WELCOME TO THE

AASHTOWare™ PAVEMENT ME DESIGN

WEBINAR SERIES

- The webinar will start at 10:00 AM Central/11:00 PM Eastern

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FY 2024 Webinar #2
Creep Compliance Input Level 2

September 19, 2023

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FY 2024 Webinar #2
Creep Compliance Input Level 2

Moderator:
- Hari Nair, P.E., Virginia Department of Transportation; Chairperson

Presenters:
- Mr. Harold Von Quintus, P.E., ARA
- Dr. Abu Ahmed Sufian, ARA

Presentation will be available for viewing on the ME-Design Resource website:
http://www.me-design.com

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Pavement ME Task Force Members

1. Ryan Fragapane, AASHTO, Product Director
2. Ben Sade, AASHTO, Associate Product Manager
3. Hari Nair, PE, Virginia DOT, Chair
4. Ian Rish, PE, Georgia DOT, Vice-Chair
5. Patrick Bierl, PE, Ohio DOT
6. Kumar Dave, PE, Indiana DOT
7. Dulce Feldman, PE, California DOT
8. Jason Simmons, PE, Utah DOT
9. Margaret Pridmore, PE, Idaho (ITD), SCOA Liaison
10. Susanne Chan, Ontario MOT, TAC Liaison
11. Tom Yu, PE, FHWA Liaison

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FY 2024 Webinar #2
Creep Compliance Input Level 2

- Phones are being muted.
- Please post your questions in the Q&A box. This can be accessed by clicking on the WebEx Q&A button.
- The presenters will answer all questions at the end of the webinar/demonstration as time permits.
- Questions not answered, because of time, will be responded to separately.

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Housekeeping Items

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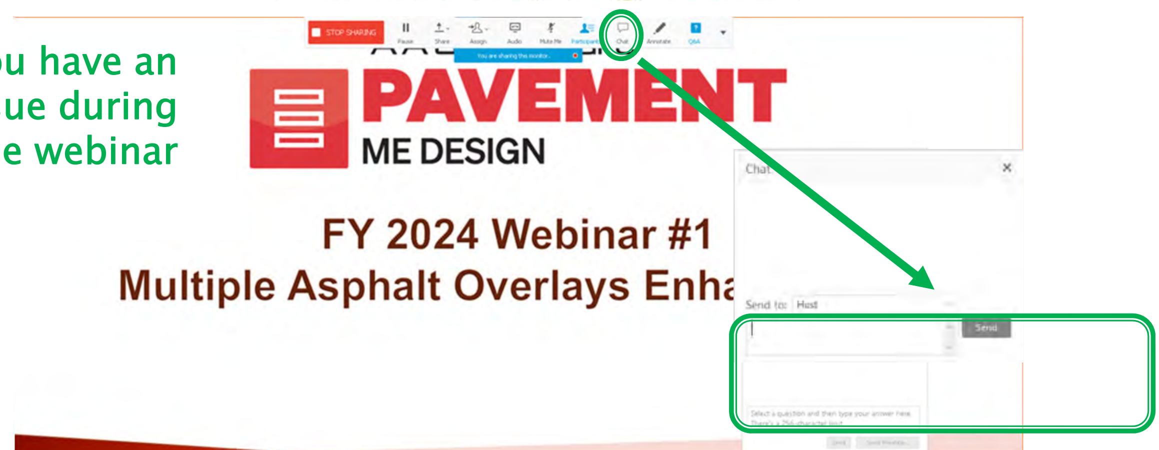

