Meeting Minutes for Mechanistic-Empirical Pavement Design Guide (MEPDG) Implementation RoadMap Workshop

Pavement ME User Group Meetings (FHWA Task Order 693JJ320F000269)

June 1-2, 2022

Participants

State Highway Agencies (SHAs): Ian Rish (Georgia Department of Transportation [DOT]), John Arambarri (Idaho Transportation Department [Idaho TD]), Kumar Dave (Indiana DOT), Chris Brakke (Iowa DOT), Adam Ross (Kentucky Transportation Cabinet [KYTC]), Justin Schenkel (Michigan DOT), John Donahue (Missouri DOT), Clark Morrison (North Carolina DOT), Nusrat Morshed (New Jersey DOT), Lauriane Collins (Utah DOT), Hari Nair (Virginia DOT), and Ali Morovatdar (Wisconsin DOT)

Industry Groups: Jim Mack (CEMEX), Bob Kluttz (Kraton Polymers), Richard Willis (National Asphalt Pavement Association [NAPA]), and Hadi Rashidi (National Stone, Sand, and Gravel Association (NSSGA])

Academia: Halil Celin (Iowa State University), Clark Graves (University of Kentucky), Syed W. Haider (Michigan State University), and Julie Vandenbossche (University of Pittsburgh)

Federal Highway Administration (FHWA): Jennifer Albert and Chris Wagner

American Association of State Highway and Transportation Officials (AASHTO): Ryan Fragapane

Applied Pavement Technology (APTech): Kelly Smith and Max Grogg

Nichols Consulting Engineers (NCE): Linda Pierce

Disclaimer

The meeting minutes herein are a summary of meeting topics and discussion, not a verbatim transcription. The opinions expressed in these minutes are of those persons and may not represent those of FHWA, APTech, AASHTO, or of all other attending participants.

Opening Session

- Welcome and initial introductions by Kelly Smith
- Self-introductions by participants
- FHWA remarks by Jen Albert
    - The workshop aims to identify what can be done to decrease the time it takes to implement the MEPDG and accompanying AASHTOWare Pavement ME Design (PMED) software, and how the implementation challenges can be overcome.
    - Pavement Design Policy: Moving forward with rulemaking, draft language is under review, and expected to be posted in the fall of 2022.

  - March 2022 Pavement Design Peer Exchange in Montana was a successful event, covering pavement design, linking the transportation asset management plan (TAMP) to pavement design, and pavement preservation.
- AASHTO and PMED Task Force remarks by Clark Morrison
  - Efforts to aid implementation are appreciated.
  - Web version of PMED software (v3.0) to be released in July 2022. The web version will give agencies greater control of inputs.
  - Producing a series of training videos on the PMED models.
  - AASHTOWare to take over Pavement ME User Group after Transportation Pooled Fund (TPF)-5(305) ends in 2023.
- Background on MEPDG/PMED implementation by Kelly
  - 3 SHAs implemented in 2013, 14 SHAs by 2016, and 18 SHAs by 2021 (with 9 SHAs using MEPDG/PMED as the primary method and 9 SHAs using it in parallel with another procedure).
  - Implementation trends in recent years have stagnated, with several "implemented" agencies reverting to the previous procedure or are using MEPDG/PMED in parallel with another method.
  - Activities to aid implementation haven't changed significantly between 2013 and today. Training in ME design, development of design inputs, and interpretation of design results are a primary focus, along with local calibration and model improvements.
  - RoadMap workshop is another way to help with implementation. Workshop objectives center on identifying challenges that SHAs have had with implementation and the actions they have taken to overcome those challenges.
  - The workshop will focus on four broad categories of implementation: design policy; design inputs; verification, calibration, and validation; and application and use.

Sharing Session Part 1–SHAs

Question Posed to SHA Representatives: What was your agency's biggest challenge to implementing MEPDG/PMED and how was it overcome?

- Georgia DOT
  - Currently using AASHO *Interim Guide for the Design of Pavements* (AASHO 1972) and AASHTO *Rigid Pavement Design Revisions* (AASHTO 1981).
  - Still transitioning to MEPDG/PMED. Software version changes have caused a need for recalibrations. Initial calibration performed in 2015/16 (using PMED v2.2/2.3). Moving forward with calibration of v2.6 using Modern-Era Retrospective analysis for Research and Applications (MERRA) data. Calibration Assistance Tool (CAT) will help move forward (yearly validations are now possible). Will eventually implement PMED v3.0.
  - Leadership changed in 2017. Have new staffing.
  - Traffic inputs were somewhat of a guess.
  - Limited materials data but have recently funded studies to evaluate more mix types (e.g., polymer-modified hot mix asphalt [HMA], concrete mixes).

  - Procuring contracts for support services to assist in-house staff.
  - Desire to use traffic speed deflectometer (TSD) data.
- Idaho TD
  - Fully implemented. Although implementation is for "all" designs, it has been burdensome to meet these expectations due to staffing limitations (Idaho relies heavily on consultants to conduct pavement designs).
  - New and rehabilitation designs require MEPDG/PMED analysis per policy, but this is not happening.
  - Retirements/turnover have been challenging. The people here today may not be the ones implementing in 5 years.
  - Don't have resilience in the system.
  - TSD data being evaluated.
  - In 2023, Idaho plans to step back and revisit the implementation roadmap from 2014; modify it as appropriate.
- Indiana DOT
  - Fully implemented in 2010.
  - Agencies need to be convinced that MEPDG/PMED is the right tool, and then upper management must buy-in.
  - The biggest design input challenge was traffic. Had 5 PhDs in the research group assist with this effort (traffic and material inputs). Divided truck traffic into 4 truck weight road groups and developed inputs.
  - Prepared materials input files too. They have input files for their six districts and different mixes.
  - Calibrated the rutting models, as they were known to be off.
  - Verification was also a challenge.
  - Have a good design manual(Indiana Design Manual Part 6) with instructions for designers (e.g., inputs and how to conduct the designs).
- Iowa DOT
  - One challenge has been the expertise required to do the calibration and validation.
  - Another challenge has been staff resources (staffing currently only includes 2 people).
  - Contracted with Iowa State University and formed a technical advisory committee (TAC) within the DOT.
  - Provided data needed for calibration and was involved with the selection of calibration and validation sites.
  - Contracted with APTech and HDR to evaluate MEPDG/PMED and PerRoad and to compare design results to current procedures (Portland Cement Association [PCA] method for concrete and AASHTO *Guide for the Design of Pavement Structures* [AASHTO 1993] for asphalt).
  - Have decided to do parallel designs for new/reconstructed pavement. For concrete, will continue with MEPDG/PMED implementation (design with PMED, use PCA as a limiter on maximum thickness, and 9 inches as a minimum thickness for highway pavements). For asphalt, will continue with MEPDG/PMED implementation but it will require some additional material property data (indirect tensile strength and creep compliance). MEPDG/PMED will be run in parallel with AASHTO 1993 (use the thinner of the two designs and use the PerRoad-based design results map as a limiter on maximum thickness).

