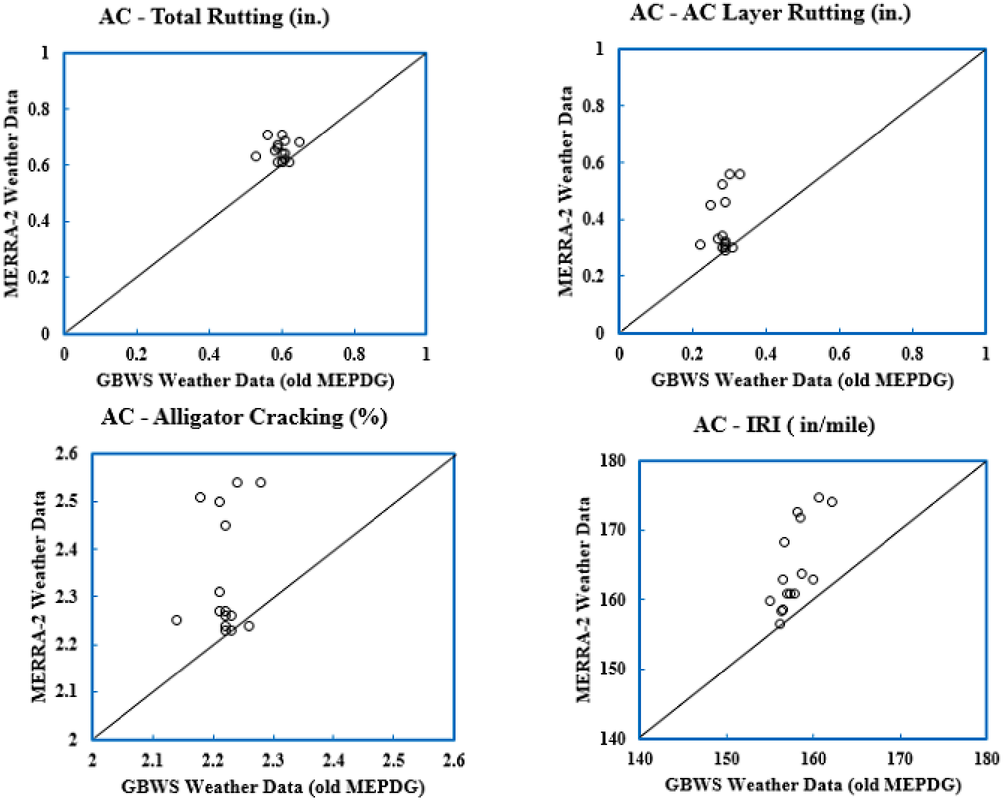


Figure 5. Comparison of HMA distress and smoothness predictions generated using GBWS and MERRA2 climatic data.

Mr. Durham shared that the performance discrepancies for the HMA designs were attributed to considerable differences in percent sunshine predicted by each climate data source, and that a possible reason for the performance discrepancies for the PCC designs was the higher wind speed values recorded for NARR. In the case of the former, he described the development of a pavement heating/shortwave radiation model for backcalculating the synthetic percent sunshine. The synthetic percent sunshine values greatly improve the surface shortwave radiation (SSR) calculations within PMED, leading to greater SSR consistency among the climate data sources and greater agreement in PMED distress and smoothness predictions.

In closing, Mr. Durham recommended re-evaluating the percent sunshine approach currently used in PMED. He added that the second phase of the study will evaluate the effect of longwave radiation on pavement performance.

2. ***Struggles with Implementation: Why Implementation Hasn't Occurred, Unique Challenges, Plans for Overcoming Challenges*** **(Mr. Bob Shugart, Alabama DOT)**—In this presentation, Mr. Shugart highlighted some of the struggles that the Alabama DOT has had relative to PMED implementation and why it has yet to be completed. He noted how implementation requires a significant change to the agency's business practices and gave some examples where this has been an issue, such as making the required changes in traffic data collection and reporting and defining more appropriate performance thresholds (e.g., not "when the agency has money to get something done").

   Unique challenges that the DOT has faced include the development of a materials library/database, the conduct of a local calibration, non-centralized pavement designs (their designs are performed at the regional offices and checked at the central office), and discrepancies between PMED-predicted pavement performance and actual historic performance. Mr. Shugart indicated that they can only afford to do one local calibration, so when they decide to do it, the results need to transcend software versions.

   Alabama DOT's plans for overcoming implementation challenges include tracking the work and progress of other SHAs and participating in the PMED activities and pooled fund studies. In addition, Mr. Shugart reported that the agency plans to re-evaluate the AASHTO 1993 structural layer coefficients and to develop an Alabama-specific software program to replace AASHTO DARWin 3.1. He indicated that the DOT will run parallel designs with the new software and PMED, and expects that implementation of PMED will not take place until after the program becomes web-based.

3. ***New Reflection Cracking Model for HMA: Challenges and Experiences*** **(Dr. Halil Ceylan, Iowa State University)**—Over 50 percent of Iowa's highway system is composite (AC/JPC) pavement with reflection cracking as the primary performance concern. Following the incorporation of the NCHRP 1-41 reflection cracking model into PMED in 2015, a study was undertaken to evaluate the effectiveness of the model to Iowa conditions and to identify the factors that have the greatest impact on reflection cracking performance. This presentation described the research that was performed and reported on the findings and recommendations.

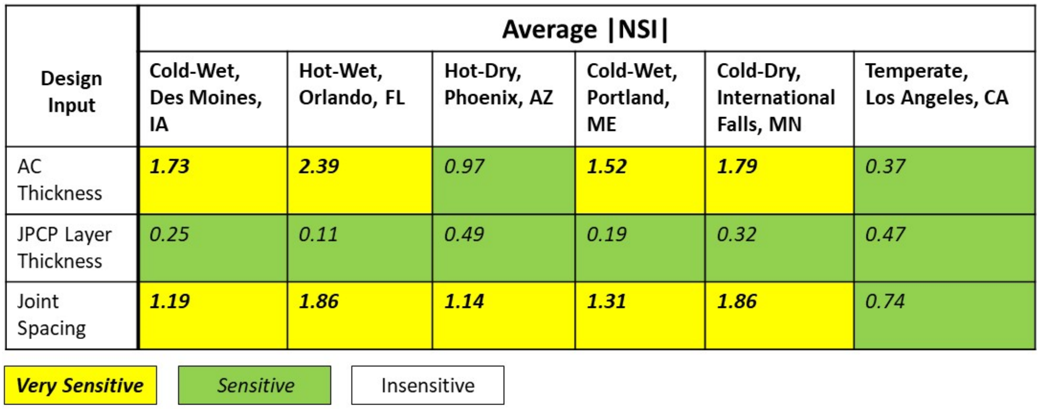
   Dr. Ceylan provided an overview of the basic mechanisms of reflection cracking—thermally-induced fatigue, traffic-induced fatigue, and surface-initiated cracking—and showed how artificial neural network (ANN) models result in better estimates of HMA modulus and stress intensity factors (SIFs), as compared to the models in previous PMED versions. Consequently, the ANN models provide for an improved analysis of crack propagation in the ME design. Dr. Ceylan demonstrated the differences in predicted reflection cracking using PMED v2.3 (old reflection cracking model) and v2.5 (new model) for two composite pavement projects in Iowa. Comparisons of the predicted versus actual reflection cracking over time showed that v2.5 does a better job of predicting the measured cracks.

The remainder of Dr. Ceylan's presentation focused on the sensitivity testing that was performed in the study to determine the design factors having the greatest effect on reflection cracking. The analysis used PMED v2.5 and the Normalized Sensitivity Index (NSI) metric to examine both the short-term (age at which 4,000 ft/mi of cracking is reached) and the long-term (20 years) cracking performance impacts of the various design parameters listed below. For each parameter, three different input values (a low-end "lower-case" value, a median "base case" value, and a high-end "upper-case" value) were used to predict reflection cracking, thermal cracking, and combined reflection and thermal cracking over time. The three values selected for each parameter are also listed below.

- AC surface layer thickness (1.5, 2.0, and 3.0 inches).
- JPC transverse joint spacing (10, 15, and 20 ft).
- JPC transverse joint load transfer efficiency (LTE) (25, 50, and 75 percent).
- HMA tensile strength at 14°F (100, 500, and 2,000 lb/in^2).
- JPC layer thickness (4.0, 8.0, and 12.0 inches).
- Average annual daily truck traffic (AADTT) (500, 1,000, and 5,000 trucks/day).