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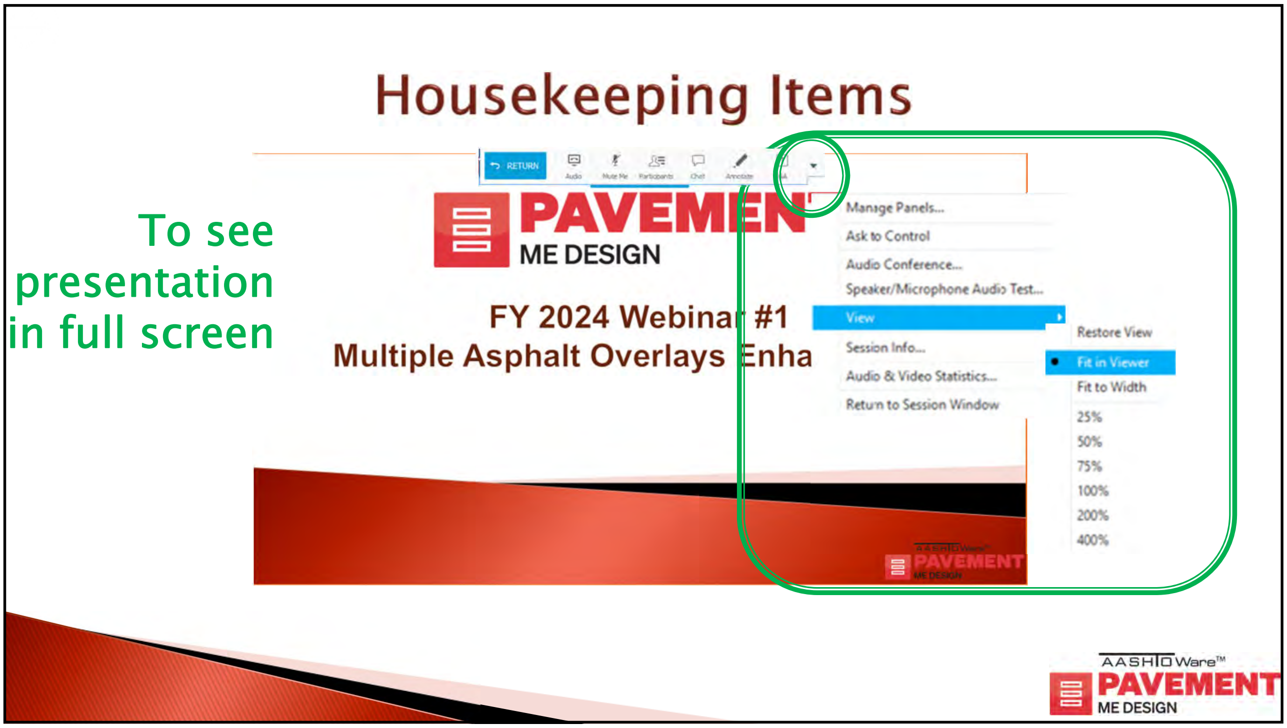
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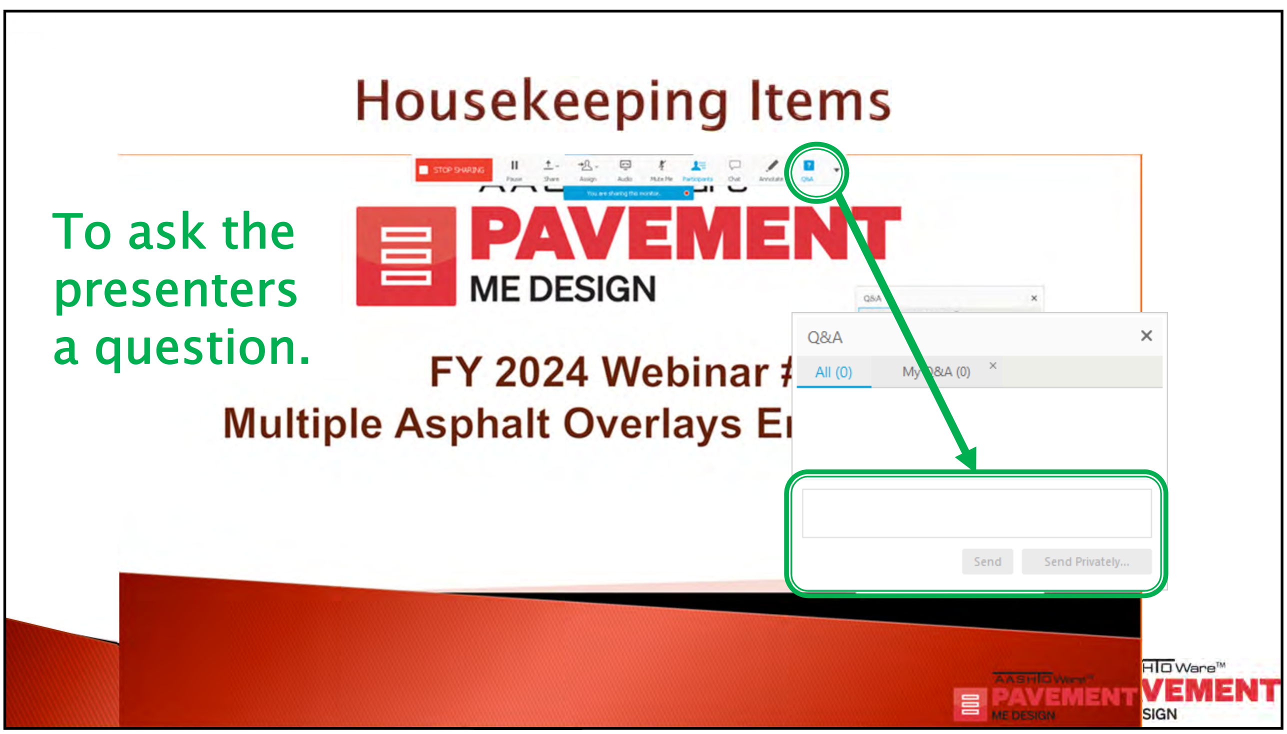
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FY 2024 Webinar #2 Creep Compliance Inupt Level 2