- Need to recalibrate the concrete faulting model and CTE data.
- Concrete issue: Using a 20-ft joint spacing results in an increase in cracking prediction. Calibration was complicated since Iowa DOT data contained maximum fault rather than an average fault value. Michigan noted that as thickness increases, the dowel diameter does not necessarily change (dowel size dictated by Standard Specifications and dowels cannot be larger than 1.5 inches diameter [unless a specialty item]). Faulting is not typically a performance issue.

- Kentucky TC
  - Primarily an asphalt state.
  - Prior to 2016, they used a Microsoft Excel sheet based on AASHTO 1993.
  - Conducted MEPDG/PMED calibration and using PMED v2.3 as a basis for an updated catalog for new design.
  - Created an online catalog similar to the Microsoft Excel sheet (rehabilitation design, based on PMED v2.6.1).
  - Updating library based on balanced mix design.
  - The biggest challenge has been staff turnover (5^{th} branch manager for pavement design since 2016).
- Michigan DOT
  - Partially implemented in 2016 for new/reconstruction designs. Since the Pavement ME design process is more complex and requires characterization of existing materials for which agency records may be incomplete or missing altogether, the DOT is not yet using the procedure for rehabilitation design. Accordingly, Michigan is going to conduct a new research project to determine how to most accurately model rehabilitation fixes in Pavement ME, characterize existing materials (and their thicknesses), and streamline the process so that the agency can use Pavement ME for rehabilitation design decisions.
  - Michigan DOT has conducted three Pavement ME calibration projects to date, with the third of those projects scheduled to end later this year. Additionally, the ongoing project is investigating non-destructive test methods to simplify the data collection of ME inputs.
  - Pavement ME implementation issues include establishing design requirements (inputs and calibration) and educating their regional staff on software use. Accordingly, the DOT held several meetings with internal and external stakeholders to define inputs and ME protocols. Furthermore, the DOT conducted training and developed worksheets, starter files, and import files to aid in ME input entry.
  - Michigan DOT has also experienced industry push back with MEPDG/PMED implementation. There is more comfort with the AASHTO 1993 design method. Specifically, the concrete industry has concerns since some ME designs have slab depths greater than 16 inches. However, it is important to note that the DOT has rules to restrict final design thickness by keeping them to ±1 inch from the AASHTO 1993 final design so excessively thick designs do not occur. Concerns and questions still persist, so Michigan DOT continues to communicate, evaluate, and work with industry groups on ME topics.

- Missouri DOT
  - An early adopter in 2005 using research-grade software. At the time of implementation, limited or unavailable standards of test and equipment were available. Built their own CTE testing frame.
  - Performed first calibration ~2009 and a second calibration ~2019.
  - Have worked with the industry to be transparent on pavement design and type selection.
  - Alternate bids for new pavement designs. Picked factors that made the most sense. Equivalent designs for alternate bidding were a challenge (e.g., what distress thresholds, what reliability levels). Michigan DOT expressed that they also experienced some challenges in alternative bidding and design/material parameters).
  - Obtained upper management buy-in.
    - Expected thinner pavements (~3 inches for concrete and 5 to 6 inches for asphalt) meant savings in costs—no resistance from upper management.
  - Biggest challenges
    - In the first calibration, they had just implemented Superpave and thus there was not a lot of data to use for asphalt validation/verification. On the concrete side, they had transitioned from jointed reinforced concrete pavement (JRCP) to jointed plain concrete pavement (JPCP) about 15 years prior. Thus there was no long-term performance data available.
    - They had an additional 9 to 10 years of data for the second calibration, which helped verify longer term performance predictions.verify.
    - Assumed a greater use of polymers than actually used.
  - Most challenges were from being an early adopter. The issues worked out over time.
  - Missouri DOT used thick rock bases and was not sure they were accurately modeled by MEPDG/PMED.
- New Jersey DOT
  - MEPDG/PMED is used for new construction/reconstruction. They are using PMED v2.6.
  - The biggest challenges have been traffic and material inputs.
  - For traffic, they developed traffic clusters from regions and functional classification. The traffic clusters and weigh-in-motion (WIM) data are available on their website.
  - The materials catalog was developed for most asphalt mixes used in the state, including stone matrix asphalt (SMA). This catalog is also available on their website.
  - New Jersey roads are ~55% composite pavement. Reflection cracking is common and thus it is a key parameter in MEPDG/PMED.
- North Carolina DOT
  - Calibration issues were encountered early on with aggregate base (1 inch of asphalt concrete [AC] equals about 8 inches of aggregate base).
  - Currently conducting a local calibration and are hoping it resolves the aggregate base and other issues.
  - They have conducted level 1 resilient modulus and have good data now.
- Utah DOT
  - Fully implemented since 2015/16 for new construction/reconstruction and widening for both asphalt and concrete pavement. MEPDG/PMED is not used for rehabilitation/resurfacing.