Results of the analyses showed that short-term reflection cracking is very sensitive (NSI>1) to joint spacing, joint LTE, and AC thickness, whereas long-term cracking is very sensitive to joint spacing only. Similar findings were observed for combined reflection cracking and thermal cracking. Additional analyses compared the sensitivity of AC thickness, JPC thickness, and joint spacing in different climates. As shown in table 19, the NSI values can vary significantly by location, indicating that climate can also be a factor to consider. Dr. Ceylan highly recommended that agencies perform their own sensitivity analyses to identify the factors most important in their overlay designs.

Table 19. Short-term NSI values for predicted reflective cracking in different climates.



Design Input	Average |NSI|					
	Cold-Wet, Des Moines, IA	Hot-Wet, Orlando, FL	Hot-Dry, Phoenix, AZ	Cold-Wet, Portland, ME	Cold-Dry, International Falls, MN	Temperate, Los Angeles, CA
AC Thickness	***1.73***	***2.39***	*0.97*	***1.52***	***1.79***	*0.37*
JPCP Layer Thickness	*0.25*	*0.11*	*0.49*	*0.19*	*0.32*	*0.47*
Joint Spacing	***1.19***	***1.86***	***1.14***	***1.31***	***1.86***	*0.74*

Very Sensitive *Sensitive* Insensitive

4. ***Successful Implementation: Challenges Overcome and Current Areas of Focus/Refinement* (Mr. Affan Habib, Virginia DOT)**—The Virginia DOT implemented ME design for new construction and reconstruction projects on interstate and primary routes on January 1, 2018. The implementation follows many years of research and development, including an initial local calibration effort for HMA and CRC pavement in 2015. The agency's Pavement ME User Manual and PMED design input files can be accessed at http://www.virginiadot.org/business/materials-download-docs.asp. This webpage serves as a one-stop shopping or use center for design consultants and other interested parties.

   Mr. Habib's presentation focused on what is needed for a successful implementation and what challenges can be expected along the way. For the former, he discussed the need for help in navigating through the process and a lot of patience in developing input procedures and the inputs themselves. He also emphasized the need for a very specific implementation plan. In Virginia DOT's case, they developed a 6-page detailed plan containing goals and target dates, and conducted weekly team meetings to discuss the progress made in executing the plan. Monthly teleconferences with other stakeholders (e.g., FHWA, VTRC, industry groups) were also conducted to provide updates on the progress and timeline.

   Mr. Habib described several technical and non-technical challenges encountered by the DOT. For example, one technical challenge has been the characterization and use of specialized materials, such as stabilized and recycled materials and SMA and PMA mixes. The agency has established a thickness multiplier for cold central-plant recycling (CCPR) material used as AC base, but has had to initiate a study to distinguish the properties of SMA and PMA from conventional HMA mixes. Another technical challenge has been local calibration. The 2015 calibration effort focused only on the bottom-up fatigue cracking and total rutting models for HMA design and the punchout model for CRC design (local calibration for JPC was not performed due to the lack of sites). Although attempts were made to calibrate the IRI models, the lack of initial IRI data prevented the development of acceptable calibrated models.

   Non-technical challenges have included things like answering questions on why implementation is taking so long, striving for perfection rather than excellence, and getting buy-in from executive management and other stakeholders. Mr. Habib noted that the DOT has been very transparent and communicative in their activities and recommended that other agencies do the same. He advised that agencies not wait for perfection to come, citing as an example the willingness to accept a tolerable difference in design thickness (say ≤1 in) between PMED and AASHTO 1993. And, in getting stakeholder buy-in, he referenced the agency's monthly stakeholder meetings, which included various solicitations for input and garnered a lot of positive feedback.

   In concluding his presentation, Mr. Habib highlighted several upcoming challenges for the DOT, including implementation of PMED rehabilitation design, characterization of special materials (as described previously), performing additional local calibrations corresponding to PMED software updates, and securing the resources for further implementation efforts. He also stressed the importance of increasing the knowledge of MEPDG fundamentals to avoid a "black box" approach to pavement design.

8. SPOTLIGHT ON ME RESEARCH

Session 6 of the meeting featured presentations on two NCHRP research studies with notable implications on future PMED releases. Summaries of the information presented and subsequent discussions are provided below. Copies of the presentations are featured as presentations 10 and 11 in Appendix C.

1. ***NCHRP 1-53, Improved Consideration of the Influence of Subgrade and Unbound Layers on Pavement Performance*** **(Dr. Bob Lytton, Texas A&M University)**—Dr. Lytton provided an in-depth presentation on the research performed to address a notable problem in PMED design—the low sensitivity of flexible and rigid pavement performance to subgrade and unbound layer properties. To overview the context of the work, he illustrated how the proposed enhancements to the subgrade and unbound base models—modulus, permanent deformation, shear strength, erosion, and foundation—would be incorporated into the ME design process and pointed out the various performance indicators that are impacted by subgrade and unbound layer inputs.

   As one example of the model enhancement, Dr. Lytton described how several resilient modulus models were reviewed in the study and a selection was made, in large part, on the model's ability to deal with anisotropy, accurately characterize moisture stress, and be easily implemented into PMED. Because the anisotropy of the base course governs much of the behavior of AC and PCC pavements, a cross-anisotropy lab test was developed in the study. In addition, the methylene blue test was selected as a quick and accurate test for characterizing water-holding capacity. Dr. Lytton presented the newly proposed inputs for each hierarchy level and noted that Level 1, which incorporates the features described above, provides for a greater amount of accuracy in the predicted resilient modulus (see figure 6) than the current PMED model. He stressed the importance of capturing moisture stress and pointed out that, because it leads to greater accuracy in performance prediction, it will greatly simplify the local calibration process. He illustrated the benefit of ANN models, which take into account both traffic and moisture stress in predicting resilient modulus, over various regression models.

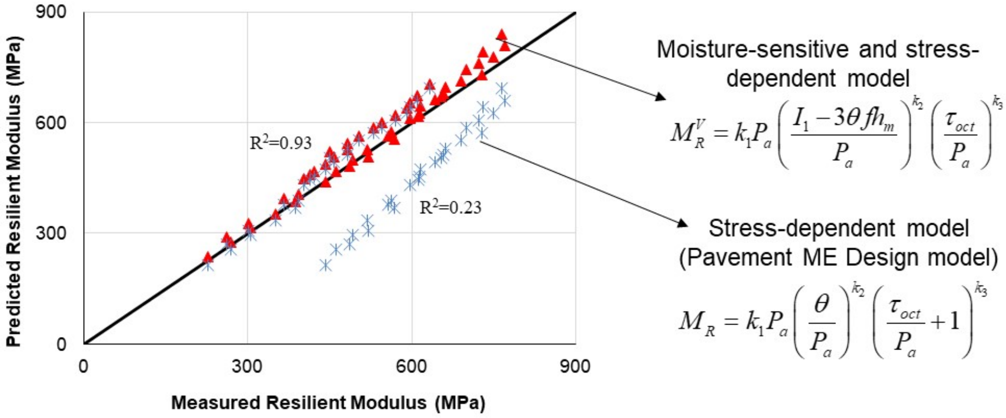


Figure 6. Predicted versus measured resilient modulus using the NCHRP 1-53 proposed model and the current PMED model.

Another example of the enhancement efforts featured in the presentation was the foundation model for PCC, consisting of two components—the interface bond stiffness model and the subgrade k-value model. Dr. Lytton discussed the need to move from the current characterization of the slab-base interface condition (i.e., bonded versus unbonded) to a more realistic approach in which the interface is either fully unbonded or partially unbonded. For this enhancement, the research team introduced an interface shear bonding parameter (which reflects the degree of bonding) and incorporated it into a moment of inertia equation (similar to how building structures are analyzed) that effectively combines the interface bond stiffness model and subgrade k-value model into one. Using joint faulting data on many LTPP PCC sections, comparisons were made between the degree of bonding values computed using the transformed section moment-of-inertia approach and those derived using the backcalculated best-fit approach (bonded=1, unbonded=0). As figure 7 shows, the proposed model better reflects the expected relationship between interface condition and joint faulting. Additional analyses using ANN models and the transformed section moment-of-inertia formula resulted in strong agreement between the backcalculated and predicted subgrade k-values. In most cases, it was found that the k-value increases if the degree of bonding increases.

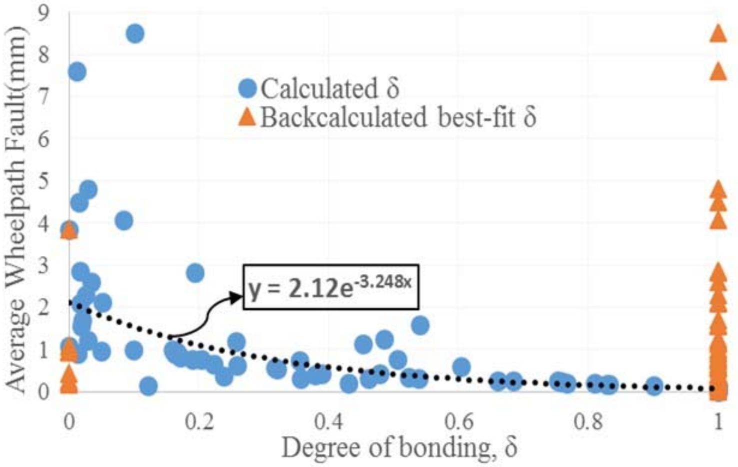


Figure 7. Sensitivity of slab-base degree of bonding on joint faulting—comparison of NCHRP 1-53 proposed model and current PMED model.