Poll 1: Questions 1, 2, and 3

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1. How many individuals are viewing this webinar at your location?
   - ❑ 1
   - ❑ 2
   - ❑ 3 to 5
   - ❑ More than 5

2. What is your affiliation?
   - ❑ State Government
   - ❑ Federal Government
   - ❑ Contractor/Association
   - ❑ Consultant
   - ❑ Academia

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3. Have you used or applied Creep Compliance input level 2 (testing at only one temperature) in older versions of the PMED software (prior to v3)?
- ❑ No
- ❑ Yes

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Prerequisites for this Webinar

Prior experience with:

1. PMED Desktop or Web app. Versions
2. PMED software for new flexible and/or semi-rigid pavement design and asphalt overlay design of all pavement design strategies.
3. Testing and characterizing of asphalt mixtures for use in new and rehabilitation designs.

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Acknowledgements and Thanks

- PMED Task Force Members
- PMED TRT Members
- Subject Matter Expert
  - Charles Schwartz
- Software Engineers:
  - Brendan Neunaber, Peter Ro, John Malmberg
- Research Team
  - Hyung Lee, Abu Sufian, Harold Von Quintus

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FY 2024, Webinar #2: Creep Compliance Input Level 2

Webinar Outline:

1. Introduction
2. Approach Methodology
3. Comparison of Input Levels for Creep Compliance
4. Use of Input Level 2 – Calibration Coefficients
5. Summary and Takeaways
6. Question and Answer Session

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Introduction

Objective:

Explain and demonstrate the new input level 2 creep compliance procedure and its comparison to the use of input level 1 and input level 3 to educate users on the differences.

Learning Outcomes:

1. Describe the new input level 2 creep compliance procedure.
2. Identify differences in predicted lengths of transverse cracking between each input level for creep compliance.
3. Explain when to use the input level 2 creep compliance procedure based on previous calibration results.

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Introduction

Previous Hierarchical Input Levels for Creep Compliance:

Input level 1 – Test in accordance with AASHTO T 322 at 3 test temperatures.

Input Level 2 – Test in accordance with AASHTO T 322 at 1 temperatures (14F).

Input Level 3 – Calculated creep compliance using regression equations in PMED software.

- Most agencies simply test the asphalt mixture at the other two temperatures that are needed for input level 1.
- Thus, most users of the PMED software use input level 1 or 3 for creep compliance.
- The majority of the global and local calibrations have been completed using input levels 1 or 3.

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Introduction

- Enhancement was authorized by task force to include a quicker procedure to estimate creep compliance from another test; more inline with the definition of hierarchical input level 2 definition.
- Dynamic modulus is commonly measured on the asphalt mixtures in accordance with AASHTO T 378.
- Thus, procedure was prepared to transform frequency-based dynamic modulus to a time-based creep compliance value.

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FY 2024, Webinar #2: Creep Compliance Input Level 2

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2. Approach and Methodology
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Approach and Methodology

- Procedure is to transform a frequency-based dynamic modulus master curve to a time-based creep compliance master curve.
- The procedure is defined as input level 2 for estimating creep compliance and replaces the current procedure based on AASHTO T 322 which uses one test temperature (14F).

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Approach and Methodology

Three approaches considered:

- Approach A, identified as the direct approach.
- Approach B, identified as the prony series conversion.
  - Frequency domain approach
  - Time domain approach
- Approach C, identified as the quasi-elastic conversion.
  - Power law-based interrelationship by Leaderman.
  - Christensen interrelationship.
  - Denby interrelationship.
  - Park interrelationship.