  - Currently working on a materials library. They have 1 standard asphalt mix and plan to add 1 SMA mix. Gathering more of their own data.
  - Good traffic data is available on their website.
  - A user guide is available on their website.
  - They plan on evaluating PMED v3.0.
- Virginia DOT
  - Implemented in 2018 for new construction/reconstruction, but not overlays. PMED v2.2.6 is used.
  - Started planning for implementation back in 2007/08. They completed several research projects and did extensive materials characterization.
  - Developed a user manual, which was considered a critical step.
  - Identified pavement management system (PMS) sites for calibration due to good performance data and limited Long Term Pavement Performance (LTPP) sites in Virginia. They had several good asphalt sections, but for JPCP and continuously reinforced concrete pavement (CRCP), there were not many sections available. They used global coefficients for these pavements.
  - Conducted a detailed sensitivity analysis focused on aggregate bases, stabilized bases, semi-rigid pavements, and recycled layers based on agency inputs. Made a policy decision to continue using an aggregate base in design.
  - Met with industry to inform them of changes.
  - Gave designers a 1-year advanced notice of the change to MEPDG/PMED.
  - Conducted several training sessions starting in 2010. These are continuing.
  - Characterizing the existing pavement as part of overlay design is a significant challenge. They are looking into PMED implementation for overlays with the adoption of PMED v3.0.
- Wisconsin DOT
  - Still using AASHO 1972.
  - Implemented MEPDG/PMED in 2016, but then stopped using it in 2017, due to inconsistent results. The initial implementation of ME was based on a preliminary calibration.
  - Recalibration (by ARA) for both flexible and rigid pavements is in progress, with major modifications that consider the site-specific features of LTTP and local sites in Wisconsin.

Sharing Session Part 2a–Industry

Question Posed to Industry Representatives: What does your organization perceive as the issue with MEPDG/PMED implementation by SHAs and what are your recommendations to overcome this problem?

- CEMEX
  - Has used MEPDG/PMED since 2007.
  - Need to motivate people to change and give them the ability to change. AASHTO has done a good job of giving people the ability to change but has not done a good job at motivating use. States are more worried about Pavement ME being "wrong" and don't see the benefits (savings) that can be made from adopting its full use.

  - Training could be improved; provide guidance on what is good and how to use engineering judgment.
  - Have concerns with using the International Roughness Index (IRI) model and criteria (increasing thickness to meet IRI), when cracking and faulting are an issue. The IRI model needs updating.
  - Need to highlight more success stories like the Indiana DOT report circa 2010, where they used MEPDG/PMED on 10 projects and saved $10 million.
  - Industry wants to be treated fairly. When known issues are not being corrected/addressed, we do not feel treated fairly and will push back.
  - The concrete industry believes agencies don't need to adopt PMED asphalt and concrete design procedures at the same time. The concrete side is ready and agencies can use global calibration for concrete.
  - While we recognize the concerns on how to develop equivalent designs, they can be overcome by basing designs on PMED results and appropriate LCCA. Step away from having 20-year designs.
  - Would like to see more accessibility to PMED, especially for college students for whom the full version should be free.
  - Make the program "open-sourced" so that "plug-in" programs (i.e. LCCA, LCA, others) could be developed to work with it.
  - American Concrete Pavement Association (ACPA) developed a user guide that can be included in any future guides.
- Kraton Polymers
  - There are new, higher-performance materials for asphalt pavements. SHAs are asking how they can use these materials for designs.
  - Problem is that the new materials don't have performance data. Two SHAs have done a lot of polymer work—Florida DOT (which doesn't use MEPDG/PMED for flexible) and Virginia DOT.
  - PMED is the tool to use but executing it is a challenge.
- NAPA
  - There are new additives in asphalt mixtures every day. How do we understand how these additives will impact pavement performance?
  - There's a lack of understanding of MEPDG/PMED. NAPA has worked with Dave Timm (National Center for Asphalt Technology [NCAT]) to help contractors understand the material inputs.
  - The biggest challenge is that, while SHAs use MEPDG/PMED for new construction/ reconstruction, most of their work is in rehabilitation. Need to focus more effort on what the SHAs need now.
  - There are also challenges with the models (IRI has been discussed).
  - At the university level, there is not a good textbook for use. Most professors have their own. Creating YouTube videos to help with training is one idea.
  - There is a free educational PMED version; however, this version has limited functionality. Hopefully, PMED v3.0 will help with this.
  - NAPA has worked with FHWA to provide a chapter in the NCAT textbook with examples using AASHTO 1993, PerRoad, and MEPDG/PMED.

- NSSGA
    - For SHAs with good quality aggregates, the structural coefficients for asphalt mixes and aggregate base materials are 0.44 and 0.11, respectively. This is a factor of about four. However, MEPDG/PMED gives a value of 6 to 10 times of asphalt to aggregate. There is a concern that the aggregate base layer is not receiving fair consideration in relation to the other layers in the MEPDG/PMED, as noted in the NCHRP Web-Only Document 264: *Proposed Enhancements to Pavement ME Design: Improved Consideration of the Influence of Subgrade and Unbound Layers on Pavement Performance*.

Sharing Session Part 2b–Academia

Question Posed to Academia Representatives: What does your organization perceive as the issue with MEPDG/PMED implementation by SHAs and what are your recommendations to overcome this problem?

