# FHWA PAVEMENT ME USER GROUP MEETINGS

**Seventh Annual National Meeting of the AASHTO Pavement ME User Group (PMEUG)**

***Technical Report***

November 1-3, 2022
Salt Lake City, UT

**https://www.pooledfund.org/Details/Study/549**

## Meeting Highlights and Key Takeaways

**Attendance**

- A total of 78 attendees participated in the seventh PMEUG meeting, representing FHWA, AASHTO, 26 state highway agencies, two Canadian provincial highway agencies, nine consulting firms, six universities, and three industry groups.

**Agency Report-Outs**

- Among the 26 reporting agencies, the PMED software version usage is as follows:
  - v1.0: 1 agency.
  - v2.1: 1 agency.
  - v2.2.6: 2 agencies.
  - v2.3: 2 agencies.
  - v2.3.1: 2 agencies.
  - v2.5: 2 agencies.
  - v2.5.3: 1 agency.
  - v2.5.5: 1 agency.
  - v2.6: 4 agencies, with 5 agencies evaluating or in process of using.
  - v2.6.1: 3 agencies.
  - v3.0: 8 agencies with plans to implement in the future.
  - Unspecified: 3 agencies.
- Agencies continue to work toward implementation by conducting material characterization, climate data characterization, model calibration or re-calibration, and updating agency PMED manuals.

**AASHTO and PMED Software Updates**

- PMED v3.0, the web-based application, was released on July 1, 2022. This version includes the NCHRP 1-51 concrete slab interface friction model, the globally recalibrated rigid pavement models, and MERRA climate data for rigid pavement design.
- FY23 planned enhancements for v3.0 include climate model adjustments for very cold regions and a new design strategy that allows for the design of 2$^{nd}$ or 3$^{rd}$ overlays of flexible and rigid pavements.
- FY24 planned enhancements for v3.0 include the addition of damaged dynamic modulus charts to the user interface, the integration of the Multiple-Stress Creep Recovery (MSCR) test, and the addition of the NCHRP 1-59 shrink/swell and frost-heave tool.

## Meeting Highlights and Key Takeaways (continued)

**Open Forum Discussion—Implementation/Adoption of MEPDG/PMED**

- Given a disconnect between the collected data for PMED distress prediction and how pavement management data are collected and used, some agencies have changed their pavement management data collection procedures or have converted their collected data to match PMED definitions.
- There is a desire among some agencies to strongly link pavement management, pavement design, and life-cycle cost analysis (LCCA).
- AASHTO plans to conduct a survey of highway agencies regarding the pavement performance measures that are being used and how they are being used. A solicitation of similar information will be made of pavement condition data collection vendors.

**PMED Software Training**

- Three training topics were presented in the meeting, consisting of:
    - Topic 1: PMED Models and Calculations for HMA (Rutting & IRI) – Linda Pierce (NCE).
    - Topic 2: PMED Models and Calculations for PCC (Joint Faulting & IRI) – Julie Vandenbossche (University of Pittsburgh).
    - Topic 3: Pavement ME Intermediate Files for Structural Response – Harold Von Quintus (ARA).

**PMEUG Future Events**

- Two PMED software training webinars are being planned for 2023—one in the spring and the other in the summer. The first one will feature a detailed presentation of the Implementation RoadMap workshop and the RoadMap report. The second one will cover a topic yet to be determined.
- The 2023 PMEUG meeting will be held September 6-7 in Madison, WI. The meeting will be organized and conducted by AASHTO.

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.

## TUESDAY, NOVEMBER 1

### 1. Call to Order, Introductions, and Meeting Agenda and Goals – Dr. Linda Pierce NCE)

Linda Pierce called the meeting to order at 8:00 a.m. Mountain Standard Time (MST) and formally welcomed everyone to the 7th annual meeting of the American Association of State Highway and Transportation Officials (AASHTO) Pavement ME User Group (PMEUG) (see Attachment 1 for a complete list of attendees). She introduced other members of the project team, including Kelly Smith with Applied Pavement Technology, Inc. (APTech) and Julie Vandenbossche with the University of Pittsburgh, and referenced the vital role of the Transportation Pooled Fund (TPF)-5(305) study (*Regional and National Implementation and Coordination of ME Design*) in the conduct of the annual meetings. After discussing the meeting agenda (see Attachment 2), she and Kelly reviewed the meeting protocols and stressed the importance of audience participation. Copies of all meeting presentation materials can be found in a separate Attachment 3.

### 2. FHWA Welcome – Dr. Jennifer Albert (FHWA)

Jennifer Albert welcomed everyone to the annual meeting and expressed her excitement for the return to in-person meetings. She strongly encouraged attendees to engage, participate, and ask questions to help achieve a successful meeting outcome. Jennifer noted that this was the final year for the PMEUG meetings contract and the TPF-5(305) website and that the responsibility for future meetings would be assumed by AASHTO. She indicated that the technical report covering this meeting would be posted on the TPF-5(305) website, along with all past meeting reports and other PMEUG event materials.

Jennifer also briefed the participants on FHWA's effort to update its Pavement Design Policy. Based on stakeholder outreach meetings conducted in 2019, the FHWA has developed proposed language for updating the Federal rule (23 CFR 626) and that language is currently under review by administrative staff and the chief council. Publication of the draft policy is anticipated in the spring of 2023. Following a review and feedback on the draft policy, it will be finalized and published.

### 3. AASHTO COMP and PMED Task Force Remarks – LaDonna Rowden (Illinois DOT) and Clark Morrison (North Carolina DOT)

LaDonna Rowden, Vice-Chair of Technical Subcommittee 5D (Pavement Design) of the AASHTO Committee on Materials and Pavements (COMP), provided a brief update on the subcommittee's activities related to five AASHTO documents. She indicated that an updated version of the 2008 *Guide for Pavement Friction* was balloted and approved by the COMP and that a second edition of the document was published and is now available at the AASHTO online store (https://store.transportation.org/). Updates to the 2010 *Guide for Local Calibration* and the 2015 *Pavement Design, Construction, and Management Digital Handbook* are being reviewed. A plan to make the Permeable Pavements Guide a separate document from the aforementioned handbook was approved and that Guide will be balloted by the COMP in 2023. Finally, a research problem statement for updating the 2012 *Guide to Pavement Management* was accepted and an RFP for updating the document will be issued in 2023.

Clark Morrison, Chair of the AASHTO PMED Task Force, briefly reported on the transition from PMED v2.6 to v3.0 and reiterated AASHTO's responsibility for organizing and conducting future PMEUG meetings. He also introduced the members of the current PMED Task Force and thanked them for their contributions.

## 4. Canadian Update – Felix Doucet (Quebec Ministry of Transportation)

Felix Doucet served as the Transportation Association of Canada (TAC) Liaison substitute this year and updated the participants on the activities of the TAC ME Pavement Design Subcommittee. He reviewed the committee structure, action items, and the role of the TAC liaison. Notable action items for 2022 included the development and delivery of two PMED papers at the TAC Annual Conference in October.

## 5. Agency Implementation Updates/Report-Outs – Designated Agency Speakers

This session of the meeting focused on state and provincial highway agency reporting of PMED implementation status. As in past meetings, Linda and Kelly requested that each designated agency speaker provide an update on their agency's implementation status. Speakers were also asked to touch on material characterization efforts (e.g., hot-mix asphalt [HMA] and portland cement concrete [PCC] properties), how PMED is being used (e.g., formal use on all projects or only select projects, sole use or parallel use with other design procedures) or not used, what the agency's future plans are for PMED use, what implementation-related activities have been going on, and what challenges and issues have been encountered.

A summary of the key aspects of PMED implementation as reported by the various agency speakers is provided in the table below. In addition, the information presented by the speakers was used to update the PMED implementation maps. These maps are shown in the figures following the table.