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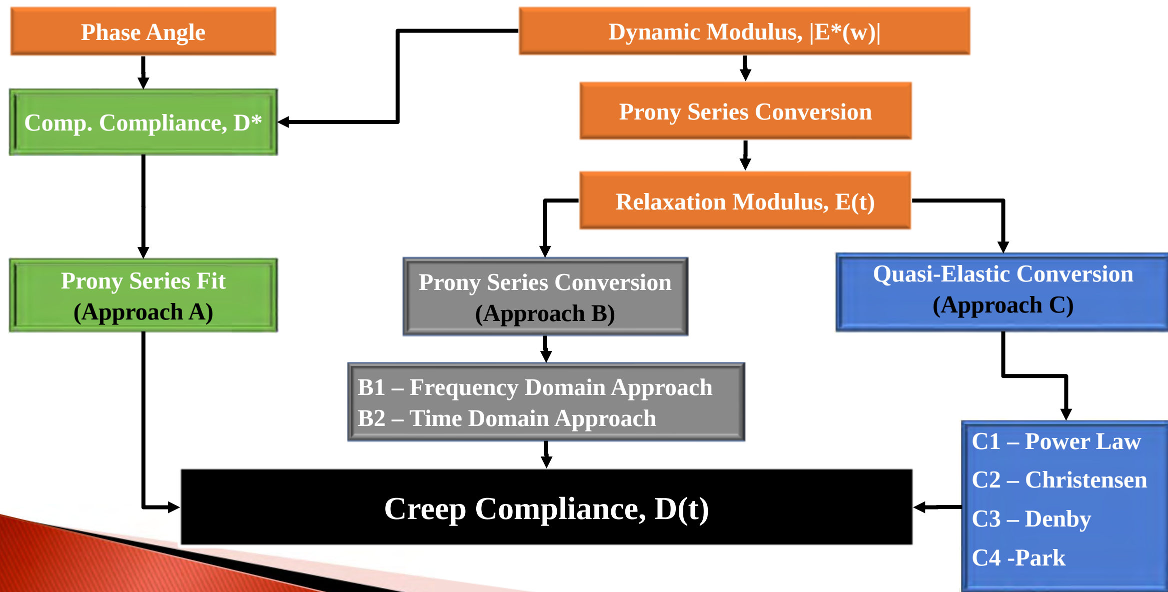
Approach and Methodology



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Approach and Methodology

- Several numerical approaches were considered for the proposed transformation process.
- Three approaches were selected based on their theory, minimum need for input variables, and ease of integration into the PMED software.
- Level 1 dynamic modulus and creep compliance data were collected from multiple sources and organizations to confirm and verify the approach.

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Approach and Methodology

- Total of 45 asphalt mixtures.
- Mixtures from 8 organizations (Colorado, FHWA, Florida, Massachusetts, Michigan, North Carolina, Pennsylvania, Wisconsin).
- Low traffic to high traffic designed mixtures.
- Mixtures without and with higher RAP amounts.
- Ground tire rubber mixtures.
- Polymer modified mixtures.
- Warm asphalt mixtures.
- Binder types vary from soft (PG58-34) to stiff (PG 76-28)

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Approach and Methodology

- Level 1 creep compliance and dynamic modulus data- collected from multiple sources and organizations.
- Level 2 creep compliance data- computed from E* data using the three approaches
- Level 3 creep compliance data- derived from the PMED software regression equations.

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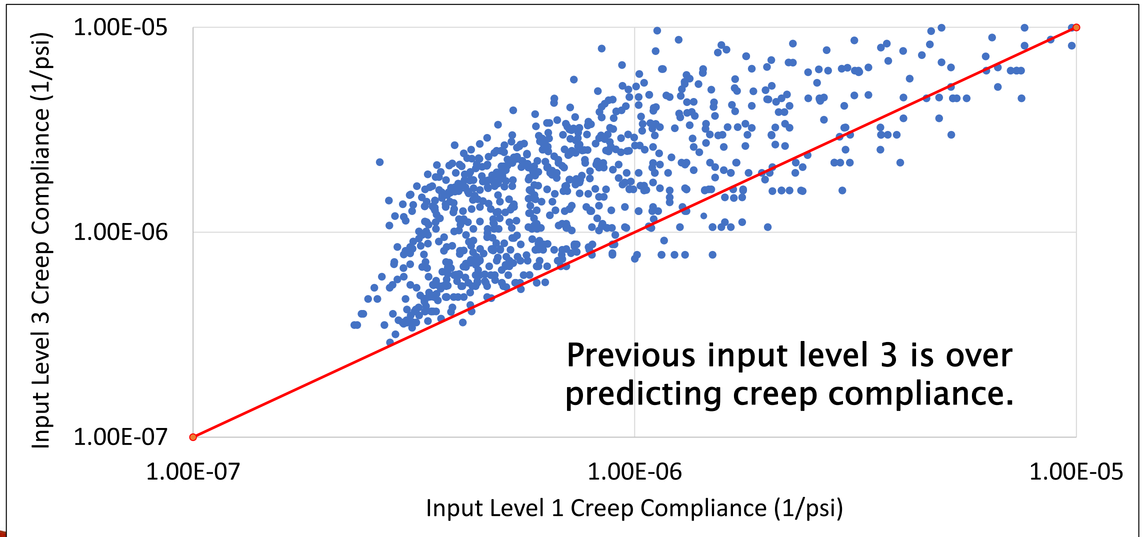
Approach and Methodology