Dr. Lytton touched upon the other subgrade and unbound layer model enhancements (permanent deformation, shear strength, and erosion) and at the end of his presentation, illustrated the sensitivity of various inputs on performance using the proposed NCHRP 1-53 models. He asserted that the research results clearly demonstrate the need for more mechanistic models and noted that the final report for the project is currently under review by NCHRP. The final products from the study will eventually be ushered through AASHTO and the PMED Task Force for consideration and possible adoption.

In response to a question from Mr. Yathi Yatheepan (Nevada DOT) regarding the effects of the new models on thickness, Dr. Lytton stated it depends significantly on the isotropic characteristics of the layer(s). The more isotropic the layer, the thicker the pavement will have to be. Fortunately, pavements are generally non-isotropic in nature.

2. ***NCHRP 20-07 Task 422, User Review of the AASHTO Guide for Local Calibration of the MEPDG* (Ms. Georgene Geary, GGfGA)**—The 2010 AASHTO *Local Calibration Guide* has seen minimal use by SHAs and others because of the perceived difficulty in understanding the document. With the many changes that have taken place with the PMED software and with many agencies in the process of conducting local calibrations (initial and/or updated), there is a need to revise the guide in a more understandable format. This presentation reported on the findings and recommendations of a study involving a general pavement design practitioner's (Ms. Geary) critical review of the *Local Calibration Guide*.

   Ms. Geary described the key work activities as consisting of: (1) an agency survey, (2) a review of existing resources on local calibration (including global calibration factors and SHA local calibration efforts), (3) a review of the current *Local Calibration Guide*, and (4) development of proposed revisions. The survey was administered through the AASHTO Committee on Materials and Pavements (COMP) and garnered responses from 46 SHAs and one PHA. More than half of the responding agencies had performed a local calibration and only a few agencies reported not being familiar with the *Local Calibration Guide*. Several SHA local calibration reports were collected and reviewed in the study, along with key reports capturing the changes made to the global calibration factors.

   Ms. Geary's review of the current *Local Calibration Guide* focused on its content, purpose, and understandability. After conducting her own mini-local calibration exercise, she identified the minimum information needed to perform a local calibration and assessed whether the current *Local Calibration Guide* includes that information. The assessment found that several pieces of information are either not covered or only partially covered in the document. Key recommendations for a revised *Local Calibration Guide* include the following:

   - Use of the basic step-by-step procedure as the main format or outline.
   - Use of consistent nomenclature and non-statistical language.
   - Addition of a method required for calibration of distress.
   - Inclusion of the performance model equations to be calibrated and the specific coefficients that are targeted for calibration (and information on how and why they should be adjusted).
   - Inclusion of detailed examples for each step in the calibration process.

   Ms. Geary shared that the final report for the 20-07(422) study was completed in July 2018 and is available on the NCHRP Projects website (http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(422)_FR.pdf). Mr. Donahue added that the report is currently under review by the AASHTO COMP and that a revised *Local Calibration Guide* will likely be delayed a little by the progress made on the semi-automated Calibration Tool ("Calibrator").

9. DESIGN APPLICATIONS AND PERFORMANCE CRITERIA

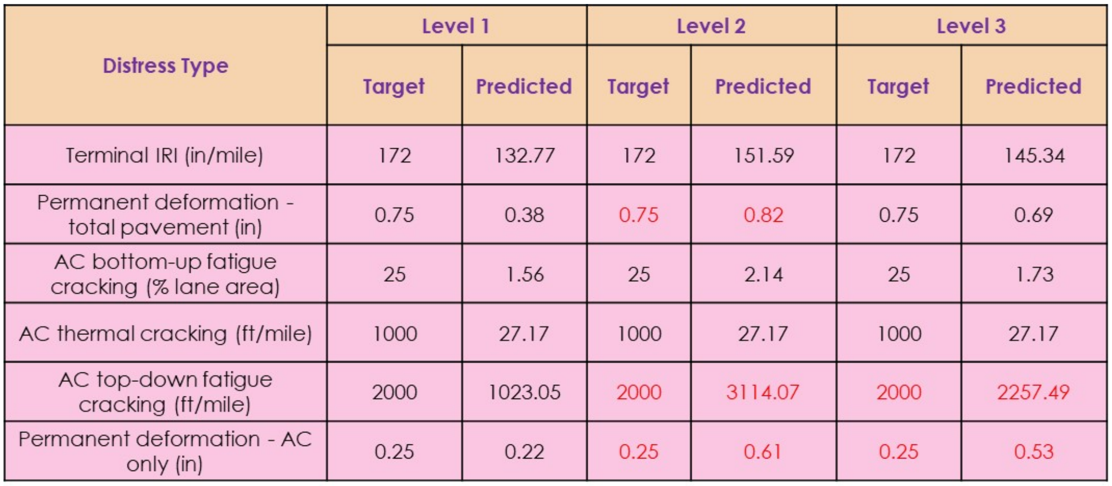
Day 2 of the Users Group meeting resumed with Session 7 covering unique design applications and the evaluation of performance criteria. Summaries of the information presented and subsequent discussions are provided below. Copies of the presentations are featured as presentations 12 through 14 in Appendix C.

1. ***Adjustments in Design Inputs* (Mr. Jeff Mann, New Mexico DOT)**—Mr. Mann delivered a presentation on the New Mexico DOT's work in developing a Level 1 database for both AC and PCC materials, and the results of an initial comparison of predicted performance using Level 1, 2, and 3 material inputs. To gauge the DOT's relative status, he asked for a show of hands on the number of SHAs that have developed a Level 1 or Level 2 database. Representatives from approximately 15 agencies responded in the affirmative.

   According to Mr. Mann, the New Mexico DOT attempted a local calibration a few years ago. Because the results were not very good, they decided to focus on developing a robust materials library. A substantial amount of time and energy was spent on asphalt materials, leading to design inputs for 54 HMA mixes (including WMA and RAP mixes) and 10 asphalt binders. The library also includes an aggregate source map, which can inform the designer what aggregate will likely be used in the HMA for a specific project.

   Mr. Mann described the dynamic modulus and volumetric data and how they were used to develop a calibrated Level 1 E* model. He highlighted eight design projects from different districts that were used as a basis for comparing performances predictions using Level 1, 2, and 3 inputs. As table 20 illustrates for one of the projects, the Level 1 inputs yield significant lower predictions for several of the distress types and smoothness.

Table 20. Performance comparison of US 54N using ME default versus lab-derived inputs.



Distress Type	Level 1		Level 2		Level 3	
	Target	Predicted	Target	Predicted	Target	Predicted
Terminal IRI (in/mile)	172	132.77	172	151.59	172	145.34
Permanent deformation - total pavement (in)	0.75	0.38	0.75	0.82	0.75	0.69
AC bottom-up fatigue cracking (% lane area)	25	1.56	25	2.14	25	1.73
AC thermal cracking (ft/mile)	1000	27.17	1000	27.17	1000	27.17
AC top-down fatigue cracking (ft/mile)	2000	1023.05	2000	3114.07	2000	2257.49
Permanent deformation - AC only (in)	0.25	0.22	0.25	0.61	0.25	0.53

The DOT has performed testing of the AC fatigue endurance limit, which could be used later for perpetual pavement design. Additionally, although New Mexico DOT has very few miles of concrete pavement, they have performed CTE, elastic modulus, and modulus of rupture tests on a number of PCC mixes and have used the results to establish Level 1 CTE values and develop Level 2 inter-conversion models. Mr. Mann shared some of the performance comparisons made using these inputs and the Level 3 default values. CTE was found to play a significant role in predicted cracking, faulting, and IRI, which reinforced the importance of characterizing PCC mixtures.

2. ***Comparison with AASHTO '93 and Adjustments in Design Reliability and Performance Thresholds*** **(Mr. Ryan Barrett, Kansas DOT)**—This presentation focused on performance comparisons for new full-depth pavements in Kansas, as predicted using AASHTO 1993 and PMED. It also presented the DOT's initial and updated performance criteria (e.g., initial and terminal IRI, joint faulting threshold, bottom-up fatigue cracking threshold) and discussed the plans for evaluating the impacts of the criteria changes as part of a current local calibration study.