| State/ Province | HMA Character-ization | PCC Character-ization | Unbound Layer & Subgrade Soil Characterization | Local Calibration | Parallel Design | Implementation | Current PMD Version | User Guide/ Design Manual |
|---|---|---|---|---|---|---|---|---|
| AL | Developed database for Level 1 & 2; conducted local verification and asphalt mix characterization (2019) | Developing database | Subgrade soils completed; study on limestone bases | Adding calibration sites, sensitivity analysis, local calibration of asphalt (Nov 2022) | Conducting design comparisons with AASHTO 1993 | Trained field personnel; use AASHTO 1993 | N/A | N/A |
| AK (no 2022 update) | Ongoing dynamic modulus University studies | N/A | Ongoing studies | N/A | N/A | No plans | N/A | Alaska Flexible Pavement Design Manual |
| AB (no 2022 update) | Level 1 and 2 inputs (150 road segments) | N/A | Some testing | Working on site selection | Consultant designs (150 projects) | In progress | v2.6.1 | Pavement Design Manual |
| AZ | Completed | Completed | Completed | 2010-2012; use global calibration defaults; recalibration with v2.6 | 2012-current | 2019; parallel with AASHTO 1993 and AZDOT SODA method on select projects | v2.1 evaluating v2.6 | Pavement Design Manual; update with v2.6 |
| AR (no 2022 update) | Completed | — | Completed | Asphalt only | AASHTO 1993 | Planning to implement | — | In progress |

| State/ Province | HMA Character-ization | PCC Character-ization | Unbound Layer & Subgrade Soil Characterization | Local Calibration | Parallel Design | Implementation | Current PMD Version | User Guide/ Design Manual |
|---|---|---|---|---|---|---|---|---|
| BC (no 2022 update) | N/A | N/A | N/A | No plans | N/A | No plans. Currently reviewing other agency efforts | — | N/A |
| CA (no 2022 update) | N/A | N/A | N/A | Global coefficients applicable to California conditions | N/A | 2008 jointed plain concrete (JPC) and continuously reinforced concrete (CRC) pavement only | — | Updating rigid pavement design catalog (Highway Design Manual, Chapter 620) |
| CO | Yes, including CIPR dynamic modulus; polymerized asphalt (2019) | — | — | 2010-2011; full calibration anticipated 2021 | 2012-2014 with AASHTO 1993 | 2014 | v2.3.1; plans to implement v2.6.2 in 2023 | ME Pavement Design Manual |
| CT (no 2022 update) | — | — | — | — | — | Planning to implement | — | — |
| DE (no 2022 update) | — | — | — | — | — | Planning to implement | — | — |
| FL (no 2022 update) | Rutting and top-down cracking; Texas A&M study for v2.6 | Constructed concrete pavement test road (52 sections) | — | Developing roadmap (complete 2023) | AASHTO 1993 for asphalt designs, evaluating v2.6 | Concrete only, AASHTO 93 for asphalt; TTI study for asphalt pavements with v2.6 | v2.2.6 | Rigid Pavement Design Manual |
| GA | Added polymer mix types | Finishing concrete properties soon | — | Initial calibration in 2015 (v2.2.3). Plan to use CAT for v2.6 calibration | Continuing comparison testing | Planning to implement; currently using AASHTO 72/81 | In progress v2.3.1; looking at v2.6, recalibration with v3.0 in 2023 | Yes |
| HI (no 2022 update) | Moving toward polymer-modified and SMA mixes | N/A | N/A | N/A | N/A | No plans | — | N/A |
| ID | Completed; noted issues | Completed | Completed | Initiated in 2012, 2018-19 completion | PMED consultant designs | 2020 | Noted issues with v2.5.3 calibration; moving to v3.0 | Updating Design Manual |
| IL | Updating asphalt materials | Updating CRC pavement | N/A | N/A | N/A | Use IDOT ME design method. Potentially will use PMED to develop CRC pavement design catalog | N/A | N/A |
| IN | Level 1 and 2 inputs | Level 1 and 2 inputs | Level 1 and 2 inputs | 2009/10; 2017 rutting models | — | 2010; approximately 500 designs per year | v2.3; calibrating v2.6, with plans to move to v3.0 | Design Manual Part 6, Chapter 601 |
| IA | Need creep compliance | Need additional CTE testing | Need better base and subgrade inputs | Completed (3rd calibration) for new construction | PCA as limiting criteria for concrete and lower value between PerRoad and PMED for asphalt pavements | Planning to implement; not using for asphalt overlay design | — | — |

| State/ Province | HMA Character-ization | PCC Character-ization | Unbound Layer & Subgrade Soil Characterization | Local Calibration | Parallel Design | Implementation | Current PMD Version | User Guide/ Design Manual |
|---|---|---|---|---|---|---|---|---|
| KS | Completed | Completed | On-going, base stabilization | Completed (2nd calibration); pooled fund study with NYSDOT for overlays | AASHTO 1993 | Yes, but conducting parallel designs while reassessing procedure | v2.6.1 for new designs | Planning to develop internal document |
| KY | Limited dynamic modulus testing | No | — | Verification using v2.3 and v2.5 | — | HMA, concrete 2019 (online design catalog based on v2.5) for new, reconstruction, and limited widening designs | v2.6 for asphalt overlays | Pavement Design and website access; plan to implement v3.0, and update tool to include rehabilitation |
| LA | Completed | Completed | Completed | v2.3 for both asphalt and concrete; using CAP tool; local calibration issues with v2.3 and new construction designs | AASHTO 1993 | Yes, but conducting parallel designs | In process v2.6.1 | Pavement Design Guide |
| ME (no 2022 update) | In progress | No | Yes, working on subbase data | v2.6 | AASHTO 1993 & PMED with global coefficients | HMA only; but have concerns with moving forward | v2.6 | — |
| MB | Completed | — | Level 1 for base and subgrade, Level 3 for subbase | Collecting data on 30 sites | AASHTO 1993 (selected projects) | Use for new and reconstruction concrete designs | v2.6; one license for v3.0 | Updating User Manual |
| MD | Completed | — | Completed | Local calibration for asphalt new and asphalt overlays (v2.6); no plans to calibrate concrete (< 3% of network) | AASHTO 1993 & PMED with national models | Planning to implement. On hold for funding reasons | — | Updating Pavement & Geotech Design Guide |
| MA (no 2022 update) | — | — | — | — | — | Planning to implement | — | — |
| MI | Completed (Level 1) | — | Completed. Ongoing 2023 research for subgrade stabilization | 1st effort in 2014; 3rd effort scheduled for completion in mid-2023 | Use AASHTO 1993; ±1 inch deviation with PMED for new and re-construction; AASHTO 1993 for overlays | Originally 2014; on hiatus 2015-2018; all reconstruction projects 2019 | Currently v2.3. Recalibrate with v2.6 in 2023; Interested in transitioning to v3.0 in the future | ME Pavement Design User Guide |
| MN (no 2022 update) | N/A | N/A | N/A | N/A | N/A | Use MnDOT ME design procedure | v1.1 for concrete | N/A |
| MS | On-going (69 LTPP field section); follow-up using SMA and polymer-modified mixes | — | Processing falling weight deflectometer (FWD) data for stabilized base and subgrade | In progress | — | Planning to implement in next 2 to 5 years | — | — |
| MO (no 2022 update) | Conducting recycled HMA characterization; additional Level 1 inputs | — | — | Initial calibration in 2009, 2nd calibration in 2019 | — | 2004 (national models) | v2.6.1 | — |