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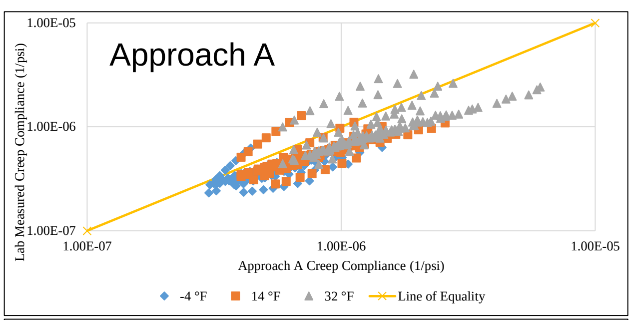
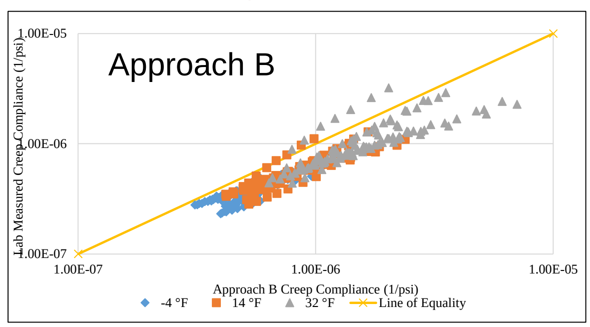
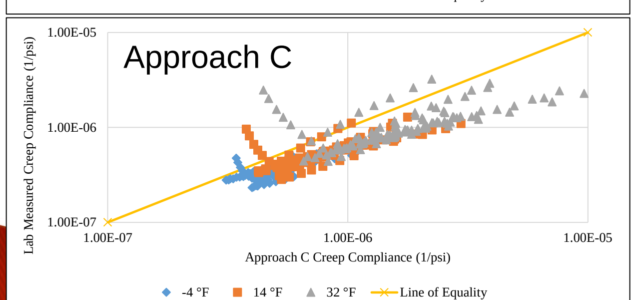
Approach and Methodology







Approach B was selected as the new input level 2 approach.

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Approach and Methodology

Approaches	SSE	Se/Sy	Bias/Aver. Observe. (%)
A	7.53E-05	982.37	6221.43
B2	1.44E-10	1.36	53.79
C2	2.86E-10	1.91	63.10

Statistical analysis confirmed Approach B as the best for estimating input level 2 creep compliance.

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Approach B2 – The Steps

1. Step 1– A dynamic modulus master curve is derived from frequency-based input level 1 dynamic modulus data.
2. Step 2 – Sigmoidal function is fitted through the master curve.

$$\log|E^*| = \delta + \frac{\alpha}{1+e^{\beta+\gamma \log f_r}}$$

3. Step 3– Sigmoidal coefficients for 70°F, are updated for creep compliance temperatures of -4°F, 14°F and 32°F.
   a) Since the only parameter that changes with temperature is β, the sigmoidal coefficients at these temperatures are easily obtained using the time-temperature shift factors.

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Approach B2 – The Steps

4. Step 4–Dynamic modulus sigmoidal coefficients converted into relaxation modulus sigmoidal coefficients with the Prony coefficients from a non-linear least squares method.

5. Step 5–Relaxation modulus Prony series coefficients converted into creep compliance Prony series.

6. Step 6–Creep compliance, D(t), is calculated from creep compliance Prony series at the various times required for PMED input. The process is repeated for other two temperatures.