   Mr. Barrett began his talk by highlighting several rigid and flexible pavement projects that were selected for analysis and showed the design thickness results obtained for each project using AASHTO 1993, PMED with global calibration factors, and PMED with local calibration factors (per the initial calibration effort completed in 2015). The projects represented a range of locations and traffic levels, and the resulting design thicknesses ranged from 6 to 12.5 inches for PCC and 7.5 to 16 inches for AC. Notable differences in thickness among the three design procedures were observed for the flexible pavements, whereas the differences for the rigid pavements were less apparent. Mr. Barrett suggested that the design reliability levels and performance criteria used in the analyses could have been a factor in the differences.

   Mr. Barrett proceeded to show both the initial and updated performance criteria for rigid and flexible design (an example of the progression in criteria for rigid design is provided in table 21). He noted that the updated criteria are rough and that the DOT will adjust them as necessary, based on the results of the current local calibration effort being performed by Kansas State University. The DOT is also part of a Pooled Fund study (TPF-5[311], *Implementation of the AASHTO Mechanistic-Empirical Design Guide for Pavement Rehabilitation Design*) that is looking at the design of AC overlays of existing asphalt and concrete pavements.

   In closing, Mr. Barrett indicated that Kansas is still learning. They previously considered themselves as an "implemented" state, but have been less trusting of the results from PMED and have stepped back to using AASHTO 1993 in parallel with PMED.

Table 21. Initial and updated performance criteria for Kansas rigid design.

Distress Type	Initial Criteria	Updated Criteria		
	Threshold Value at End of Design Life	Threshold Value at End of Design Life	Reliability Level—New Design, %	Reliability Level—Overlay Design, %
Terminal IRI, in/mi	164	Interstate (A): 160	85	85
		Principal Arterial (B): 180	75	75
		Principal/Minor Arterial (C): 190	75	75
		Minor Arterial (D): 200	65	65
		Major/Minor Collector & Local: 200	60	60
Transverse Cracking, %	5	Interstate (A): 10	95	95
		Principal Arterial (B): 10	85	85
		Principal/Minor Arterial (C): 10	85	85
		Minor Arterial (D): 10	75	75
		Major/Minor Collector & Local: 10	70	70
Mean Joint Faulting, inches	0.375	Interstate (A): 0.12	95	95
		Principal Arterial (B): 0.15	85	85
		Principal/Minor Arterial (C): 0.20	85	85
		Minor Arterial (D): 0.25	75	75
		Major/Minor Collector & Local: 0.25	70	70

3. ***Incorporation of Recycled Asphalt Mixtures into the MEPDG* (Mr. Ramon Bonaquist, Advanced Asphalt Technologies)**—Resource responsible asphalt mixtures (R^{2}AMs) are asphaltic-based materials containing one or a combination of recycled products, including high (>30 percent) reclaimed asphalt pavement (RAP), recycled asphalt shingles (RAS), ground tire rubber (GTR), and high polymer-modified asphalt. Such mixtures can also include other unique materials, such as WMA and cold-recycled mixtures. This presentation discussed the work being performed in the FHWA project, *Deployment of Performance-Based Technologies for Mechanistic-Empirical Pavement Design and Resource-Responsible Materials Design*, including the development of its two key products:

   - Practitioner's Guide for Performance Testing of R^{2}AMs.
   - Practitioner's Guide for Mechanistic-Empirical Design of Pavements with R^{2}AMs.

   The purpose of these guides is to provide information on how to measure and interpret the test results for use in the PMED software.

   Mr. Bonaquist provided an overview of the different types of recycled mixtures included in the test program (RAP, RAS, GTR, and high-polymer mixes from five different SHAs) and the material properties considered (dynamic modulus, repeated load permanent deformation, low-temperature creep and strength, and flexural fatigue). He outlined the differences in testing for R^{2}AMs as compared to standard, neat mixtures, noting that both specimen preparation differences and dynamic modulus testing differences are minor. In the case of the latter, RAP mixes increase the high-temperature grade by 6°C per 0.15 units of reclaimed binder ratio (RBR).

Mr. Bonaquist also reviewed the contents and outline of the Performance Testing Guide. The document includes a chapter on each material property listed above, and each of these chapters detail the equipment and procedures for specimen fabrication and testing and the data quality and analysis techniques used to establish the material properties. The Performance Testing Guide includes many pictures of the testing equipment and provides example project data and typical test results for R^2AMs. Mr. Bonaquist reported that a draft of the Performance Testing Guide was completed and reviewed by FHWA, and a final version is being prepared. He also noted that the Practitioner's Guide for ME Design has been drafted and is currently under review by FHWA.

10. LOCAL CALIBRATION EXPERIENCES

Session 8 of the meeting featured presentations on agency efforts to calibrate and validate the MEPDG, as well as a presentation on the semi-automated Calibration Tool. Summaries of the information presented and subsequent discussions are provided below. Copies of the presentations are featured as presentations 15 through 18 in Appendix C.

1. ***Missouri's Second Calibration Effort*** **(Mr. Jason Blomberg, Missouri DOT)**—The Missouri DOT was one of the first SHAs to implement the ME pavement design procedure developed under NCHRP Project 1-37A. That implementation, which adopted the national performance models, took place in 2004 and was followed-up with a first local calibration in 2008. A second calibration study was initiated in 2016 and is currently on-going. That second calibration study was the focus of Mr. Blomberg's presentation.

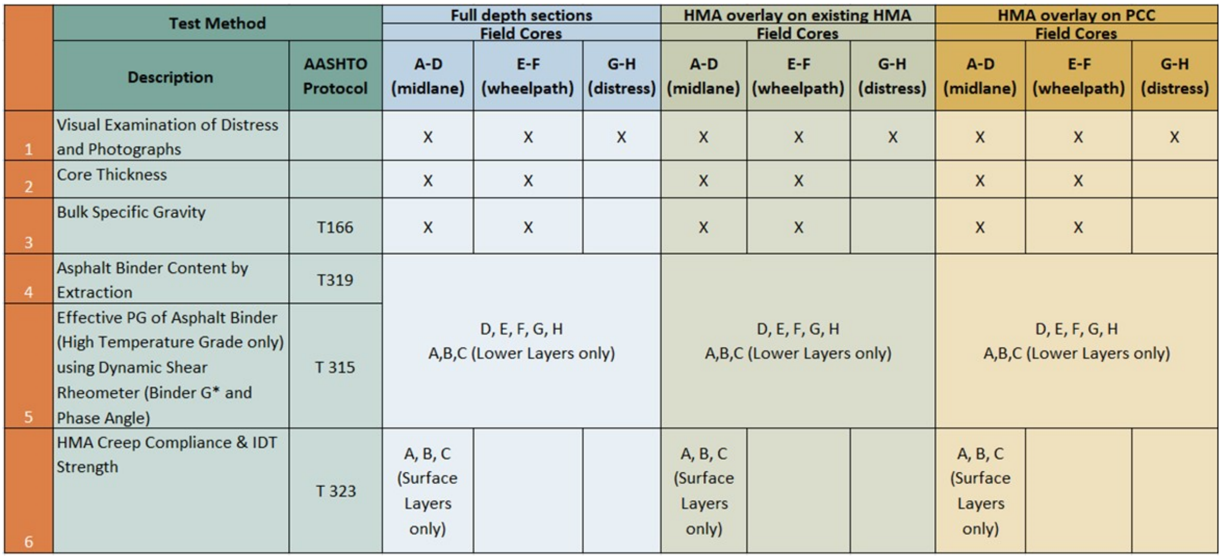
   As reported by Mr. Blomberg, the second calibration study expanded the number of full-depth pavement projects for calibrating the models for new design, and added several HMA overlay projects for calibrating the models for rehabilitation. The full slate of projects consist of the following:

   - Original Calibration Projects
     - 7 full-depth HMA pavements.
     - 25 full-depth PCC pavements.
     - 5 unbonded PCC overlays.
   - New Calibration Projects
     - 6 full-depth HMA pavements.
     - 6 HMA overlays over full-depth HMA pavement.
     - 5 HMA overlays over full-depth PCC pavement.

   Mr. Blomberg noted that, although more projects were desired for a more robust analysis, DOT staff limitations prevented this from happening. For the projects that were included, however, a fairly detailed field and lab testing program was developed and executed. For HMA pavements and overlays, field testing included strategic coring, augering, and FWD testing, while lab testing included a variety of tests on many different asphalt mixtures. These tests were performed on both extracted cores (see table 22) and on specimens prepared from loose-mix samples.