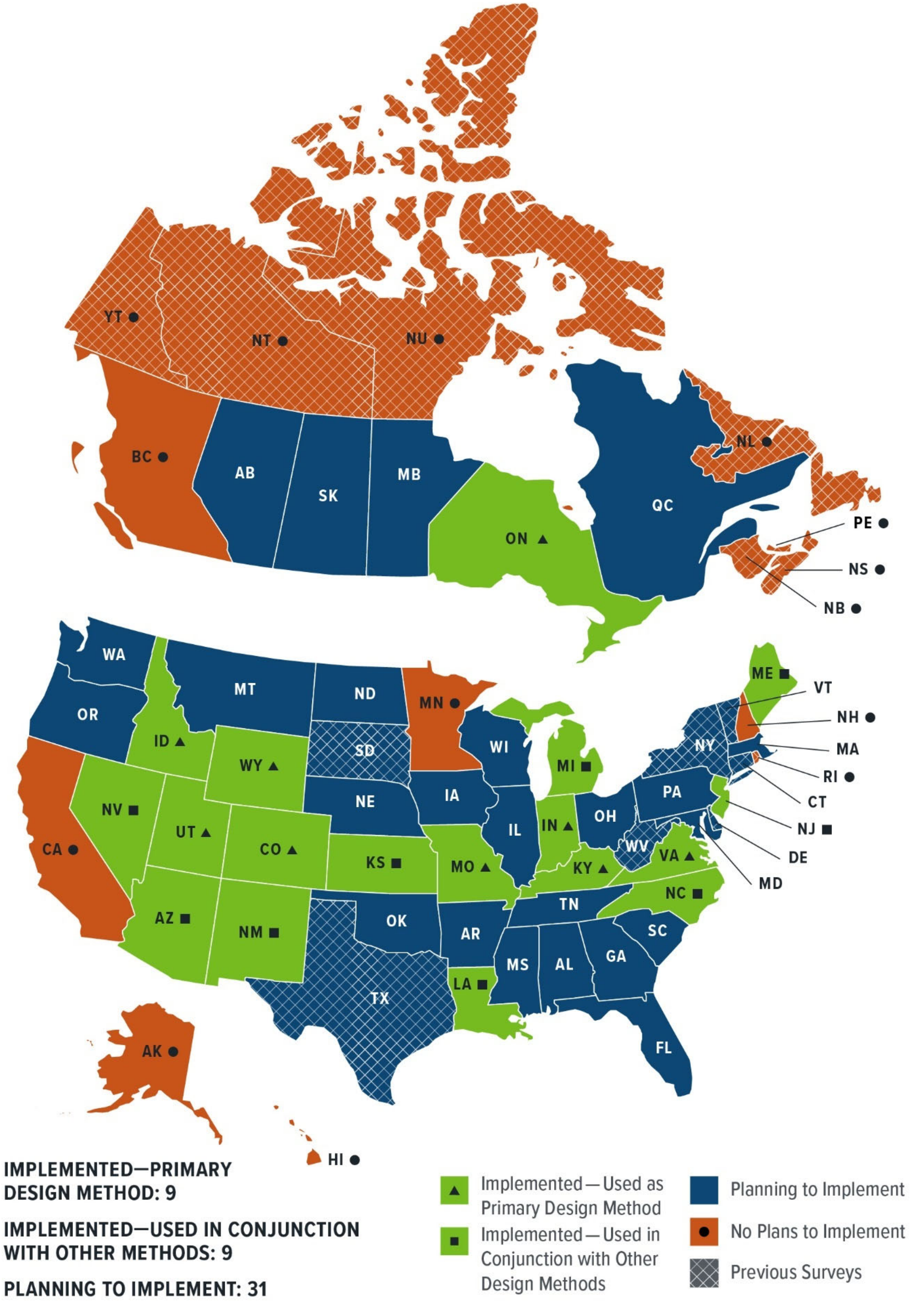
| State/ Province | HMA Character-ization | PCC Character-ization | Unbound Layer & Subgrade Soil Characterization | Local Calibration | Parallel Design | Implementation | Current PMD Version | User Guide/ Design Manual |
|---|---|---|---|---|---|---|---|---|
| MT | — | — | Using R-value for subgrade, but looking to go to resilient modulus | — | Using AASHTO 1993 | Looking at v3.0 | — | — |
| NE | — | — | Conducted FWD testing and coring in 2021 | Initiated 2019; use mostly global coefficients for asphalt and concrete | — | New concrete designs only | v2.6 | In progress |
| NV (no 2022 update) | Completed | Completed | Database (regional calibration) of unbound SWCC inputs | Asphalt reflective cracking model; national calibration values for concrete | AASHTO 1993 | 2015 | v2.3.1 | Updating ME Design Manual |
| NB (no 2022 update) | — | — | — | — | — | No plans | — | — |
| NH (no 2022 update) | — | — | — | — | AASHTO 1972 | No plans | — | — |
| NJ (no 2022 update) | Completed Level 1 | — | — | Flexible pavements only | AASHTO 1993 for resurfacing; using PMED as a cross check | Yes | v2.6.1 | Traffic User's Manual |
| NM (no 2022 update) | Yes | CTE study | — | asphalt only | AASHTO 1993 | 2019 | — | — |
| NY (no 2022 update) | — | — | — | — | — | Planning to implement | — | — |
| NL (no 2022 update) | — | — | — | — | — | No plans | — | — |
| NC | Completed | Completed | Yes | New calibration study for flexible designs completion in 2023 | Yes, use AASHTO 1993 with PMED shadow design | Yes, 2011-2015, currently using AASHTO 1993, but will re-implement PMED in future | — | — |
| ND | Working on HMA mix characterization | Yes | Yes | 2013-2014 concrete, asphalt recalibration with v2.5 release | AASHTO 1993 for asphalt rehabilitation, new PCC and PCC overlay designs | Yes, concrete (primarily default values, NDDOT CTE values); AASHTO 1993 for asphalt | v2.5.5 | — |
| NS (no 2022 update) | — | — | — | — | — | No plans | — | — |
| OH (no 2022 update) | — | — | — | 2009 LTPP sites resulted in over and under design comparisons; will recalibrate in 2022 | — | No specific plans. PMED sometimes used for major rehabilitation designs | — | — |
| OK (no 2022 update) | — | — | — | PCC only; asphalt underway | AASHTO 1993 | Planning to implement (AASHTO 1993 primarily used) | — | — |

| State/ Province | HMA Character-ization | PCC Character-ization | Unbound Layer & Subgrade Soil Characterization | Local Calibration | Parallel Design | Implementation | Current PMD Version | User Guide/ Design Manual |
|---|---|---|---|---|---|---|---|---|
| ON (no 2022 update) | Level 3 | Level 3 | Level 3; some subgrade characterization | v2.5.1 asphalt models (2015); verifying concrete models | Yes | Consultants required to use PMED as check for high-profile projects; agency use for forensic studies and project-specific designs | v2.6 | Updating Design Guide; developing step-by-step guide |
| OR (no 2022 update) | Completed | Completed | — | Poor validation results for asphalt pavements | — | CRC pavement designs | v2.5 | Yes |
| PA | Completed; includes SMA and RAP | Completed | Completed | 2017 asphalt and concrete (v2.3.1), 2018 review with v2.5; use local calibration coefficients for asphalt and concrete | Yes, AASHTO 1993 (for truck traffic > 500 vehicles) | Concern with quantifying frost heave, impact of CTE, and faulting; waiting for NCHRP 1-59 implementation; PITT-RIGID simplified version of PMED | v2.5; looking at v3.0 for concrete and rehabilitation | User Guide, Pavement Policy Manual |
| PE (no 2022 update) | — | — | — | — | — | No plans | — | — |
| QC | Completed | Completed | — | Year 1 of 2 gathering data on existing pavements and matching to pavement management system data; calibration with v3.0 | — | Use AASHTO 1993 along with frost heave model; use PMED on complex designs | — | — |
| RI (no 2022 update) | Conducting materials characterization | — | Conducting materials characterization | Regional effort | — | No plans | — | — |
| SK (no 2022 update) | Collected data will work with PMED | — | Collected data will work with PMED | — | — | Developing an implementation plan | v2.6 | — |
| SC | Completed | Completed | Aggregate base, cement treated/stabilized bases and subgrades | On-going study | AASHTO 1972 for lower volume routes | Developing design catalog | — | In-house pavement design catalog |
| SD (no 2022 update) | — | — | — | — | — | Research study to look at full-, partial, or no PMED implementation | — | — |
| TN (no 2022 update) | Completed 2013 | Completed 2013 | Completed 2013 | 2015 | AASHTO 1993 | Planning to implement by August 2021 | — | User Manual and Input Design Guide |
| TX (no 2022 update) | Completed | — | — | — | — | Considering asphalt models only | — | — |
| UT | Completed, working on top-down cracking, E* curves, and data library | Completed | Completed | Completed | No (PMED is only design method used) | 2010; new and reconstruction only | v2.6.1; plans to use v3.0 | Pavement Design Manual of Instruction |
| VT (no 2022 update) | Underway | — | Underway | National calibration values (2015) | AASHTO 1993 | Planning to implement | v2.5.4 | Draft |

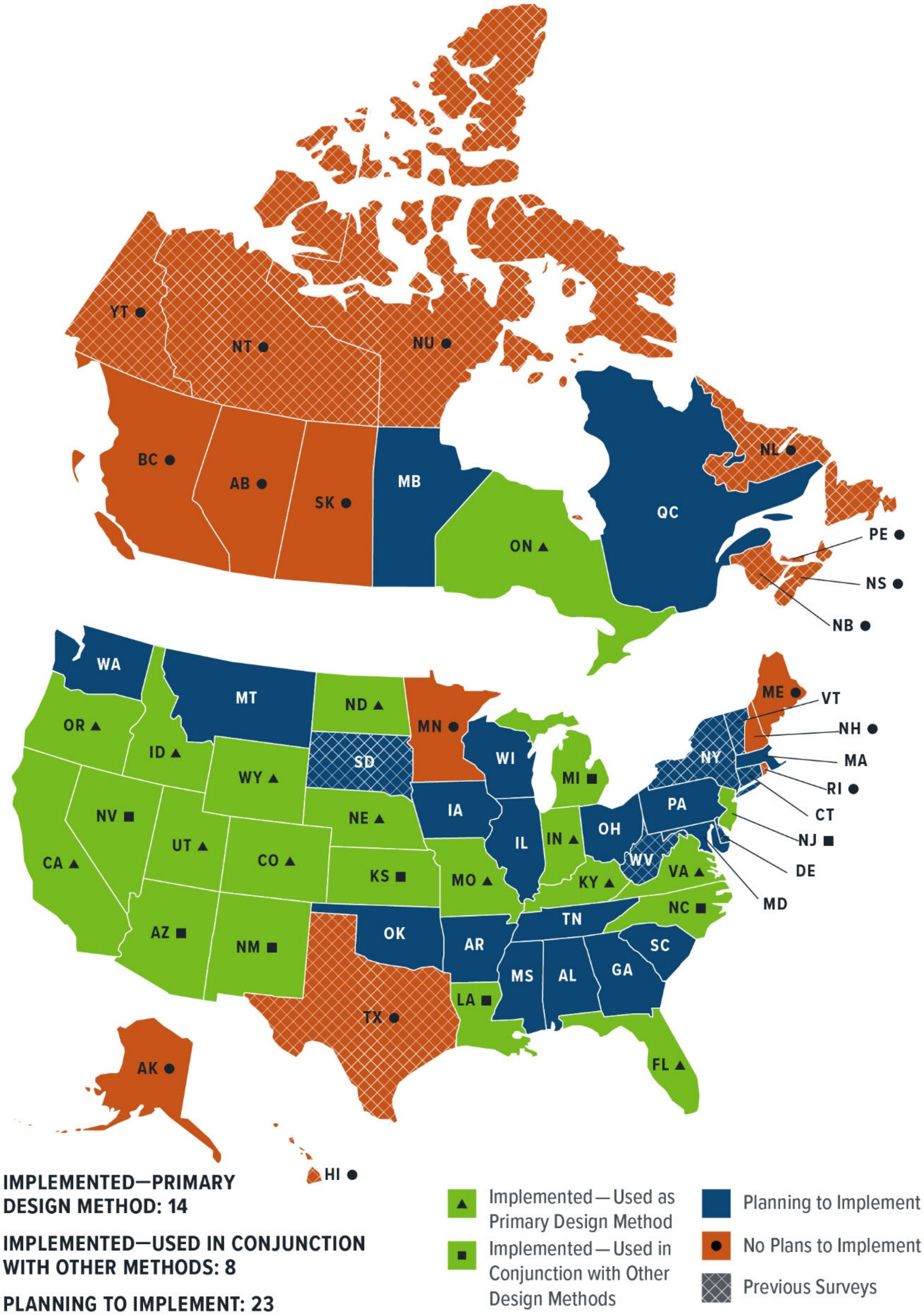
| State/ Province | HMA Character-ization | PCC Character-ization | Unbound Layer & Subgrade Soil Characterization | Local Calibration | Parallel Design | Implementation | Current PMD Version | User Guide/ Design Manual |
|---|---|---|---|---|---|---|---|---|
| VA | Level 1 | — | — | 2015 | — | 2018, new and reconstruction (for Interstate, primary, and secondary routes with AADT > 10,000) | v2.2.6; reviewing v2.6 and v3.0 | User Manual |
| WA | — | — | — | JPC pavement in 2005 and asphalt in 2008 | — | Design catalog updated in 2009; PMED used as a baseline | v1.0 | Pavement Design Policy |
| WV (no 2022 update) | — | — | — | — | — | Planning to implement | — | — |
| WI | Completed Level 1 | Updating Level 1 | Completed Level 1 | Initial calibration in 2014 using v2.1. Recalibration in progress with v3.0 | Future decision on using PMED or use in conjunction with AASHTO | Pilot implementation in 2016, inconsistent designs led to reverting back to AASHTO 1972 (WisPave 4) in 2017 | v3.0 to be used | Yes (updating when recalibration is complete) |
| WY | — | — | On-going study | 2012-2015 study, use local calibration coefficients; use pavement management data for local calibration in the coming years | — | Implemented in 2012; challenges with reclamation and cold in-place recycling (CIR) projects | v2.6 | — |