- Iowa State University
    - The number 1 issue is transparency. The inclusion of climate models has more impact than traffic.
    - The climate data is a black box in PMED. Unable to do a peer review of the data or even teach it. Have wanted to make the EICM available to students, but the software is not obtainable.
    - The educational copy of PMED has significant limitations, such as access to remote students. Cost is another issue; PMED is among the most expensive pavement design/analysis software.
    - Need to make more educational materials available.
    - For MEPDG/PMED, there are no models for longitudinal cracking and corner breaks.
    - Documentation of all the models and their application (similar to the original NCHRP 1-37A report) is needed to address all the new models and updates. The PMED Task Force noted that they will limit model updates, such that model re-creation will require recalibration about every 5 years.
- University of Kentucky
    - Shift user license to service to make it easier to get access (IT doesn't have to get involved with service).
    - Implementation targets—More training/webinars on more types of rehabilitation are needed.
    - Local calibration/validation is ongoing. Their question is "how to use PMS data to do the validation? Is there a way to globally calibrate?"
    - Maybe this needs to be looked at a little differently. Material properties change every day (e.g., balanced mix designs, new cracking tests); how do we account for those changes with performance in MEPDG/PMED?
- Michigan State University
    - Have performed one calibration for Michigan DOT. Getting more data to perform another calibration.
    - How do you get performance data from the PMS when it's not in the same units as what's in the MEPDG/PMED models? How will calibration impact the state of the practice in pavement designs?

  - Reliability is used in designs. How are outliers accounted for?
  - Rehab will be a challenge. The backcalculation is not open-sourced for examination.
  - Backcalculation Tool (BCT) is not included with the PMED license.
  - Made note that the ride quality has been a fundamental part of pavement design. The AASHTO 1993 design method utilizes a ride metric of PSI, which is similar to IRI, so it would be appropriate for ME designs to utilize terminal IRI for design decisions. Moreover, IRI is the only common design criterion between the two pavement types (flexible and rigid), further emphasizing its importance for design considerations. Finally, IRI is also useful as it is a function of structural distress.
- University of Pittsburgh
  - Recommend decoupling the JPCP faulting model from the thickness model because you don't fix faulting with thickness. This was done for PennDOT.
  - With parallel designs (e.g., comparing AASHTO 1993 with MEPDG/PMED), you still need engineering judgment.
  - Supplemental design files are invaluable. Need to ensure they don't get lost in new versions of the software.
  - Access is very important. One should think about what students need to know and then provide the ability (access) to the needed information.
  - Professors should communicate with SHAs as to what they want students to know.

Breakout Session 1A–Design Policy

The purpose of this breakout session was to collect information on policy development for SHAs that are implementing MEPDG/PMED. Policy issues were defined as:

- Pavement-type applications and determination.
- Hierarchical input level.
- Reliability.
- Performance criteria.

Participants noted two items that were not included in the original listing, but which they identified as significant in the successful implementation of MEPDG/PMED.

1. The overall goal for adopting and implementing MEPDG/PMED. It was stated as "How do I use MEPDG/PMED to develop the optimal design?" There are multiple solutions for any location and the SHA needs to decide how they will select the optimal design. What items are important to the SHA and the users of the facility.
2. As sustainable pavements become more of an emphasis, SHAs need to decide how they will use MEPDG/PMED in sustainable pavement applications. Those applications may include designing longer-life pavements, reducing maintenance and rehabilitation activities, and consideration of the asset management requirement of life-cycle planning (LCP). Although MEPDG/PMED provides predicted IRI values that can be used for fuel consumption calculations, participants expressed concern with the accuracy of the predicted values.

Pavement Type Applications and Determination

For MEPDG/PMED implementation, the consensus of the participants was that SHAs should concentrate on the application of new construction and reconstruction. For rehabilitation, resurfacing, and preservation activities, MEPDG/PMED implementation is complicated. The ability to characterize the underlying material, even with a full forensics study, made modeling for rehabilitation, resurfacing, and preservation difficult. These difficulties included:

- Variability in thickness and cross-section.
- Location of damaged layers (stripping of asphalt, D-cracking, etc.).

Most SHAs are required to develop equivalent designs that are used in their pavement type determination process or used for alternative bidding purposes. SHAs will need to determine their definition of equivalent designs using a MEPDG/PMED approach. Potential approaches suggested by participants included:

- Use the AASHTO *MEPDG Manual of Practice* (MOP) recommended failure criteria and equal reliability. The MOP has guidance on this issue.
- Design the pavement based on equal pavement foundations.
- Design based on what is important in your SHA and what can be controlled. For example, is faulting a critical distress, or does the dowel size adequately control concrete pavement faulting. Fatigue cracking may be critical for both pavement types.
- Design thicknesses need to be competitive.
- Compare designs with long, similar lives
- Use the PMED output to inform LCCA schedules and use the LCCA results over a long time period (e.g., 50 years) to determine equivalent designs.

The Missouri DOT noted that the alternate design/alternate bid (ADAB) approach was the reason for the quick implementation of MEPDG/PMED. ADAB has also been used by the Indiana DOT and the Kentucky TC.

For performance periods, participants stated that a 20-year design period was a good starting point, but that a 30-year design may be more applicable for concrete pavements.

Participants recommended that SHAs adopting MEPDG/PMED steer away from the consideration of routine maintenance and user costs in the pavement type determination, as it made the procedure overly complex.

The use of MEPDG PMED in determining the timing and selection of treatment applications over the life of a pavement was discussed, but no recommendation was made for a SHA implementing MEPDG/PMED.

Hierarchical Input Level

Participants stated that designing a pavement using all level 1 inputs was unrealistic and not a reasonable approach for a SHA implementing MEPDG/PMED. Participants noted that they were unsure whether the use of higher-level inputs provided better pavement designs. Higher-level inputs required additional effort and expense with limited documented benefits. The participants recommended that new adopters strive for level 2 inputs if they can be obtained reasonably.

SHAs implementing MEPDG/PMED should determine the most sensitive inputs and concentrate on obtaining quality data for those inputs.

Reliability

Table 7.2 of the MEPDG MOP documents suggested minimum levels of reliability. Participants discussed the definition of reliability for PMED. The participating SHAs had different approaches to reliability and how it was linked to the performance criteria. There was discussion that the selection of the performance criteria may be more important than that of the reliability level. The Indiana DOT noted that its reliability selections were based on functional class.