   Mr. Blomberg added that a meticulous analysis of traffic data for each project has been performed by the study consultant, and that the consultant is currently comparing the effects of NARR and MERRA datasets on HMA design. The local calibration is underway and is being performed using PMED v2.5.2. The study is expected to be completed in Spring 2019 and the results are expected to include an updated ME design manual, guidance on new calibration coefficients, guidance on HMA overlay design, an updated materials database, and a final report.

Table 22. Testing matrix for HMA cores extracted from Missouri calibration projects.



	Test Method		Full depth sections Field Cores			HMA overlay on existing HMA Field Cores			HMA overlay on PCC Field Cores		
	Description	AASHTO Protocol	A-D (midlane)	E-F (wheelpath)	G-H (distress)	A-D (midlane)	E-F (wheelpath)	G-H (distress)	A-D (midlane)	E-F (wheelpath)	G-H (distress)
1	Visual Examination of Distress and Photographs		X	X	X	X	X	X	X	X	X
2	Core Thickness		X	X		X	X		X	X	
3	Bulk Specific Gravity	T166	X	X		X	X		X	X	
4	Asphalt Binder Content by Extraction	T319	D, E, F, G, H A,B,C (Lower Layers only)			D, E, F, G, H A,B,C (Lower Layers only)			D, E, F, G, H A,B,C (Lower Layers only)		
5	Effective PG of Asphalt Binder (High Temperature Grade only) using Dynamic Shear Rheometer (Binder G* and Phase Angle)	T 315									
6	HMA Creep Compliance & IDT Strength	T 323	A, B, C (Surface Layers only)			A, B, C (Surface Layers only)			A, B, C (Surface Layers only)		

2. ***Michigan's Recalibration Effort*** **(Dr. Syed Haider, Michigan State University)**—The Michigan DOT conducted an initial local calibration of the JPC performance models in 2014 using PMED v2.0. Evaluation and testing of the next releases of software (v2.2 and v2.3) yielded significant changes in the JPC design thicknesses due to changes in the models and various bugs in the software. This finding led the agency to suspend the outright use of PMED and to initiate a study to recalibrate the concrete models. This presentation focused on the recalibration effort, including the resampling techniques that were used.

   Dr. Haider began the discussion by reviewing the steps in the local calibration process and conveying the objectives of the recalibration. He noted that only the cracking and IRI models were included, since Michigan DOT places dowels at joints and doesn't experience faulting. He also noted that several JPC pavements included in the initial calibration were removed, which led to a smaller pool of projects for the analysis (28 new and unbonded overlay pavements). Furthermore, he illustrated a summary table that was prepared containing the cracking and IRI local calibration coefficients established by other SHAs. These values were used as a guide by the DOT, in terms of acceptable ranges for the new coefficients.

   The next part of Dr. Haider's presentation covered the three model calibration techniques that were used in the study: (1) no sampling (using all the data without validation), (2) bootstrapping (multiple small data sets using random sampling with replacement), and (3) repeated split sampling. Each technique resulted in lower values of bias and standard errors of the estimate (SEE), as compared to the global models, and it was determined that the bootstrapping technique provides a more robust way of defining the standard error of the models when using a fewer number of projects.

   The new local calibration coefficients were used to perform design runs for various JPC projects using PMED v2.3. Thickness results were compared with AASHTO 1993 and with PMED v2.0 and v2.3 using the old calibration coefficients, as shown in figure 8. IRI was found to be the critical performance parameter in the recalibrated designs, and zero cracking was predicted despite noticeable cracking observed in some of the projects. A model developed for predicting permanent PCC curl showed some improvement in the calibration as related to cracking, however, IRI remained as the critical performance parameter and significant variations in thickness persisted.

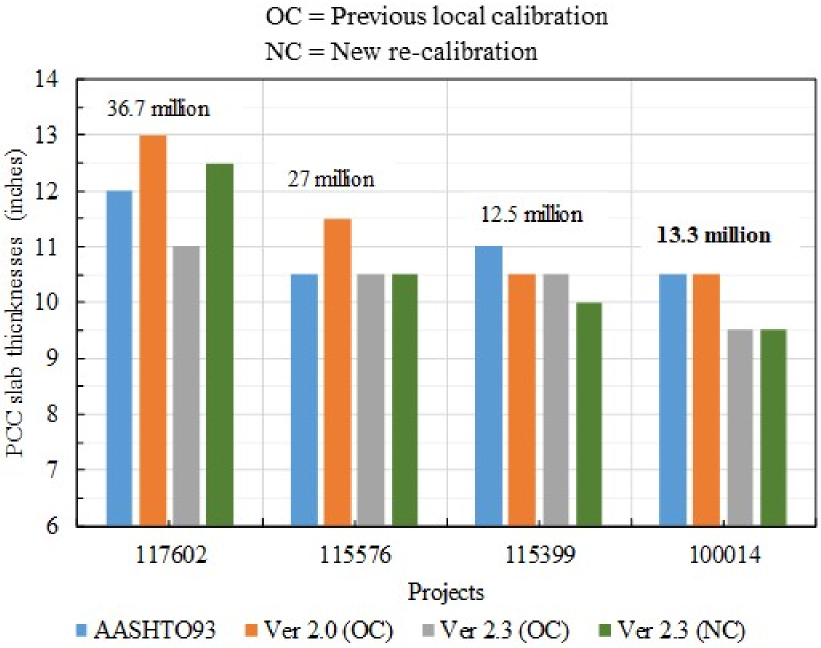


Figure 8. JPC design thicknesses for selected Michigan projects using AASHTO 1993 and PMED with old and new local calibration coefficients.

3. ***Data Challenges for Local Calibration/Validation: Issues with Test Sites and/or Data Collection Procedures and Changes Made to Resolve Those Issues* (Ms. Rhonda Taylor, Florida DOT)**—The focus of this presentation was on the history of the Florida DOT's local calibration efforts and the challenges and successes the agency has had with these efforts. The presentation also provided a glimpse of a major concrete test road being developed by the DOT that, among other things, will provide extensive data for conducting future local calibrations.

   To begin the presentation, Ms. Taylor described the initial calibration undertaken in 2008. Although about 160 asphalt and concrete pavement sections were initially identified as candidates for calibration, that number was reduced to 31 (15 asphalt and 16 concrete sections) following an intensive screening process. Because most asphalt cracking in Florida is top-down fatigue cracking and there was no top-down model in PMED at the time of the calibration, the DOT suspended the HMA calibration. Work on the PCC calibration was continued but required some changes in the calibration sections used; namely, pavements with CTB were removed due to performance issues and they were replaced with LTPP sections from Georgia and Alabama. The calibration resulted in new values for all four cracking model coefficients.

Ms. Taylor reported that a second local calibration for PCC was completed in 2015 using even fewer sections. This calibration resulted in adjustments to two of the four cracking model coefficients. Because of the limited number of sections in this latest calibration, the DOT decided to construct a concrete test road to expand the pool of sections. Construction of the test road, located on US 301 between Gainesville and Jacksonville, was begun in 2017 and is expected to be completed in 2020.

Ms. Taylor described and illustrated the site layout (see figure 9), noting its size (2.5 mi long) and makeup (52 total test sections, including 20 structural experiment sections, 16 drainage experiment sections, and 16 calibration experiment sections). She also discussed the various design variables and the comprehensive plan for collecting pavement response, performance, and other data over the long-term. Ms. Taylor noted that some of the sections will be designed thin in order to experience relatively early cracking.