– No information available.
N/A: Not applicable.

## PMED Implementation Status (11/1/22)—Asphalt Pavements and/or Overlays



**PMED Implementation Status (11/1/22)—Concrete Pavements and/or Overlays**



## 6. AASHTO Briefing – Ryan Fragapane (AASHTO)

Ryan Fragapane gave a brief overview of the AASHTOWare program management, from the highest level (AASHTO Board of Directors) down to the lowest level (product and project task forces and user groups). He described the task force member appointment process and the corresponding terms of appointed members. He also reviewed the current PMED Task Force membership.

Ryan provided links to the AASHTOWare (https://www.aashtoware.org/products/pavement) and ARA (https://me-design.com/MEDesign/) and described the types of pertinent PMED information available on each site, including the PMEUG meeting and training webinar recordings and materials.

Ryan provided a summary of AASHTOWare PMED licenses and described *AASHTO's Training and Implementation Assistance* program. He reported on the *Executive Business Review* meetings conducted with two agencies in FY22 and noted that four more review meetings will be conducted in FY23 (both virtual and live). He gave a quick overview of PMED v3.0, which is a full web version that is fully integrated with the Long-Term Pavement Performance (LTPP) InfoPave Site for Modern-Era Retrospective analysis for Research and Applications (MERRA) climate data. He addressed the strategic direction of the design software, including the plan to release versions on 5-year cycles to allow agencies time to catch up on calibrations.

Lastly, Ryan stated that AASHTO will take over the User Group meetings starting in FY23. He asked the group to save the date for the next User Group meeting, which will take place in Madison, Wisconsin on September 6-7, 2023.

## 7. Software Updates and Enhancements – Chad Becker (ARA)

Chad Becker focused on the enhancements and updates made to the current version of PMED (v3.0, released in July 2022) and those planned for FY23 and FY24. Prior to discussing these updates, Chad provided information on current PMED usage statistics, which include 94 active agency accounts and an average usage rate of four users per day. Chad noted that various data analytics are planned that will be used to improve existing workflows and user interfaces.

Completed and planned enhancements of the PMED v3.0 software are summarized below.

PMED v3.0 Completed Enhancements

- Addition of an option for generating and displaying dynamic modulus charts and the creep compliance master curve chart.
- Inclusion of traffic user interface charts in output reports.
- Addition of axle load user interface updates for visualizing traffic data.
- Ability to edit the international roughness index (IRI) model standard deviation.
- Addition of links to the Help Manual and the *Mechanistic-Empirical Pavement Design Guide (MEPDG) Manual of Practice (MOP)* .pdf files.
- Inclusion of the equivalent single-axle load (ESAL) computation output in the .docx and .xlsx reports.

PMED v3.0 FY23 Planned Enhancements

- Inclusion of custom metadata module.
- Improvements to the report customization.
- PMED training videos (updating of the Principles of M-E Design Concepts for Pavement Design video series for consistency with the current *MEPDG MOP* and PMED software).
- Preparation of test procedures and protocols without an ASTM or AASHTO specification.
- Inclusion of a new design strategy to allow for design of 2$^{nd}$ or 3$^{rd}$ overlays of flexible and rigid pavements.
- Addition of a dynamic-modulus-to-creep-compliance conversion.
- Climate model adjustments for very cold regions.
- Addition of Library viewer component.

PMED v3.0 FY24 Planned Enhancements

- Improvements to the access and use of JULEA.
- Refactoring of the Enhanced Integrated Climatic Model (EICM) to improve maintainability and performance.
- Updated coding (C-sharp) of 30 different analysis modules to improve program maintainability and performance.
- Addition of damaged dynamic modulus charts to the user interface.
- Updated website (new location will be at www.pavementmedesign.com).
- Integration of Multiple-Stress Creep Recovery (MSCR) test.
- Addition of the NCHRP 1-59 shrink/swell and frost-heave tool.
- Inclusion of default material properties for CIR and full-depth reclamation (FDR) for asphalt designs.
- Incorporation of pulverized reclaimed asphalt pavement (RAP) as a sandwich layer for rehabilitation designs.

Other Updates

- The Calibration Assistance Tool (CAT) is now available for use in PMED v3.0. Users are advised to run designs in PMED first before analyzing them in the CAT tool.
- The Backcalculation Tool (BcT) will be made into a web-based application tool and will be fully integrated in PMED v3.0. It is expected to be available for use in July 2023 and the ME Task Force is looking for beta testers in the March/April timeframe.
- PMED future releases will consist of (1) minor updates every 2 weeks, which do not affect calibration or analysis results, and (2) major updates every 5 years which do affect calibration and analysis results (including NCHRP integrations).

*Comments/Questions: Mesbah Ahmed inquired about the ability to integrate past PMED files into PMED v3.0. Chad indicated that all design files are forward compatible. Asked by Pankaj Patel if PMED v3.0 allows for more than three asphalt concrete (AC) layers, Chad said no. Bruce Barrett inquired if there are issues with calibration in going from PMED v2.6 to v3.0. Chad responded that there are issues only on the concrete side; this is because the models for rigid design were globally recalibrated, the NCHRP 1-51 slab interface model was incorporated, and the climate data source was changed from NARR to MERRA. Larry Scofield asked if AASHTO has ever selected some sites and run designs using each PMED version to see how the results compared. Chad said no but suggested this should be an action item for the future.*

## 8. NCHRP Research Update – Linda Pierce (NCE)

Linda provided a brief overview of past, current, and future NCHRP research efforts pertaining to the MEPDG and PMED software. She noted several updates since the 2021 PMEUG meeting, including:

- Results from NCHRP Project 1-51 (*Incorporating Slab/Underlying Layer Interaction into the Concrete Pavement Analysis Procedures*) and NCHRP Project 20-50(21) (*Climatic Inputs and Related Models Using MERRA*) were incorporated into PMED in 2022.
- NCHRP released Synthesis 579, *Subsurface Drainage Practices in Pavement Design, Construction, and Maintenance*, in 2022.
- NCHRP Project 9-67 (*New Materials and Technology Deployment in Asphalt Pavement Structural Design*) has not been initiated yet.
- Although not directly related to PMED, a request for proposal (RFP) for NCHRP Project 1-62 (*Impact of Flooding and Inundation on the Resiliency of Pavements*) will be issued in 2023.

In total, NCHRP has supported PMED through research projects totaling more than $20 million over the last 25 years.

Lastly, Linda noted that Dr. Claudia Zapata (Arizona State University) was scheduled to provide a presentation to the group on NCHRP Project 1-59 (*Effects of Shrink/Swell and Frost Heave*).