The question was also raised about management's understanding of reliability. An implementing SHA should consider this in their process as they develop a reliability policy. Reliability is different from the AASHO 1972 to AASHTO 1993 to MEPDG/PMED. Users and management must understand that reliability encompasses durability, traffic projection error, material variability, and construction practices.

The participants recommended that adopters of MEPDG/PMED consider a balance of functional classification, construction acceptance practices, and risk when selecting reliability values. There was a strong recommendation for the minimum values in the MEPDG MOP.

Performance Criteria

Table 7.1 of the MEPDG MOP contains the design criteria or threshold values recommended for the performance criteria to use in the judging of the acceptability of a trial design. The Michigan DOT stated that its values are close to those shown in the MOP.

Participants noted that SHAs should ensure the performance criteria policy they adopt correlates with their PMS and its treatment triggers. SHAs should check on the alignment of their asset management, pavement management, and pavement design policies and practices. Participants noted that SHAs need to better account for variability when selecting performance criteria.

Participants were interested if the MEPDG MOP recommended performance criteria were related to the FHWA transportation performance management (TPM) items documented in 23 CFR 490 Subpart C.

The only common performance criterion between the two pavement types is IRI. The Indiana DOT noted that they use an IRI level of 130 to 140 in/mi as a similar functional performance level for both pavement types.

The participants recommended that new SHA adopters use Table 7.1 from the MOP as a starting point.

Key Takeaways

Participants noted the following items as key takeaways in developing policies as SHAs implement MEPDG/PMED:

- Do your homework on the background of issues and the consequences of the policies that are established.
- Do not set unreasonable expectations that will lead to implementation failure.
- Do give yourself a reasonable time for implementation so you can be successful.
- Do not let perfect get in the way of good as you are in the implementation process.

- Do use the default values in the MEPDG MOP as a starting point for value selection.
- Do not throw away AASHTO 1993.
- Include engineering judgment in your policies.
- Ensure that the pavement designers understand the SHA's construction practices regarding material variance and thickness tolerances for each layer.

Breakout Session 1B–Design Inputs

The purpose of this breakout session was to gather information on the development of design inputs (for both new pavements and rehabilitated pavements) that would be useful to a SHA that is implementing MEPDG/PMED. Topic areas included:

- Reliability levels for calibration.
- Accounting for variability in the inputs.
- Inputs levels.
- Materials characterization.
- Traffic.
- Climate.

Reliability Levels for Calibration

Section 2.2 of the AASHTO *Guide for Local Calibration* states that a reliability level of 50 percent should always be used for predicting distresses to confirm or adjust the location calibration coefficients. Although considered to be more of a policy question, most participants seemed to subscribe to this approach, but a couple of alternative ideas were offered. In the case of the latter, one individual indicated that success was had in matching predicted with actual performance by picking the right reliability level. Another offering was that "if you design at 95 percent, why not calibrate at 95 percent as a way of getting a better estimate." It was noted that the 50 percent reliability given in the MOP is guidance, not policy and that any value can be used. Virginia DOT pointed out that reliability levels greater than 50 percent account for the variability and thereby reflect a safety factor. This sentiment was echoed by another and it was noted that reliability isn't something that is modeled.

Accounting for Variability in the Inputs

Participants agreed that while inputs are often based on averages, it is important to know the variability. Evaluation of historical information includes a broad assessment with variability and SHAs can use construction documents for the most critical inputs. Kentucky TC shared that while they have average and standard deviation data, they don't use the latter in design yet. Nonetheless, incorporating something like an "average minus standard deviation" approach may be needed.

Variability was viewed as a bigger issue for rehabilitation design than new design (i.e., there's greater variability for what's in place than what is produced). Iowa DOT tries to narrow projects down to uniform sections to reduce variability. Kentucky TC conducts ground penetrating radar (GPR) testing prior to falling weight deflectometer (FWD) testing and segments projects by thicknesses. This gives good results. New Jersey DOT also performs FWD testing and backcalculation, and while they generally use average backcalculated modulus values, they sometimes use values that capture the 80th percentile. New Jersey DOT also conducts segmentation; they frequently see high levels of variability along a mile stretch of road and across lanes (due partly to pavement type and/or cross-section changes). Michigan DOT indicated that the variability associated with the characterization of existing pavements is extremely complex and that there is a need to look at more practical, simpler approaches.

Inputs Levels

MEPDG/PMED includes many different input parameters, for which different hierarchical input levels can be used based on the sources and accuracy of the data. Level 1 inputs are typically used with design-build projects while designs for other projects generally include a mix of design input levels. This discussion centered on the input levels being used by SHAs.

Kentucky TC indicated they have developed level 1 inputs for HMA mixes but can't always apply them, so they average the mixes and levels 1 and 2 when needed. New Jersey DOT also described mixing and matching the input levels and noted that the ability to do so is a good feature of MEPDG/PMED. Other noteworthy comments included:

- Critical inputs are determined by sensitivity analysis.
- Some inputs are more critical than others, and those inputs need to have the best data.
- Users have to use what they have, which sometimes means compromising on input level.

Materials Characterization

Participants discussed the characterization of pavement material for MEPDG/PMED. The discussion began with asphalt mix properties and proceeded into unbound base/subbase layer and subgrade soil properties, based on FWD and other forms of testing.

Virginia DOT reported that they characterized one mix type for each asphalt layer (e.g., one asphalt surface mix, one asphalt base mix) on a statewide basis. They didn't look at contractor-specific mix characterizations. North Carolina DOT picked the most common mix in each of the three regions to develop input properties for MEPDG/PMED. Georgia DOT focused on four mixes from two contractors and expanded the numbers when they went to polymer binders.