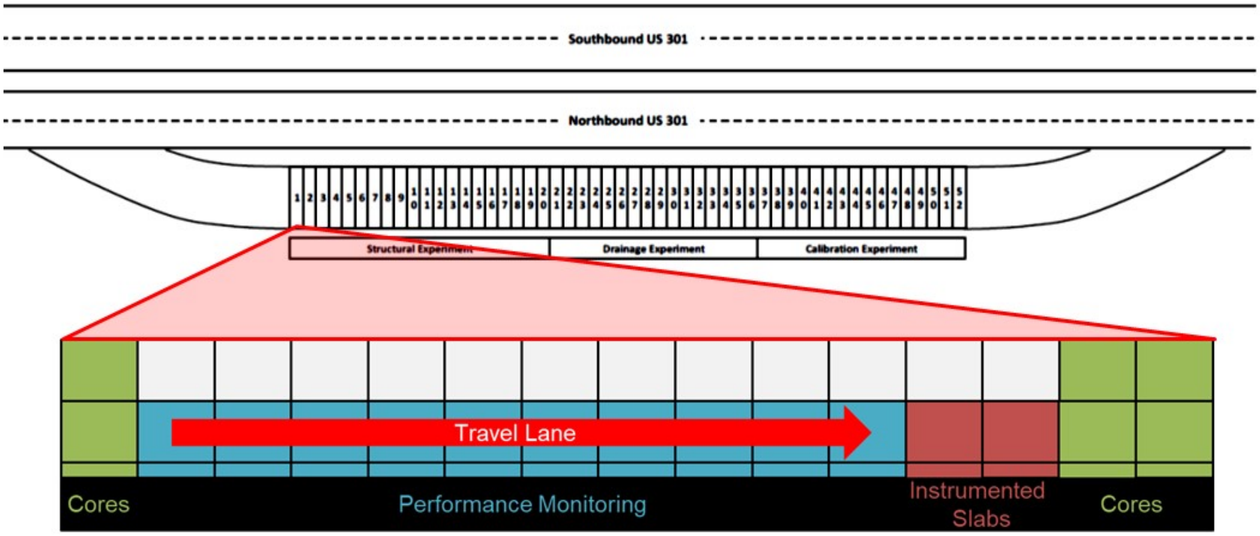
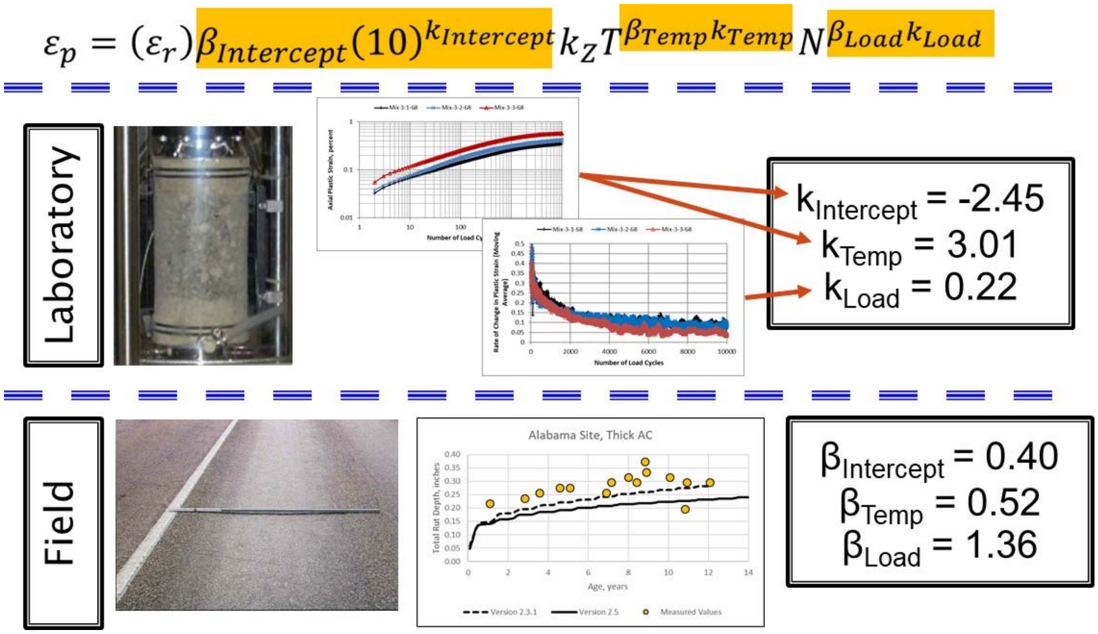


Figure 9. Schematic of Florida's concrete test road.

4. ***AASHTO Effort in Developing Automated Calibration Tool*** **(Dr. Wouter Brink, ARA)**—As mentioned in earlier chapters, work is underway to develop the semi-automated Calibration Tool and to integrate it with PMED v2.6 in July 2019. The tool is greatly needed as a way for agencies to expedite and simplify the local calibration process, particularly as it relates to recalibration efforts. This presentation provided an update on ARA's development of the Calibration Tool and an in-depth description and demonstration of the tool.

   Dr. Brink first reviewed the objectives of local calibration by describing the key concepts of verification (assessing performance model prediction bias), investigation (determining the cause(s) of bias), calibration (developing adjusted model calibration factors that eliminate bias and minimize error), and validation (confirming the adequacy of the adjustment factors). He then touched upon the main deliverables of the tool development project, which consist of a stand-alone, web-based calibration program and an integrally linked global calibration database (LTPP data sets). The global database can be expanded to include agency-specific data for use in the calibration work.

Dr. Brink shared with the audience the model coefficients that are considered when conducting a local calibration. The coefficients include K-values, which represent properties or values derived from laboratory testing, and β-values, which represent field-shift values intended to remove the bias between predicted and measured distresses. Dr. Brink illustrated the two sets of coefficients for three HMA distress prediction models, including the rut depth model shown in figure 10.



$$\varepsilon_p = (\varepsilon_r)\beta_{Intercept}(10)^{k_{Intercept}} k_Z T^{\beta_{Temp}k_{Temp}} N^{\beta_{Load}k_{Load}}$$

$k_{Intercept} = -2.45$
$k_{Temp} = 3.01$
$k_{Load} = 0.22$

$\beta_{Intercept} = 0.40$
$\beta_{Temp} = 0.52$
$\beta_{Load} = 1.36$

Figure 10. HMA rutting model calibration coefficients.

The Calibration Tool is being developed in accordance with the 11-step procedure given in the AASHTO *Local Calibration Guide* (2010). Dr. Brink described and demonstrated the five parts of the tool, and the series of manual and automated steps associated with each part.

- Part 1, Getting Ready for Calibration—The sampling matrix is established, test sections are selected, and the matrix is populated with data from the calibration database. The user selects the pavement and distress types to be used and the program selects the sections that fit the criteria for each distress type.
- Part 2, Review Distress Data—The distress data are extracted and reviewed, statistics for the data are computed, and a decision is made about the sufficiency of the number of test sections for the matrix. The program develops a distribution (and statistics) of the distress levels and pavement ages and presents an experimental matrix showing the sections that fit the cells of the matrix.
- Part 3, Set-up Project Files and Execute ME Design—Project design files are established, batch file runs are made, and the predicted performance data are extracted for analysis.

- Part 4, Analysis of Distress Predictions—Comparisons between predicted and measured distress values are made (including bias and standard error calculations) and the calibration coefficients to be modified are selected. The program yields measured vs predicted values for each distress and lists the statistics needed to determine if a local calibration is needed (hypothesis test results). If a hypotheses fails, the program directs the user to a page that allows them to filter through the factors, replot/recalculate the statistics, and identify the focus of the local calibration.
- Part 5, Optimization of Calibration Coefficients to Eliminate Bias—Batch file runs are made to optimize the coefficients to eliminate bias and minimize standard error. The program uses Excel Solver-like calculations to perform the optimization for the selected distress types. Dr. Brink advised that it is best to start with transfer functions and then move to structural response functions, if adjustments to the former don't produce meaningful improvements.

Mr. Harold Von Quintus (ARA) pointed out the importance of using a balanced number of sections within the cells of the experimental matrix. He noted that he is working with Dr. Ceylan on developing a weighting process within the program that will give proper balancing. Dr. Haider added that there needs to be guidance included on a balanced versus unbalanced calibration matrix.

Mr. Von Quintus also pointed out that the Calibration Tool offers the advantage of quickly performing calibration using different PMED versions, as well as assessing the impacts of MERRA and NARR data.

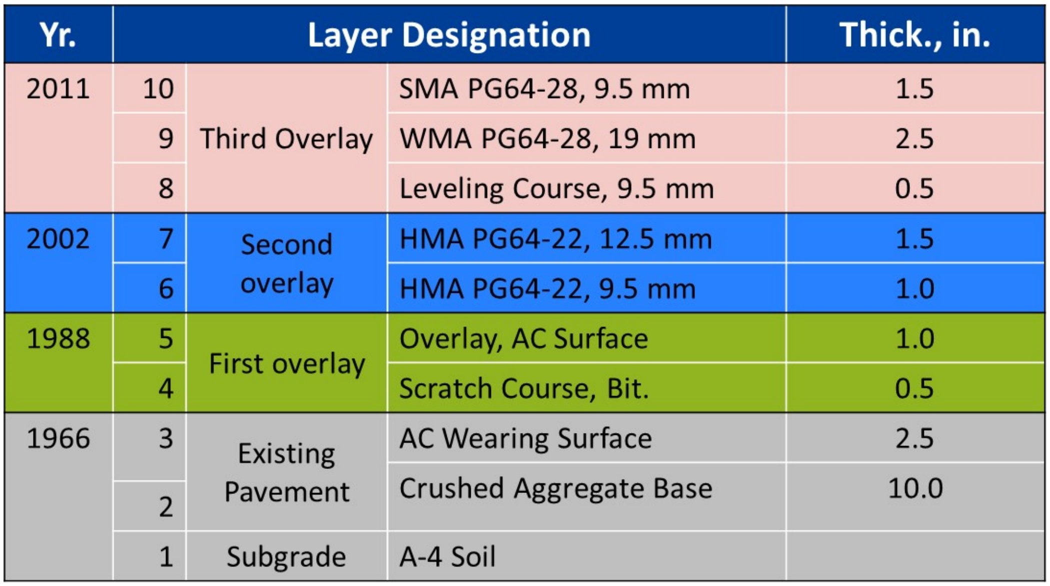
Dr. Brink indicated that ARA is in the process of developing the optimization routines. He also informed the participants that beta testers for the tool are needed, starting in April 2019.