## 9. FHWA Research Update – Tom Yu (FHWA)

Tom Yu described FHWA's Pavement Design Program vision, which is to lead the way in providing durable, long-life pavements. The FHWA supports this vision through the improvement of pavement design and construction practices, promoting transition to long-life pavements, providing resources for effective pavement rehabilitation, and enhancing resiliency of pavement structures. Tom provided an update on several FHWA efforts and projects, including:

- Pavement Foundation Design and Failure Mechanisms. A 1-day Technical Working Group (TWG) meeting was conducted on October 4, 2022 and will be the basis for a white paper on this topic.
- Two pavement design-related training courses are under development and are expected to be released in the latter half of 2023. Both are revivals of previous NHI courses.
    - Principles of ME Pavement Design.
    - HMA Pavement Evaluation and Rehabilitation.
- Composite Pavements Peer Exchanges.
- Permeable Pavements Tech Brief.

Tom noted that, as a follow-up to the five regional pavement design peer exchanges conducted in 2019, FHWA is looking to form a TWG on pavement design.

## 10. Effect of Subgrade, Granular Base, and Concrete Mix Properties on the PMED Predicted Distresses (Mr. Yasir Shah, Manitoba Transportation and Infrastructure)

Speaking on behalf of the Canadian TAC Pavement ME Design Subcommittee, Yasir Shah presented the results of the group's PMED software trials looking at the effects of subgrade materials (Trial #1), subbase/base materials (Trial #2), and PCC materials (Trial #3) on JPC pavement performance. Fixed inputs in all three trials included vehicle class distribution, slab length (4.5 m) and width (4.3 m), design life (25 years), initial smoothness (IRI=1.0 m/km), and design reliability (90 percent). Fixed inputs for each specific trial included traffic loading, JPC thickness, and dowel bar size. Variable inputs included subgrade material (five different untreated soils and a crushed rock subgrade) and climate for Trial #1; base material (five different stabilized and unbound base materials), subbase material (two different unbound granular materials), and base/subbase layer thickness for Trial #2; and concrete mix compressive strength, cementitious content, coefficient of thermal expansion (CTE), water/cement ratio, and density for Trial #3.

The PMED design runs were completed using v2.6, with some runs also completed using v3.0. Climatic inputs were obtained from eight different climate stations located throughout Canada. JPC thickness ranged from 150 to 250 mm, representative of Canada's low- to moderate-volume routes. Some key findings of the trials included the following:

Trial #1

- Stiffer subgrades resulted in higher predicted slab cracking.
- Use of a crushed rock subgrade resulted in decreased IRI.
- Predicted faulting was inconsistent.
- No effect on predicted transverse cracking was observed, regardless of climate and stiffness.
- Predicted transverse cracking with PMED v3.0 was lower than that with v2.6.

Trial #2

- Lower quality and thinner base/subbase materials resulted in higher predicted IRI and faulting.
- Inconsistent variation in predicted transverse cracking was observed among the base materials.
- PMED v3.0 provided unexpectedly high transverse cracking for treated base materials and, in general, it predicted reduced transverse cracking for weaker base materials.

Trial #3

- Increased cementitious content, CTE, w/c ratio, and lower density resulted in increased IRI and faulting.
- Increased compressive strength resulted in increased IRI (opposite of expectations).
- In general, no effect on predicted transverse cracking was observed. Only a CTE greater than 8.0 had an effect on transverse cracking and PMED v3.0 had a more pronounced effect compared to v2.6.
- The predicted transverse cracking varied with change in concrete mix properties using PMED v3.0

Overall

- In several of the trials, the 25-year design life was not achieved.
- In most of the trials, the predicted transverse slab cracking was low.
- In general, PMED v3.0 yielded a slightly higher IRI and a slightly lower level of faulting than v2.6. The predicted slab cracking was similar for the two PMED software versions.

In closing, Yasir indicated that upcoming trials will examine variations in concrete thickness, CTE, joint spacing, dowel bar sizes, and traffic loadings.

*Comments/Questions: Eric Ferrebee commented that the ACPA is experiencing challenges in getting a concrete design to work for IRI with an AASHTO A-7-6 soil. He asked if this is an issue in Canada. Yasir indicated that they are having trouble modeling weak subgrades and are experiencing heaving at the transverse joints due to frost susceptible soils. This results in higher IRI, which must be addressed through diamond grinding and panel replacements (at 7 and 15 years). Kumar Dave inquired about how CTE was measured. Yasir reported that the values were based on estimates and that there are plans to purchase CTE testing equipment in the coming year to better assess concrete mixes.*

## 11. Kentucky ME Design Catalog (Mr. Clark Graves, Kentucky Transportation Center)

In this presentation, Clark Graves discussed and demonstrated the Kentucky Transportation Cabinet's Online Pavement Policies and Design Program. He provided a brief overview of the history of the Department's pavement design procedure, which has long been based on mechanistic analysis and field experience and was first instituted in design catalog form in MS Excel in 1999. He explained the need in recent years for an updated design catalog program that is both web-based and PMED-based and that retains a certain degree of consistency in processes as the previous program.

Clark described the scope of the program development in terms of the pavement types, layer types and thicknesses, subgrade strengths, and traffic levels that were included, as well as the performance thresholds that were used in conducting thousands of PMED v2.3 design runs and transforming the results into a design catalog. He noted that PMED model calibration/ verification was done using surrounding states' calibration factors and Kentucky verification sites, and that the design catalog is currently only applicable for new flexible and rigid pavement design.

Clark reported that the new program is available to the public, but that individuals are required to register to use the program. He provided a preview of the various components of the program (including cost analysis [initial and life-cycle costs], design selection, and project approval) and illustrated several of the input and output forms. He wrapped up the presentation by discussing future enhancements to the program, including revising the catalog to reflect the most recent versions of PMED (v2.6 and v3.0), evaluating v3.0 rigid designs with MERRA data, and incorporating rehabilitation design.

*Comments/Questions: John Senger inquired if the Department has thought about using the pavement design data from projects as a link or merge to asset management. Clark said this has been talked about but not acted on. Ali Morovatdar asked if LCCA is used on any type of road project. Clark responded that life-cycle costs are automatically computed, but that whether the results are used by a designer is dependent on the project.*

## 12. Indiana ME Design Catalog for Small Structure Replacements (Mr. Kumar Dave, Indiana DOT)

Kumar Dave presented on Indiana DOT's ME design catalog for short stretches (100 to 200 ft) of new pavement associated with small structure replacement work. He began the presentation by providing an overview of the Department's pavement design history, including implementation of Pavement ME in 2010, the number of statewide pavement designs performed annually (between 400 and 700), and the types of work for which ME designs are performed (e.g., new construction, reconstruction, widenings, rehabilitation, small structure replacements).

Kumar reported that pavement designs for small structure replacements represent about 20 percent of the Department's designs and they mostly consist of HMA pavement. With such a high number of small-sized projects and the need for a quick turnaround (<120 days), the DOT opted to develop a design catalog to expedite the design process. Using the design catalog, the pavement design is selected based on average annual daily truck traffic (AADTT) and ESAL categories, road class, District (climate and binder grade factors), and traffic speed (binder grade factor). For HMA pavement, conservative design thicknesses of 10, 12, and 14 inches are used, corresponding to the above inputs.

In closing, Kumar recommended that agencies implement Pavement ME, but do their due diligence when implementing the procedure. He also recommended developing a design catalog for small projects as a way of saving time and money for an agency.

# WEDNESDAY, NOVEMBER 2

## 13. FHWA/Montana Pavement Design Peer Exchange (Mr. Miles Yerger, Montana DOT)

Miles Yerger discussed the FHWA/Montana DOT pavement design peer exchange that was held on March 9-10, 2022 in Helena, Montana. The purpose of this meeting was to obtain ideas and information from other state DOTs that could be considered by the Department in its attempt to revamp its pavements program (they had recently experienced a large turnover in staff and a reorganization of offices). The primary areas of focus in the peer exchange were pavement design policies, field investigation practices, preservation practices, and integration of design with pavement management.

Miles reported that the meeting was attended by representatives from seven DOTs and the FHWA and included multiple breakout sessions to cover the various topic areas. Miles and other Department representatives made a lot of good contacts and determined that Montana DOT is in a similar situation with other DOTs as it relates to their pavements program. He indicated that Montana is working on switching to PMED and that they anticipate seeing more use of concrete and SMA in the future. Currently, the central office does a lot of preventive maintenance treatments and it is likely they'll push this work to the districts to give more attention to PMED and other weighty matters.

*Comments/Questions: LaDonna Rowden asked if Montana DOT has ever considered alternate bidding. Miles indicated they do it for recycling projects and let the districts make the final choice. The initial costs of concrete are too high to make it a viable choice. The*

*Department does conduct LCCAs and they currently use MODCOMP for FWD backcalculation (they will evaluate the use of the BcT tool during the PMED trial period).*

## 14. Pavement ME Rehabilitation Design Implementation: Challenges (Mr. Hari Nair, Virginia DOT)

The Virginia DOT implemented Pavement ME v2.2.6 for new construction, reconstruction, and lane widening in January 2018. Since that time, the Department has been focused on implementing the procedure for rehabilitation design using AC overlays. In this presentation, Hari focused on this implementation effort and the various challenges that have been encountered along the way. A report on the effort is available online at https://www.virginiadot.org/vtrc/main/online_reports/pdf/22-R13.pdf.