New Jersey DOT, Kentucky TC, Michigan DOT, and North Carolina DOT indicated they conduct FWD testing, while Georgia DOT does not. Michigan DOT added that they have conducted laboratory testing and are looking into in situ (non-destructive) testing and evaluation to characterize material properties. Michigan DOT has resilient modulus (M_r) ranges for subgrade (based on past research) and uses an effective M_r (no adjustment for seasonal variation is made). Kentucky TC runs project-level M_r and California Bearing Ratio (CBR) laboratory tests for these types of materials as part of their geotechnical investigations. Kentucky TC uses an average M_r based on a soaked CBR (M_r = 1500 x CBR), but because the correlation between the two parameters is not the best, they also look at the M_r from FWD testing. Virginia DOT uses subgrade soil classification based on historical data by location. New Jersey DOT conducts FWD testing and Dynamic Cone Penetrometer (DCP) testing on all resurfacing projects. They use backcalculated M_r, CBR, and soil class to develop the design input for MEPDG/PMED and apply seasonal adjustments. North Carolina DOT uses values provided in the NCHRP 9-23B study conducted by Dr. Claudia Zapata (for their approaching new calibration, they are not sure what they will use). Wisconsin DOT is planning to use the laboratory resilient modulus values that are estimated for various WI soils when implemented.

Traffic

Traffic inputs were briefly discussed by the participants. Virginia DOT reported using cluster analysis by functional classification, along with site-specific average annual daily truck traffic (AADTT) data. North Carolina DOT has observed different axle distributions for I-95 versus the rest of the state's highways. Wisconsin DOT shared that they are comfortable with their traffic data and are using the most updated WIM data in their ongoing calibrations. Finally, one participant noted that the default traffic values in PMED are based on higher volume roads; thus, they wouldn't apply to low volume roads.

Climate

Climate data discussion centered around the data sources available for use in PMED v3.0 and what data source to use for calibration. For the latter, it is highly recommended that SHAs calibrate the MEPDG/PMED models and conduct designs using the same climatic database (e.g., calibrate using MERRA, design using MERRA). Michigan DOT would prefer to use North American Regional Reanalysis (NARR) data for both flexible and rigid pavement design, rather than MERRA-2 which will become an option for rigid in PMED v3.0. Though it was initially stated that PMED v3.0 will only allow the use of MERRA data, a correction was made indicating that users can choose any of the climate data sources (ground-based weather stations, NARR, MERRA, and MERRA-2) in PMED v3.0.

Key Takeaways

Key takeaways from the design inputs breakout session included the following:

- Variability is an essential consideration in the development of inputs for MEPDG/PMED. Reliability helps account for variability by serving as a safety factor.
- Rehabilitation design can be expected to entail much greater variability than new design.
- With the possible exception of design-build projects, a combination of hierarchical input levels for the various design inputs can be expected for most projects. The desired strategy is to use the highest possible input level for the most critical/sensitive inputs.
- SHAs have different approaches to developing MEPDG/PMED design inputs; some use history information and others use a gamut of testing to generate the best possible inputs.
- Climate data can have a significant impact on predicted pavement performance. When calibrating performance models, SHAs should use the same climate source data as what they will use for design. PMED v3.0 will allow users the ability to select any of the climate datasets.

Breakout Session 2A–Verification, Calibration, and Validation

The AASHTO *Guide for Local Calibration* provided the procedures and guidance needed to analyze the appropriateness of the global MEPDG/PMED models for a given location and, if needed, to develop locally calibrated and validated models. The purpose of this breakout session was to collect information on the verification, calibration, and validation process, which could be useful to SHAs that are implementing MEPDG/PMED. Topic areas included:

- Calibration planning (selection of sites and data considerations).
- Calibration analyses.
- Implementation.

Calibration Planning (Selection of Sites and Data Considerations)

Participants were asked how pavement calibration sites are selected and what some of the key data considerations are. It was pointed out that while all SHA's have pavement performance data, there are many challenges with identifying pavement sites for the calibration study and obtaining sufficient good-quality data for analysis. Michigan State University stated that any sites that have received maintenance treatments should be removed from consideration and that the sites should have at least 3 years of time-series condition/performance data (preferably 5) for quantifiable trends. Significant jumps or drops in condition from one year to the next should be looked at closely, as they could indicate premature distress development, undocumented treatments, or equipment measurement issues. Michigan participants also described the challenge of having no initial IRI data for some calibration sections and how they backcasted IRI measurements to get an initial IRI that was consistent with the ride specification in effect at the time. For concrete pavements, it was advised that faulting data associated with cracks should be removed from the calibration dataset, so those data don't bias the joint faulting data. Virginia DOT reported on how they reviewed IRI and cracking data for a given site, and if significant and unexplainable changes occurred over time, it was removed from the calibration. Utah DOT indicated that, while they have good pavement management data, they have had challenges with obtaining and reviewing scanned construction plans containing additional design input data. Lastly, North Carolina DOT noted the challenges of converting PMS distress data to the condition characteristics used in the MEPDG/PMED model development.

On the topic of site selection for calibration analyses, participants typically targeted and used PMS sections over LTPP sections. Specially constructed calibration sections did not appear to be common but were considered preferable by some. The Missouri DOT described the development of an initial "wish-list" experimental matrix and the subsequent reduction of the matrix the further they got into the site selection process. Automated pavement condition data were not particularly useful in Missouri DOT's first calibration but proved more valuable in their second calibration. North Carolina DOT reported using both LTPP sections and PMS sections for calibration. Their first cut of sites was based on pavement constructed within a certain timeframe. Virginia DOT identified calibration sites in each of its districts and used quality performance data from their automated pavement condition surveys. They followed the AASHTO *Local Calibration Guide* and focused on identifying six sites (consisting of different bases and different AC thicknesses) from each district. For calibration of new and reconstruction designs, they assumed that all low-severity cracking was top-down and that medium- and high-severity cracking was bottom-up cracking. Because they were unable to calibrate the IRI model, this parameter is not used as a performance criterion. Wisconsin DOT selected regional calibration sites using PMS sections (49 flexible and 29 rigid sections). Wisconsin DOT focused on getting an appropriate distribution of sites across all five regions and used stationary WIM data when available; otherwise, they used traffic data from the cluster analysis, with consideration of the prominent features such as AADT, truck percent, roadway functional class, and urban/area zone for each specific project. Michigan DOT focused on finding an equal number of sites in each of their regions when developing their experimental matrix. In 2020 and 2021, Michigan DOT identified eight additional sites for obtaining, testing, and quantifying materials. They will use these eight sites to add to their material library for future verification of MEPDG/PMED.