11. SOFTWARE TRAINING

Session 9 of the meeting featured demonstration-based training by Mr. Von Quintus (ARA) on the use of PMED for different design applications. The training included live use of the programs, supplemented with various output screen shots and Microsoft PowerPoint slides. Topics included in the training were: (1) rehabilitation design of pavements with multiple overlays, (2) new composite pavement design, and (3) using laboratory test results to characterize AC mixtures for rehabilitation design. A summary of each block of the training is provided below, along with key discussions generated by the presentations. A copy of the software training presentation is featured as presentation 19 in Appendix C.

1. ***Designing Rehabilitation Strategies with Multiple AC Overlays***—The first training block featured as an example an existing AC pavement containing three overlays and exhibiting top-down cracking (see table 23). Mr. Von Quintus defined the proposed rehabilitation strategy as consisting of milling off the most recent (2011) overlay and applying a new HMA overlay. In demonstrating the rehabilitation design, he discussed how the lower layers of HMA that remain after milling should be characterized and he introduced two design enhancements to the overlay itself—(1) the incorporation of a future preventive maintenance treatment and (2) the use of Level 1 inputs for indirect tensile strength.

Table 23. Existing pavement structure summary for rehabilitation design example.



Yr.	Layer Designation			Thick., in.
2011	10	Third Overlay	SMA PG64-28, 9.5 mm	1.5
	9		WMA PG64-28, 19 mm	2.5
	8		Leveling Course, 9.5 mm	0.5
2002	7	Second overlay	HMA PG64-22, 12.5 mm	1.5
	6		HMA PG64-22, 9.5 mm	1.0
1988	5	First overlay	Overlay, AC Surface	1.0
	4		Scratch Course, Bit.	0.5
1966	3	Existing Pavement	AC Wearing Surface	2.5
	2		Crushed Aggregate Base	10.0
	1	Subgrade	A-4 Soil	

Characterization of the milled pavement structure on which the new overlay will be placed requires defining the level of damage for the existing layers. For the design example presented, Mr. Von Quintus advised the use of the best known distress data for pavement structure that existed prior to the most recent (2011) overlay. In addition, he discussed how the thicknesses and dates of the individual overlays and the original pavement need to be examined and a logical decision made as to how to group the HMA layers into no more than two layers for the design analysis. For the design example presented, the second (2002) overlay was assigned as one layer and the first (1988) overlay and original (1966) AC wearing surface were combined and assigned as the second layer.

Mr. Von Quintus used the PMED software to demonstrate the rehabilitation inputs for the example design. He pointed out that milling depth is specified for informational purposes only and that, with a milling application, Level 2 distress data (and not Level 1 FWD data) are used. He also noted that crack LTE has a significant effect on reflection cracking over time and demonstrated how FWD LTE values can be entered for use.

Mr. Von Quintus also showed the set-ups for specifying a preventive maintenance treatment at Year 15 and entering the Level 1 inputs for indirect tensile strength for the new overlay. As noted earlier, the Maintenance Strategy Tool in PMED v2.5 resets selected performance parameters (rutting, IRI, etc.) to reflect the changes in conditions associated with the specified treatment.

Predicted performance charts for the design example are shown in figure 11. Mr. Von Quintus noted that a stiffer HMA mix had to be used to satisfy the threshold criterion of the controlling distress—AC total thermal and reflective cracking.

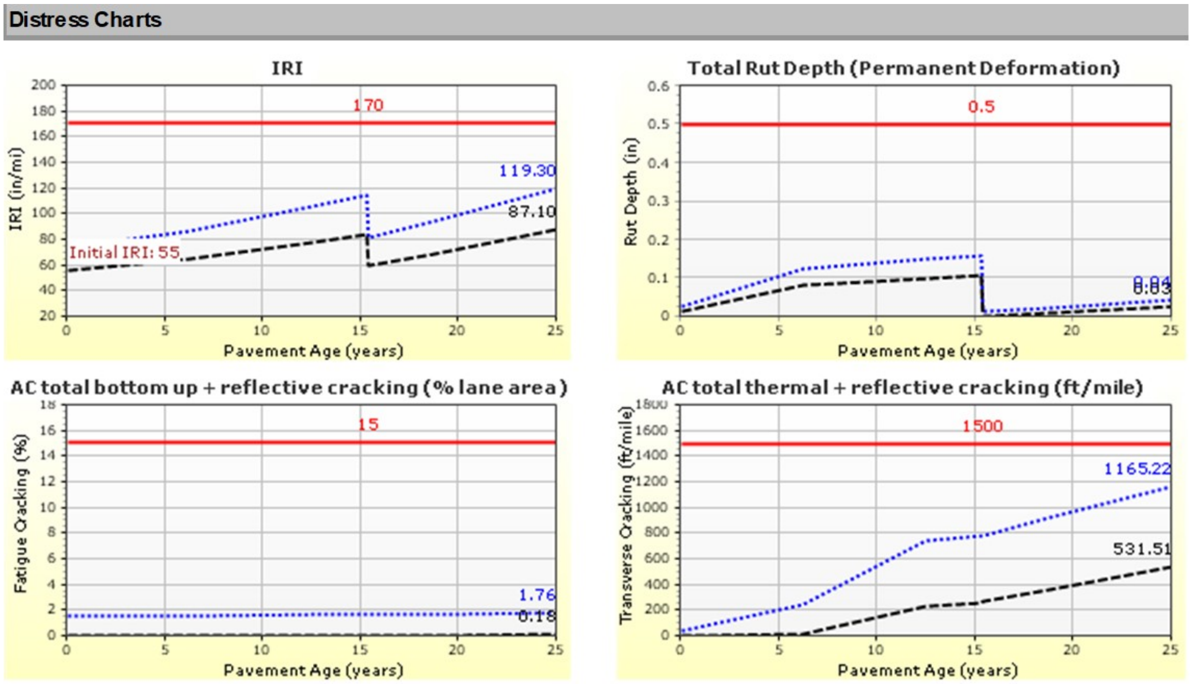


Figure 11. Performance prediction plots for the HMA multiple overlays rehabilitation design example.

2. ***Designing Composite Pavements with Current Software***—The second training block focused on describing and demonstrating the design of a new composite pavement consisting of a new HMA surface placed on a new JPC pavement. Because the current PMED software does not include composite pavement as a design type, users have to specify the design type as an "Overlay" and the pavement type as "HMA over XXXX," where XXXX is the underlying pavement structure.

   Mr. Von Quintus pointed out that for composite HMA over JPC, joint faulting is not a direct performance indicator. Instead, the designer first performs a design run that considers IRI and distresses such as bottom-up and top-down fatigue cracking, rutting, and JPC transverse cracking, and then conducts a faulting check using only the JPC portion of the composite pavement. Thus, the key aspects for this type of composite pavement are the PCC damage (slab cracking), HMA reflective cracking, IRI, and the PCC faulting check.

   The design example for this demonstration consisted of a 4-inch HMA surface (2 lifts) and 10-inch PCC base with 1.5-inch dowel bars. The selected design life and forecasted traffic were 30 years and 70 million cumulative trucks, respectively. The Maintenance Strategy Tool was used to reflect an ultrathin HMA overlay or diamond grinding treatment at Year 15.

   Mr. Von Quintus alerted participants to the fact that the HMA over JPC design analysis uses the MERRA climate data, whereas the JPC faulting check uses the NARR climate data. He also pointed out that the HMA over JPC design analysis requires the user to specify at least 1 year difference between the time the JPC is constructed and the HMA surface is placed. Additionally, to truly reflect a new composite pavement structure, the user should input zero distressed slabs before repair and zero distressed slabs after repairs.

   Predicted performance charts for the design example are shown in figures 12 and 13. Mr. Von Quintus pointed to the joint reflection cracking predictions and the need for a mitigation strategy for this distress. He noted that, while strategies such as saw-and-seal and interlayer treatment exist, they sometimes are not very effective.