Hari shared that the implementation effort is based on data and analysis for a limited number of projects involving AC overlays over AC (26 sites), AC overlays over JPC (14 sites), and AC overlays over CRC (12 sites). He noted that the DOT's approach to implementation was to use the cracking and rutting calibration coefficients obtained for new designs and apply them to the selected overlay projects. Key aspects of the rehabilitation design implementation process and some of the challenges Virginia DOT encountered as part of its investigation included:

- Assessment of overall condition of the existing pavement.
    - What is the extent of pavement evaluation that is needed?
    - What evaluation tools are needed (e.g., FWD, ground penetrating radar [GPR], coring, laboratory testing, dynamic cone penetrometer [DCP] testing, backcalculation software)?
- Input levels for characterizing damage in the existing pavement.
    - For AC overlays over AC:
        - Level 1 nondestructive testing inputs (e.g., FWD data, GPR data, transverse cracking) may not always be feasible (inability to do testing) and are probably not cost effective in some cases.
        - How should Level 2 distress data, such as fatigue cracking amount and percentage, be selected in the case of a mill-and-overlay design?
- Damage characterization for AC overlays over AC: Level 1 FWD data versus Level 2 distress data.
    - Past studies have shown significant differences in the damaged modulus curves obtained from FWD data and distress data, which in turn has resulted in large differences in predicted fatigue cracking. Is a study needed to further evaluate level 1 and level 2 inputs?
    - Very few guidelines are available for determining which level to use. Can a calibrated damage prediction equation be developed?
- Damage characterization for AC overlays over JPC.
    - Is FWD testing for characterizing joint load transfer efficiency (LTE) required for all projects?
    - Can joint faulting from distress data be helpful to calculate LTE?
- Local calibration factors for AC overlays over AC.
    - Are separate rutting and cracking calibration factors needed for rehabilitation and new design?
    - How should changes in the global calibration coefficients in the latest software versions (v2.6 and v3.0) be handled?

*Comments/Questions: Harold confirmed that an agency can use the calibration coefficients for new designs and apply them to rehabilitation (subject to verifications). He also described several projects where Level 1 and Level 2 inputs resulted in different design strategies (e.g., mill-and-overlay vs. reconstruction) and recommended that at the very least Level 1 inputs be used on high-profile projects.*

### 15. Improved Consideration of the Influence of Subgrade Soils Susceptible to Shrink/Swell and/or Frost Heave on Pavement Performance (NCHRP 1-59) (Drs. Claudia Zapata and Austin Olaiz, Arizona State University)

The objective of NCHRP 1-59 was to enhance Pavement ME design procedures to better reflect the influence of subgrade soils susceptible to shrink/swell and/or frost heave on pavement performance. Drs. Claudia Zapata and Austin Olaiz described the efforts to develop climate-site distress models (estimating volume change on expansive/shrinking soils and frost heave) for predicting IRI, calibrating and validating developed models, and highlighting implementation considerations.

Claudia shared that research conducted by Lytton et al. (2005) (*Design Procedure for Pavements on Expansive Soils*) and Vann and Houston (2021) (*Field Soil Suction Profiles for Expansive Soil*) was used to predict long-term volume change (accounts for swelling as well as shrinkage during drying periods) in shrink/swell soils. The research team developed an improved suction-based framework for estimating volume change due to time-varying climatic effects. The framework included the following activities:

- Determine climate boundary conditions: Identify weather stations (monthly precipitation and average temperature) and determine monthly Thornthwaite Moisture Index.
- Determine suction envelopes: Establish long-term suction parameters, backcalculate variables for Mitchell's equation, and develop long-term wet/dry suction profiles.
- Generate monthly suction profiles: Estimate monthly changes and limits of suction variation at the surface, fit the Fourier equation to the monthly surface suction change, generate a monthly suction profile, adjust suction profile for varying surface boundary conditions, and determine the net normal stress profile.
- Determine volume change: Estimate the Suction Compression Index and calculate the monthly strain and monthly volume change.
- Generate stochastic (allows for variability in climate and material properties) solution: Generate random soil properties, apply forecasting model for random generation of time-series climate parameters, and apply models to estimate potential monthly shrink-swell volume change.

For determining frost depth and frost heave, a simplified one-dimensional finite element model was developed. The simplified model includes boundary conditions (heat flux caused by ground surface temperature gradient), ground water table impacts, supports level-based design, and is able to calculate both frost heave and frost depth. The research team built in other models for estimating initial temperature, segregation potential (function of gradation and Atterberg limits), and thermal properties. Frost heave is calculated as the expansion due to water and segregation potential. The model was calibrated using the LTPP data and validated using six sites in Finland.

The current PMED IRI model includes a site factor (SF) that addresses volume change. Based on this research, variance and standard deviation associated with the volume change will serve as a surrogate and replace SF.

Austin also demonstrated the stand-alone software program developed as part of the research effort. The research utilized National Oceanic and Atmospheric Administration (NOAA) data; however, incorporation of the MERRA dataset is possible. The developed models use similar inputs as the current PMED version. The research team is working on completing the final report.

*Comments/Questions: Asked about the simulation process in the software program, Austin said it uses two Monte Carlo runs.*

## 16. LTPP Analysis-Ready Materials Dataset (ARMAD) (Ms. Jane Jiang, FHWA)

Jane Jiang provided a virtual presentation on the ARMAD developed by the LTPP Program team at FHWA. The ARMAD development objectives included identifying essential properties to characterize each material type (e.g., AC, PCC, unbound materials including subgrade, chemically treated layers), consolidating LTPP tables from many to a few for all material types, developing representative materials characterization data, and interpreting data to ensure meaningful material properties are provided. The development process consisted of three phases—a planning phase in which the LTTP data were initially evaluated and input was gathered from subject matter experts (SMEs), a design phase in which data were wrangled and reviewed by the SMEs, and a launch phase in which the database was populated, checked, and released on the LTPP InfoPave website (https://infopave.fhwa.dot.gov/Data/ReadyMaterial).

Jane provided an overview of the material properties targeted for inclusion in the ARMAD and the LTPP source tables containing the materials property data. She illustrated how to access, view, and select the desired materials data and demonstrated how the ARMAD was used on NCHRP 20-50(18) (*LTPP Data Analysis: Significance of As-Constructed Asphalt Pavement Air Voids to Pavement Performance*). Jane described various purposes for the dataset, including using it to conduct a local calibration of the PMED software.

Jane reported that the LTPP Program team expects to release additional LTPP analysis-ready datasets in August 2023, including a pavement performance dataset, a climate dataset, and a traffic dataset.

*Comments/Questions: Asked by Jay Goldbaum how frequently the data are collected, Jane responded that the data are collected throughout the year but that the datasets are refreshed annually (QC/QA checks are needed).*

## 17. Nebraska Calibration and Backcalculation Challenges (Mr. Bruce Barrett, Nebraska DOT)

Bruce Barrett began his presentation by speaking about Nebraska DOT's lessons learned regarding backcalculation. He indicated that the agency uses both a KUAB (in-house) and a Dynatest (consultant) FWD for its nondestructive testing and began using the BcT for backcalculation about a year ago. Among the lessons they have learned are:

- FWD operators need to log/record the correct mile markers during testing and add comments when appropriate.
- BcT users need to:
  - Specify the correct FWD input files (KUAB or Dynatest) in the program.
  - Specify a target load in the program that is within 500 lb of what was recorded during FWD testing.
  - Use GPR data (when available) in conjunction with FWD data to segment projects for design analysis.
  - Use a minimum modulus of 1 ksi for the AC, granular base, and subgrade layers.

Bruce also provided an update on Nebraska DOT's Pavement ME calibration efforts for new flexible and rigid pavements. Their first calibration study was completed in 2020 and used 63 pavement management sections and 18 LTPP sections. XML input files were developed for Nebraska asphalt mixes, standard PCC mixes, and three foundation course materials. Except for one PCC slab cracking coefficient, no changes to the global calibration coefficients for flexible and rigid pavements were identified. The Department uses traffic clusters since they don't have any weigh-in-motion (WIM) sites.

## 18. Michigan Rigid Pavement Model Calibration (Dr. Syed Haider, Michigan State University)

Dr. Syed Haider presented on the Michigan DOT rigid pavement local calibration study. The third of three such studies conducted since 2005, this effort used an expanded set of JPC pavement sections (114 total) with additional years of time-series data to develop calibration coefficients for the improved prediction of slab cracking, joint faulting, and IRI.

Syed began his presentation with an overview of the local calibration process, the Pavement ME JPC performance models, and the Michigan DOT pavement management data used for the calibration. He explained some of the restrictions imposed on the analysis dataset (e.g., at least 3 years of time-series data, filtering out of non-deteriorating performance data, capping of faulting data to 0.3 in.) and some of the assumptions made in lieu of missing data (e.g., 28-day compressive strength of 5,239 lb/in$^2$). He also described the process of backcasting IRI trends to obtain the initial IRI for sections with no recorded initial IRI.