Calibration Analyses

On the topic of calibration analyses, most SHAs reported contracting this work out to consultants/universities, while at least one SHA performed this task in-house. Michigan State University reported using the CAT tool for calibrating rutting and faulting models but using other tools for the other performance models. Michigan State University strongly suggested identifying the calibration coefficients that have the highest impact on performance prediction and adjusting those coefficients accordingly. They also discussed an issue encountered involving a long run-time for the CAT tool, possibly tied to the cloud and host-server limitations. This issue is expected to get better with the release of PMED v3.0.

Several SHA's agreed that the first calibration effort could be difficult and time-consuming; however, future recalibrations are much easier once the database is generated. The expected time for completing a calibration study can vary, but it generally can be done quicker in-house than via a contract; however, in-house calibration will likely require shifting staff from other work activities.

Michigan participants advised using the global or local calibration results that give the least bias and the lowest standard error, and then backing it up with a reasonableness check (i.e., if the best calibration gives unreasonable results, then don't use it and consider alternatives). There was considerable interest among the participants in having a continuously updated summary of readily available calibration coefficients that SHAs have developed and are using.

Implementation

As the final discussion item for the breakout session, SHAs were asked what the status of implementationimplementation status is in their agency. Below is a summary of the responses.

- Georgia DOT: Plans on calibrating soon using PMED v3.0.
- Idaho TD: Currently using PMED v2.6 and will evaluate implementing PMED v3.0 in 2022.
- Indiana DOT: Currently using PMED v2.3 and is currently conducting a calibration using PMED v2.6. Completion of this calibration is expected in 2022. The agency will then determine whether to implement PMED v3.0.
- Iowa DOT: Currently working on calibration of PMED v2.6, with no decision on implementation of PMED v3.0.
- Kentucky TC: Using PMED v2.6 to update their internal design tool and will evaluate the implementation of PMED v3.0.
- Michigan DOT: Since they are calibrating to v2.6, they are not currently planning to implement PMED v3.0. However, they will continue to evaluate v3.0. Per their past experience with new versions and calibration cycles, they estimate that they will move to v3.0 (or newest web-based version) in about 5 years.
- Missouri DOT: Currently using PMED v2.6 and will evaluate/implement PMED v3.0.
- North Carolina DOT: Currently working on calibrating PMED v2.6 and will decide at a later date whether or not to implement PMED v3.0.
- Wisconsin DOT: Calibrating with PMED v3.0 and plan to implement PMED v3.0.
- Virginia DOT: Currently calibrating with PMED v2.6, with no decision on PMED v3.0 implementation.

In closing, it was pointed out by Michigan DOT that a SHA can move forward with using the global MEPDG/PMED models and see how the designs turn out in relation to their current procedure. This is a low-cost and easy first step, involving using everything right out of the box (i.e., PMED defaults).

Key Takeaways

Key takeaways from the verification, calibration, and validation breakout session included the following:

- Traffic data comes down to a choice between WIM or cluster data. The former may not be necessary.
- Backcasting time-series IRI data is one way of obtaining a missing initial IRI value, which can be an important factor in predicting performance.
- Important aspects of the site selection process for calibration studies include establishing an appropriate range of performance data, understanding that not all cells in the experimental design matrix will get filled, and identifying sites that have typical performance trends (i.e., removing sites with unique problems).
- The current CAT tool may have a run-time issue, but this issue should be mitigated with the release of PMED v3.0.
- Don't waste time trying to calibrate coefficients that don't have an effect.
- Be very aware of what each dataset represents and how to use them appropriately as part of PMED.
- The easiest and quickest way of getting SHAs to move forward with implementing MEPDG/PMED is to have them start using PMED with the global models immediately and compare the results with current procedures.

Breakout Session 2B–Application and Use

The purpose of this breakout session was to discuss the application and use of MEPDG/PMED by SHAs. Principal topics discussed included:

- Champion.
- Steering committee.
- Implementation plan.
- Industry involvement.
- Staffing (In-house versus out-sourced resources for implementation).
- Training.
- User manual.
- Concurrent designs.
- Input libraries.
- Catalog of designs.
- Key takeaways.

Champion

Participants mentioned that the use and importance of a champion for MEPDG/PMED implementation was dependent on the organizational structure of the SHA and where pavement design is located in that structure. Structural considerations include the power and budget of pavement design and its ability to drive research projects. Successful implementation of MEPDG/PMED requires the support of the materials, traffic, and research sections of the SHA.

Participants noted that the champion needs to be in the central office. The role of the champion is more difficult if decentralized pavement design is planned. An item to consider if decentralized pavement design is planned is will the central office review and approve pavement designs? Kentucky TC noted that designs are performed in the districts but approved by the central office.

Participants stated that upper management's role is one of support for resources and dealing with industry and other inquiries on the process. The Georgia DOT noted that they had difficulty getting research support so engaging upper management was important. The Iowa DOT stated they had engaged with management early on to gain funding and support.

Steering Committee

SHAs mentioned that a wide variety of inputs are necessary for the successful implementation of MEPDG/PMED. Steering committees may include representatives from various sections in a SHA, since many of them will also be called upon for resources during the implementation. Steering committees allow the other sections to have a clearer understanding of the data needs of the MEPDG/PMED processes. Typical steering committees included representatives from the following sections:

- Materials.
- Design.
- Research.
- Traffic.
- Construction.
- Pavement management.
- Geotechnical.
- Districts if the SHA plans on using decentralized design.