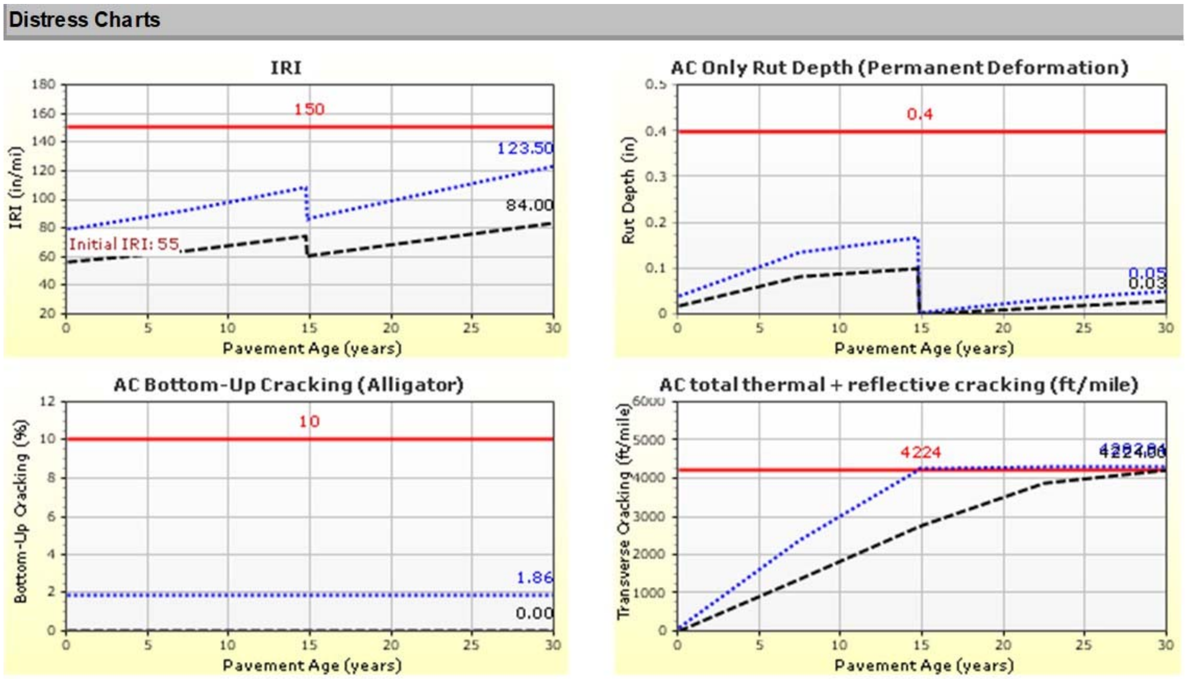


Figure 12. Performance prediction plots for the new composite pavement design example—HMA over JPC.

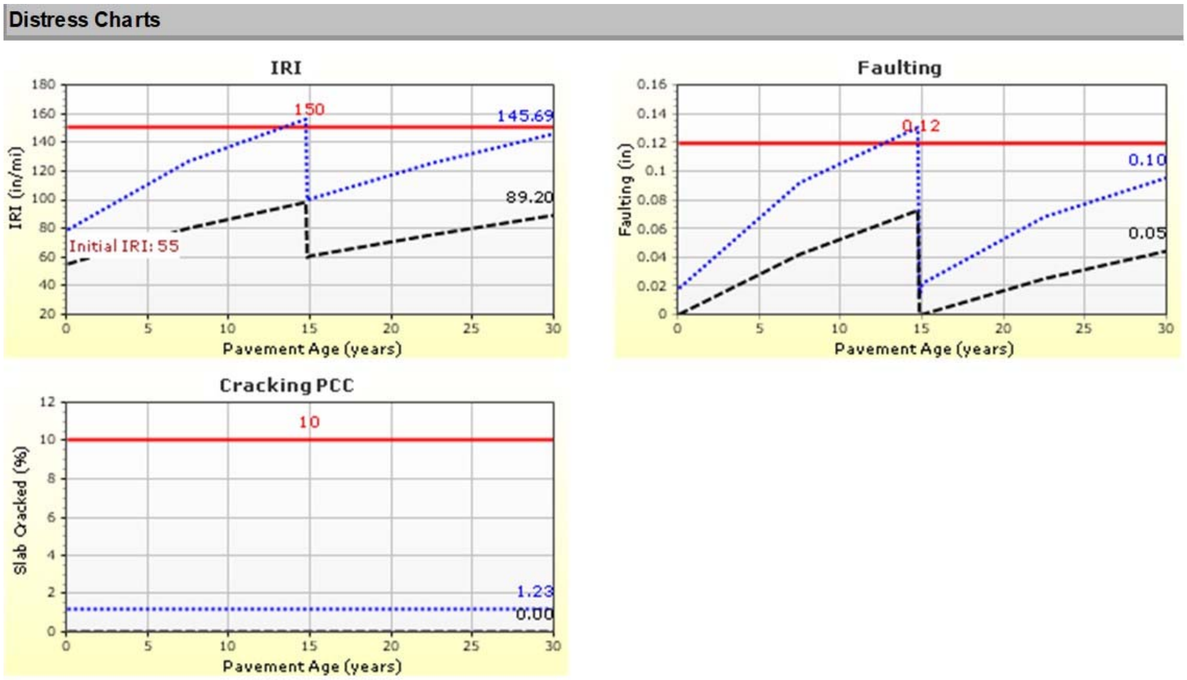


Figure 13. Performance prediction plots for the new composite pavement design example—JPC faulting check.

3. ***Using Laboratory Test Results to Characterize AC Mixtures for Design***—The third and final training block examined issues related to calibration and PMED use, relative to material characterization. Mr. Von Quintus explained that in the latest global calibration effort for the HMA models, a major change was made in the way K-values were derived. Prior to PMED v2.5, K-values were developed using a combination of laboratory and field results. In v2.5, the laboratory and field coefficient values were separated out, with K-values defined by laboratory results and β-values defined from the field.

   Mr. Von Quintus provided a brief comparison of the new (v2.5) and old (v2.3.1) global calibration factors for the rutting, bottom-up fatigue cracking, and transverse cracking models.

12. RESEARCH, TRAINING, AND SOFTWARE NEEDS

Session 10 of the meeting featured an open forum discussion of the research, training, and software needs related to the MEPDG and PMED. Dr. Pierce facilitated the discussion, focusing on some of the more common suggestions provided by the participants in the pre-meeting survey. A summary of the discussion topics is provided below.

- PCC widened slab design—The benefit associated with a widened slab needs to be re-examined. Longitudinal cracking is not evaluated, but can significantly occur in the widened-slab design scenarios.
- Traffic data—Truck traffic is a major factor in pavement design. An emphasis must be placed on having a sufficient number of WIM sites to properly characterize and forecast traffic.
- Modeling traffic on tied and untied PCC shoulders—Modeling unique traffic patterns (e.g., traffic straddles the longitudinal lane/shoulder joint) is not possible with PMED. For these situations, a finite-element approach is needed.
- Composite design—Additional guidance is needed for modeling these types of pavements, particularly in the case where multiple overlays have occurred over time.
- Integration of pavement structural design and mix design—FHWA has an ongoing project to develop the FlexPave software program. FlexPave is intended to simplify the flexible pavement design process by connecting the structural and mixture design components. The program is not intended to undercut or undermine PMED, but should be viewed as a possible supplement toward achieving a full mechanistic design methodology. Mr. Richard Duvall (FHWA) indicated a willingness to make a presentation on FlexPave at the 2019 ME Users Group meeting.
- Impacts of drainage layers—Additional research is needed to examine the thickness requirements of drainable versus non-drainable pavements. However, as noted by Mr. Yu, drainage should not be perceived as a thickness issue (i.e., poor drainage cannot be overcome by additional thickness).
- Modeling of specialized materials—Some materials, such as SMA, open-graded drainage layer (OGDL), and open-graded friction courses (OGFC), cannot be properly modeled in PMED. As these materials have gained popularity in their use, there is an increased urgency in being able to properly characterize them in PMED.
- Complexity of ME pavement design and the changing landscape of PMED users—With the increased complexity of the design process and a shift in the makeup of PMED users (from older experienced engineers to younger inexperienced individuals), is there a need to de-couple PMED into a simplified version and a complex version? Mr. Yu indicated that the design process itself is relatively simple and straightforward, but that the complexity arises in the many different design iterations that have to be made to solve the specific problems of each project. Mr. Becker noted that some steps in de-coupling are being made, whereby older models are being unhooked and newer better models are being adopted.

13. PLANS FOR THE FOURTH ANNUAL USERS GROUP MEETING

At the conclusion of the meeting, Dr. Pierce informed the group that planning for the 2019 Users Group meeting was underway and New Orleans, Louisiana has been selected as the next meeting location. The meeting will be held at the Crown Plaza New Orleans-Airport hotel on November 6-7, 2019. Additional details regarding this meeting will be communicated to potential participants in the summer of 2019.

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