The local calibration was conducted using PMED v2.6. Different statistical techniques (e.g., bootstrapping, repeated split sampling) were used to minimize the bias and error in the performance prediction models and only the most sensitive calibration coefficients were evaluated. The number of pavement sections used in the calibration of each model was 64 for cracking, 107 for faulting, and 65 for IRI. The CAT tool was used only for calibrating the faulting model; calibration of the IRI and cracking models was done outside of the CAT tool.

Syed presented a summary table showing the local calibration coefficients obtained from the analysis, as well as those obtained from the previous local calibration and the global model coefficients. Accordingly, he noted that the global model for cracking predicts lower values as compared to the measured values in Michigan, whereas for IRI and faulting predicted values are higher. Syed also noted that every time his research team develops new local calibration coefficients, Michigan DOT pavement design engineers evaluate the v2.6 designs, using the new calibration coefficients, and compare them to previous designs and/or past experience. This is critical to avoid having overpredicted or underpredicted designs, prior to implementing the local calibration coefficients.

*Comments/Questions: Asked if Michigan DOT does flexural strength testing, Syed stated that compressive strength testing is mostly used and that flexural strength values can be obtained through correlations with compressive strength. Bipad Saha inquired what the initial IRI for JPC is. Syed said it is typically around 72 in/mi.*

### 19. Calibration of AASHTOWare Pavement ME for Maryland Conditions (Mr. Hector Figueroa and Mr. Robert Steudler, Maryland SHA)

This presentation covered the four phases of a Maryland SHA project aimed at implementation of Pavement ME within the agency. Robert Steudler began the presentation by introducing the four phases—(1) Verification of National Models, (2) Sensitivity Analysis, (3) Local Calibration using PMED v2.6, and (4) Updates—and briefly discussing the work and results of phase I completed in 2016. In that effort, data from Maryland LTPP sections and a few Maryland pavement management sections were used to compare measured values of asphalt pavement distress and IRI versus values predicted by PMED. Results showed a need for calibration of the PMED performance prediction models.

Next, Hector presented on phase 2 of the project, which was also completed in 2016. The sensitivity analysis consisted of developing an experimental factorial matrix involving different asphalt pavement types, traffic levels, and climatic regions and ranking the sensitivity of 17 design input parameters based on the normalized sensitivity index (NSI). For both new AC pavement and AC overlays of flexible pavement, the design parameters with the most significant effect on predicted performance were asphalt base course thickness, asphalt binder content, and air void content.

Hector continued the presentation by discussing the local calibration study in phase 3. He described the pavement sections selected for analysis and the compilation of available performance, traffic, geotechnical, and materials data. He also described how some assumptions had to be made to develop transverse crack data from the functional crack density (FCD) measurement that is used by Maryland SHA for pavement management. Hector noted that the CAT tool was used to calibrate all the pavement models, except for the total fatigue cracking model for AC overlays of flexible pavement (for this model, the tool failed to capture the reflection cracking component of total fatigue cracking). He illustrated the predicted versus measured plots of distress associated with the verification, calibration, and validation steps, and reported that the calibration resulted in noticeable improvements in performance prediction. The study was completed in 2022 and the results are in the process of being implemented into design practice.

Robert concluded the presentation with a briefing on phase 4 planned activities. These include implementing the traffic and material libraries into Maryland SHA's Engineering Data Warehouse and updating the agency's pavement design guide with the local calibration coefficients and materials and traffic properties.

*Comments/Questions: Claudia Zapata asked the presenters to elaborate on the geotechnical soil properties database/map. Hector shared that it is a Google Earth-based map that reads from another geo-reference file.*

## 20. Quebec Calibration Efforts (Mr. Felix Doucet, Quebec Ministry of Transportation)

Felix provided a presentation on the Quebec Ministry of Transportation's (MOT) calibration work done to date and future planned work. He discussed the objectives and methodology of the effort, which include developing a flexible pavement performance database, calibrating the PMED performance prediction models, and developing a supplemental tool to account for the effects of climate change.

The work completed to date includes the identification of reference sections and the development of a performance database for local calibration analysis (353 Quebec pavement management sections) and validation analysis (several Quebec LTPP sections). It also includes the compilation of materials property data and traffic data for the reference sections. Felix described the agency's process for using pavement video imagery and FWD data to estimate bottom-up and top-down fatigue cracking for the reference sections. He also provided a breakdown of the number of reference sections on different highway systems containing different distress types (e.g., fatigue cracking, transverse cracking, rutting).

Remaining work activities include local calibration of the PMED models using the CAT tool, establishing climate change criteria that can be incorporated into the supplemental climate change tool, and then validating both tools. Felix emphasized the importance of calibrating PMED using reference sections and conditions that emulate routine pavement design practice.

## 21. Overview of New IDOT Test Track (Mr. John Senger, Illinois DOT)

John Senger provided the participants with an overview presentation of the new Illinois Certification and Research Track (ICART). This test track is located along US 50 in Clinton County in southern Illinois and was constructed in the spring and summer of 2022. The track is 0.75 mi long and consists of three lanes—an inside lane built with CRC pavement, a center lane built with full-depth HMA pavement, and an outside lane built with JPC pavement. The test lanes contain multiple segments (400 to 800 ft long) consisting of a variety of asphalt surface mixes or concrete surface textures for friction testing and certification. Artificial joint faulting and wheelpath rutting are included in several of the segments for profile/smoothness testing and certification. John showed several pictures of the test track construction work (including the 3-inch HMA base layer on which the pavements were placed), as well as the completed lanes and surfacings.

## 22. Implementation RoadMap Workshop and Report (Mr. Kelly Smith, APTech)

Kelly Smith provided a presentation covering the MEPDG Implementation RoadMap workshop and the RoadMap report that was developed based on the results of the workshop. He began his presentation with an overview of the history of MEPDG/PMED implementation, including the entities that have helped lead the implementation efforts (Lead States, FHWA, AASHTO, NCHRP) and the progress made by agencies over the years to implement the procedure and software. He also noted the challenge of a common definition for "implementation," given the different ways Pavement ME can be used (e.g., sole, parallel, shadow, or design check use) and the various types of designs it can be used for (new asphalt, new concrete, asphalt overlays, concrete overlays, etc.).

Next, Kelly spoke about the 1.5-day RoadMap workshop conducted in Chicago, Illinois on June 1-2, 2022. He reported on the participating agencies, the goals and objectives of the workshop, and the structure and nature of the sessions comprising the workshop. He also described the four main topic areas (design policy; design inputs; verification, calibration, and validation; and application and use) covered in the workshop and the many subtopics in which participants were able to share their implementation experiences, challenges, successes, and lessons learned.

Lastly, Kelly provided an overview of the RoadMap report that was developed in the fall of 2022. This report consists of five chapters and is intended to help highway agencies in shortening the timeframe for Pavement ME implementation by communicating the successful practices of some of the experienced agencies. It discusses the various types of implementation challenges that can occur at both the technical and administrative levels and provides detailed strategies for overcoming the challenges. As additional aids to the reader, the report contains several highlighted examples and links to valuable resource materials. Kelly informed the participants that both the RoadMap report and the RoadMap workshop meeting minutes are available on the TPF-5(305) website (https://www.pooledfund.org/details/study/549). He added that a more detailed presentation of the RoadMap workshop and RoadMap report will be featured in software training webinar #5 expected to take place in the spring of 2023.

## 23. Open Forum Discussion – Meeting Participants

Linda Pierce led an open forum discussion related to agency PMED implementation challenges. Participants were asked to provide viewpoints on implementation issues not related to staffing and funding. Below are some of the key discussion items from the open forum.

- Clark Graves indicated there is a disconnect between the collected data for PMED distress prediction (LTPP-based) and how pavement management data are collected and used. Harold Von Quintus noted that some agencies have changed their pavement management data collection procedures or have converted the collected data to match PMED definitions.
- Ryan Fragapane reported that AASHTO will be sending out a survey asking agencies what pavement performance measures are being used and how they are being used. He added that AASHTO will also be reaching out to the pavement condition data collection vendors.
- Kumar Dave stressed the importance of linkages between pavement design, pavement management, and LCCA.
- Bipad Sah shared that it would be helpful to have guidance on modeling/designing FDR and CIR.