The Indiana DOT noted that they had a long-standing pavement committee that dealt with various issues. MEPDG/PMED implementation became the responsibility of a subset of its pavement committee. The New Jersey DOT stated that its steering committee is more pavement-focused and does not include a broad representation.

Many pavement designers are heavily involved in the production of projects and have limited time for managing research projects.

Implementation Plan

Most of the SHAs participating in the breakout group did not have a formal, written implementation plan when they implemented MEPDG/PMED, but they can see its value. Participants stated that any plan developed needed to be flexible as there will be changes in organization, staffing, materials, and other practices that will need to be addressed during implementation.

Participants noted that the implementation plan needs to address how MEPDG/PMED is going to be applied (new construction, rehabilitation, use of catalogs, use of consultants, etc.).

Additionally, it was stated that the use of innovative materials and MEPDG/PMED should be addressed in the implementation plan.

Kentucky TC noted that it intended to go from the AASHTO 1993 and a spreadsheet to a catalog based on MEPDG/PMED. Only a handful of individuals in Kentucky TC run the PMED software. Kentucky TC had used a catalog approach previously and was happy with it.

Industry Involvement

Participants stated that the support of industry was necessary for the successful implementation of MEPDG/PMED. They suggested having ongoing discussions with the industry, starting with the initial results of calibration. The industry does not like sudden changes, especially those that may affect the division of dollars between the two industries. The industry is not as interested in absolute thickness as they are in a competitive balance and total dollars, so that should be kept in mind when briefing the industry representatives.

Life-cycle cost analysis (LCCA) may also change with different maintenance treatment cycles. MEPDG/PMED may be used to recommend maintenance treatment timings based on predicted distress.

Staffing (In-house versus out-sourced resources)

Although most participants had used outside resources (either universities or consultants) in the implementation of MEPDG/PMED, they noted difficulties with this approach. Expertise in MEPDG/PMED is difficult to find and many universities and consultants do not have a PMED license. One industry participant noted that finding a knowledgeable consultant to assist with small projects is especially troublesome.

Training

For SHAs implementing MEPDG/PMED, training generally included:

- General background on mechanistic-empirical pavement design principles.
- Overview of PMED design methodology.
- Design using PMED software.

Participants said that consultants who conduct pavement designs for the SHA need to receive MEPDG/PMED training as well as SHA staff. Most of the SHAs in the breakout used consultants for pavement design due to staffing restrictions. SHAs need to be aware that consultants have staff turnover, so training is a continual process.

SHAs noted that peer exchanges and design assistance programs were useful for continued implementation and problem-solving. The Indiana DOT drew a parallel to Superpave implementation and suggested that it be used as a model for MEPDG/PMED implementation.

AASHTO Service Units are available for SHAs to use for training.

User Manual

A user manual is typically a product of the initial implementation effort by a SHA. Typical topics covered in a user manual include:

- General information.
- Performance criteria.
- Design reliability.
- Traffic inputs.
- Climate inputs.
- Structure and materials inputs.
- Rehabilitation inputs and designs.
- Performance outputs.
- Performing overlay designs.
- Example designs.

Participants advised that SHAs implementing MEPDG/PMED should not be overwhelmed with the number of inputs required. Service units are also available for assistance to SHAs in developing user manuals.

Concurrent Designs

Most SHA participants used concurrent (i.e., parallel) designs with their existing pavement design procedure during the implementation process. They did say that when comparing the results, both are pavement designs, but they are not necessarily the same.

Input Libraries

Most SHA participants said they had developed input libraries for PMED for materials, traffic, and climate inputs. It was stated that MEPDG/PMED requires additional testing beyond what SHAs use for acceptance. Some items noted by the participants were:

- Georgia DOT stated that libraries are a necessity for designers and reviewers to maintain their sanity.
- New Jersey DOT noted that its libraries are used by both in-house staff and the consultants that perform pavement designs.
- SHAs observed that the libraries might need to include consideration of design-build projects.
- Industry representatives stated that the libraries should make allowances for the use of innovative materials. New Jersey DOT added that they update their library annually to include new material information based on research and implementation efforts.

Catalog of Designs

Pavement design catalogs are useful for initial designs for project development, by local agencies, and on low-volume projects. Key discussion points on catalogs included:

- Kentucky TC uses a catalog that was developed with PMED v2.6. They are presently looking at updating the material properties and software version to produce a new catalog of designs.
- Georgia DOT has a spreadsheet that was developed from PMED and is used for designing projects with less than 10,000 AADT. This decision was driven by limited access to the software and training.

- Indiana DOT uses a catalog for small projects (e.g., approach pavements for bridge replacements) using three different traffic levels. The catalog relieved stress on the pavement design staff.
- Iowa DOT has used a catalog in the past for smaller projects but has not developed one using the MEPDG/PMED approach.
- New Jersey DOT has standardized sections for simple projects.

Participants recommended that SHAs adopting MEPDG/PMED should consider a hybrid approach with a catalog for simpler designs on smaller projects while relying on a detailed analysis for more complex projects. Rehabilitation and resurfacing should also be a consideration for catalogs.

Key Takeaways

Key takeaways noted by participants included:

- Traffic is a key and sensitive input, so SHAs should ensure they expend adequate effort to provide the best data. Traffic needs to understand the critical role its data plays in the success of MEPDG/PMED implementation.
- SHAs need a true "simple performance test" for asphalt materials that describes their performance under traffic. This missing test is a barrier to level 1 implementation. Most of the cracking tests are index tests.
- Concentrate on implementation for new and reconstruction and then move to overlay design.
- Do not let yourself be overwhelmed with the volume of inputs required for MEPDG/PMED.
- Use concurrent/parallel designs to build confidence in MEPDG/PMED implementation.

Closing Session

A summary of items discussed during the closing session included:

- Workshop minutes are to be developed and distributed to FHWA and participants for review and comment.
- Implementation RoadMap Report to be developed containing information and findings from the workshop, as well as proven practices for expediting and streamlining MEPDG/PMED implementation.