## 24. Software Training Topic 1 – PMED Models and Calculations: HMA Rutting & IRI (Dr. Linda Pierce, NCE)

For the first training block, Linda began by describing the PMED HMA rutting models and calculations. As described in the previous HMA cracking model training webinar, critical pavement responses related to rutting include the compressive vertical strains within the asphalt layer, the base/subbase layer, and the subgrade. There are a number of factors affecting rutting (and rut accumulation), which include the asphalt mixture (layer thickness, dynamic modulus and changes due to temperature and aging, binder grade and binder hardening due to aging, air voids, and effective binder content), unbound base (type, thickness, stiffness, moisture variation), traffic (load, tire contact area, tire pressure, operating speeds impact on rate of loading, and wander), and temperature and environmental (freezing and thawing) conditions. There are three phases of rutting: primary (volumetric change), secondary (volumetric change and as shear deformations increase), and tertiary (shear deformations and no volume change conditions). The MEPDG/PMED rutting model accounts for the primary and secondary phases, while tertiary is addressed through mix design. The NCHRP 1-37A project determined rutting for each load level, sub-season, and month of the analysis period. Rutting was assumed to be zero for chemically stabilized materials, concrete fractured slabs, and bedrock. For asphalt mixtures, the rutting model was a function of accumulated plastic strain and resilient strain (function of mix properties) and is influenced by layer thickness, depth of measure, temperature, and number of load repetitions. For unbound layers and subgrade, the rutting model was a function of material properties (water content, modulus, depth to ground water table), resilient strain as measured in the laboratory, average vertical strain, layer thickness, and number of load repetitions.

NCHRP Project 9-30A (NCHRP Report 719) recalibrated the NCHRP Project 1-37A rut prediction models based on 45 in-service pavement sections from various studies (LTPP, WesTrack, NCAT, MnROAD, and CA I-710 Long Beach). NCHRP Project 9-30A measured Level 1 volumetric properties, dynamic modulus, and repeated-load plastic deformation. This research method added an alternative rut-depth transfer function, allowed the user to add layer-specific plastic deformation coefficients, fixed a software data entry error for unbound base layers, and added the ability to use normal rather than uniform distribution of truck traffic between limits of wander.

The PMED model also incorporates an incremental calculation for each sub-season and mid-depth of each layer, uses a strain-hardening approach to account for monthly changes, and is based on laboratory testing results and adjusted to field conditions. Since the LTPP database did not contain rut depth for each layer, "measured" layer rut depth is based on proportioning of the total rut depth. The PMED rutting model for each individual layer is a function of:

- Asphalt layer: Layer thickness, location depth, load applications, mix or pavement temperature, and calibration coefficients.
- Unbound layers and subgrade: Average vertical strain, resilient or plastic strain, layer thickness, load applications, water content, resilient modulus, and calibration coefficients.

Linda completed the rutting model presentation by providing a list of considerations for reducing the rutting potential, including:

- Asphalt layer: Increase mixture stiffness, increase binder grade, lower asphalt binder content (meets mix design criteria), and ensure higher quality material in the upper layers.
- Unbound layer: Improve layer quality (e.g., higher CBR, R-value or layer moduli), use stabilized or treated layer, increase thickness of layers.

Next, Linda presented the PMED HMA IRI model. The distresses included in the IRI model are transverse cracks, fatigue cracks, and rut depth, as well as user inputs for sealed longitudinal cracking and block cracking. Other factors included in the model are initial IRI, pavement age, and a site factor. The IRI model is a function of base type, which includes unbound bases, asphalt-treated bases, and chemically stabilized bases.

Linda provided a summary of findings of input sensitivity from NCHRP Project 1-47. Although based on MEPDG v1.1, many of the following hypersensitive and very sensitive inputs are also applicable to the current PMED version rutting model:

- Asphalt layer: Dynamic modulus, Poisson's ratio, and thickness.
- Unbound base layer: There are no inputs that are hypersensitive or very sensitive to the results of the rutting model; however, thickness, Poisson's ratio, and modulus are sensitive to the calculations of rut depth.
- Subgrade: There are no inputs that are hypersensitive or very sensitive to the results of the rutting model; however, P200 and liquid limit are sensitive to the calculations of rut depth.
- Total rut depth: Dynamic modulus, Poisson's ratio, and thickness.

For IRI,
- Asphalt layer: Dynamic modulus and thickness.
- Unbound base: There are no inputs that are hyper or very sensitive to the results of the rutting model; however, modulus is sensitive.
- Subgrade: There are no inputs that are hyper or very sensitive to the results of the rutting model; however, modulus and P200 are sensitive.

## THURSDAY, NOVEMBER 3

### 25. Software Training Topic 2 – PMED Models and Calculations: PCC Joint Faulting & IRI (Dr. Julie Vandenbossche, University of Pittsburgh)

In the second training block, Julie Vandenbossche first covered PMED PCC joint faulting models and calculations. Julie described the faulting mechanism and how PMED predicts joint development based on material properties (joint width, shear capacity, load transfer efficiency [LTE], and dowel stiffness). She highlighted the various steps conducted by PMED for fault prediction which included:

- Process traffic (number of axles occurring between 8:00 PM and 8:00 AM), temperature profile (EICM-generated hourly profiles converted to effective nighttime difference by month), and relative humidity (differential shrinkage for slab warping) data.
- Calculate initial maximum faulting (function of base freezing index, slab corner deflection, base/subbase erodibility index, subgrade soil P200, average annual wet days, and overburden on subgrade) and evaluate joint LTE (dowel, base, or aggregate interlock).
- Calculate current maximum faulting (function of differential energy density of subgrade deformation, corner deflection of loaded and unload slab, and load applications).
- Determine critical incremental pavement responses (shear stress at slab corner and maximum dowel bearing stress).
- Evaluate loss of shear capacity (function of slab thickness, joint opening, and shear stress) and dowel damage (function of concrete compressive strength, dowel diameter, dowel stiffness, deflection at corner of loaded and unloaded slab, and dowel spacing in the wheel path).

- Calculate faulting increment (function of base freezing index, maximum mean transverse joint faulting by month, mean joint faulting at the beginning of the month, differential energy density of subgrade) and cumulative faulting (mean joint faulting at beginning of month plus incremental monthly change in mean transverse joint faulting).

Julie also summarized work completed in 2014 on updated calibration coefficients (corrected CTE values, balanced factorial designs, and updated climatic files) and discussed NCHRP 1-51 (research completed in 2017 and incorporated into PMED in 2022), which accounts for the slab-base interface bond degradation and produced updated calibration coefficients for new $LTE_{base}$. Julie also suggested decoupling slab thickness and faulting prediction in the PMED.

In part 2 of her presentation, Julie discussed the JPCP IRI model and described that it is a function of cracking, spalling, faulting, and a site factor. Calibration of the JPCP IRI model had not been conducted until the release of PMED v3.0.

### 26. Software Training Topic 3 – Pavement ME Intermediate Files: Structural Response (Mr. Harold Von Quintus, ARA)

In the third training block, Harold Von Quintus presented on the PMED intermediate files containing structural response calculations (i.e., deflections, stresses, and strains). He prefaced his discussion by reminding participants that the PMED software is a production-ready design tool, not a research tool and, as such, the intermediate files are limited in their ability to serve investigative pursuits. Harold described the history of the PMED structural response files, pointing out that the evolution of the software into a more robust and computationally faster program necessitated limiting the storage of response calculations.

Next, Harold reviewed the structural responses captured in the intermediate files of the current version (v3.0) of the software. For flexible pavement design, they include the horizontal tensile strain and the vertical compressive strain in the wearing surface. For rigid pavement design, they include the deflections on the loaded and unloaded sides of the joint and the stresses at the top and bottom of the slab. Harold showed where to access the structural response files in the program (*Tools→Options* in the Explorer pane), described the data fields associated with the structural responses, and illustrated some example output data.

In Harold's opinion, the structural responses for rigid pavements are somewhat useful in further evaluating a design, whereas those for flexible pavements are not very useful. He noted that external apps or tools can be used to extract specific structural responses for extended use. As an example, he described the use of WinJULEA in evaluating possible overstressing or shear failure in unbound layers.

In closing, Harold indicated there are a few other intermediate files that could be of value to a designer. These included the daily frost depth file, the equivalent single-axle loads (ESALs) file, the JPCP cracking (bottom-up and top-down) file, and the transverse joint spalling file.

*Comments/Questions: Asked by Ali Morovatdar if the intermediate files can be used for perpetual design, Harold said no. He explained that although PMED does allow for endurance limit, the endurance limit value in the program is a single value and is not appropriate because the endurance limit is mix and temperature dependent. For perpetual* *design in PMED, Harold said the proper approach is to set a very low threshold value of bottom-up cracking at a high reliability level (95 to 99 percent) and long design life.*

## 27. Future User Group Events and Meeting Wrap-Up – Kelly Smith (APTech), Tom Yu and Jennifer Albert (FHWA), and Ryan Fragapane (AASHTO)

At the conclusion of the meeting, Kelly informed the group that there are two software training webinars being planned for 2023—one in the spring and the other in the summer. Tom and Jennifer touched on options for additional event planning using leftover TPF-5(305) funds. Ryan provided some key details about the next PMEUG meeting, which will be organized and conducted by AASHTO. These are as follows:

- Date: September 6-7, 2023.
- Location: Madison, WI.
- A user group charter will be drafted by the ME Task Force and ratified at the user group meeting.
- Leadership roles will be established for developing the agenda and selecting future meeting locations.

Linda, Kelly, and Jennifer thanked everyone for their participation in the meeting and expressed appreciation to all the speakers and presenters. Also, Linda reminded the group that a meeting report will be prepared and made available in the coming weeks. Linda adjourned the meeting at 11:45 a.m. MST.