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Approach B2 – PMED Software Enhancement

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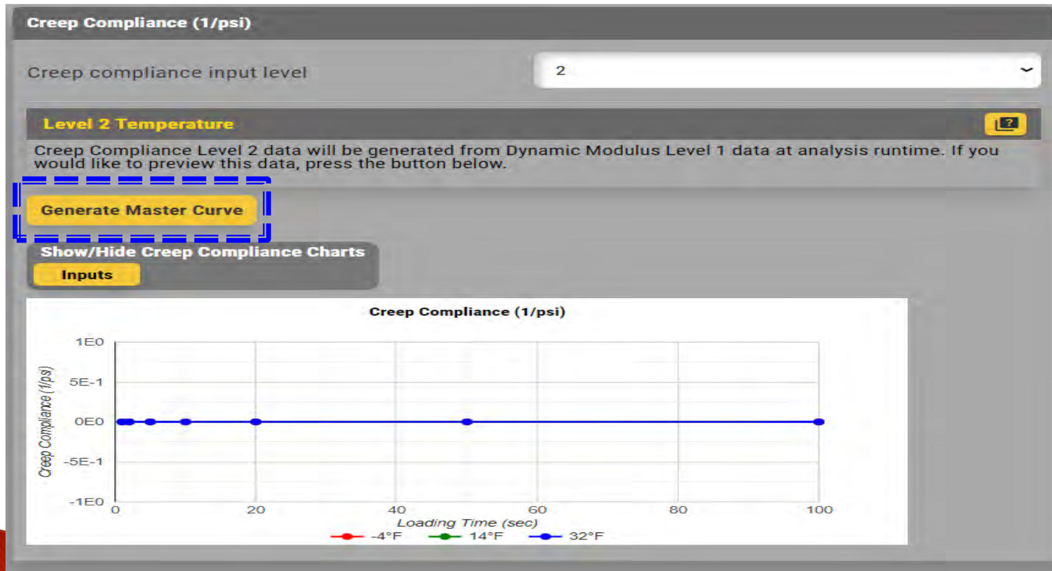
Approach B2 – PMED Software Enhancement



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Approach B2 – PMED Software Enhancement

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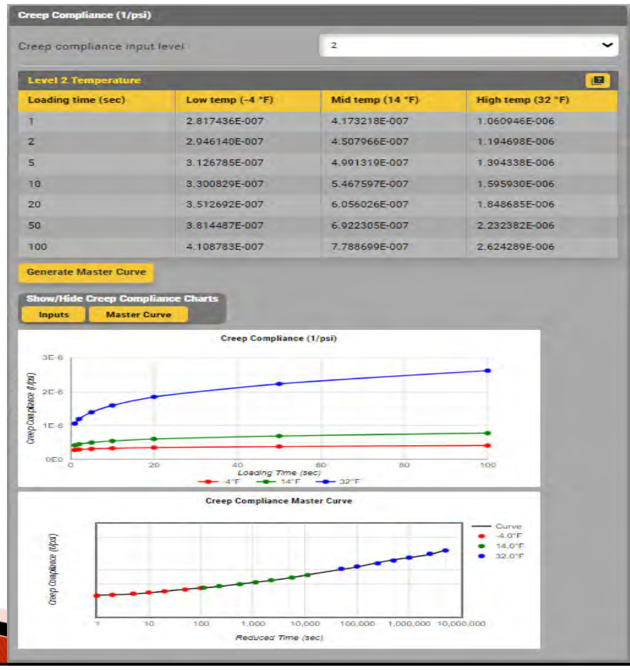
Approach B2 – PMED Software Enhancement



Loading time (sec)	Low temp (-4 °F)	Mid temp (14 °F)	High temp (32 °F)
1	2.817436E-007	4.173218E-007	1.060946E-006
2	2.946140E-007	4.507966E-007	1.194698E-006
5	3.126785E-007	4.991319E-007	1.394338E-006
10	3.300829E-007	5.467597E-007	1.595930E-006
20	3.512692E-007	6.056026E-007	1.848685E-006
50	3.814487E-007	6.922305E-007	2.232382E-006
100	4.108783E-007	7.788699E-007	2.624289E-006

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FY 2024, Webinar #2: Creep Compliance Input Level 2

Webinar Outline:

1. Introduction
2. Approach Methodology
3. Comparison of Input Levels for Creep Compliance
4. Use of Input Level 2 – Calibration Coefficients
5. Summary and Takeaways
6. Question and Answer Session

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Comparison of Creep Compliance Input Levels

- Level 1 creep compliance and dynamic modulus data- collected from multiple sources and organizations.
- Level 2 creep compliance data- computed from input level 1 E* data using the three approaches.
- Level 3 creep compliance data- derived from the PMED software regression equations.

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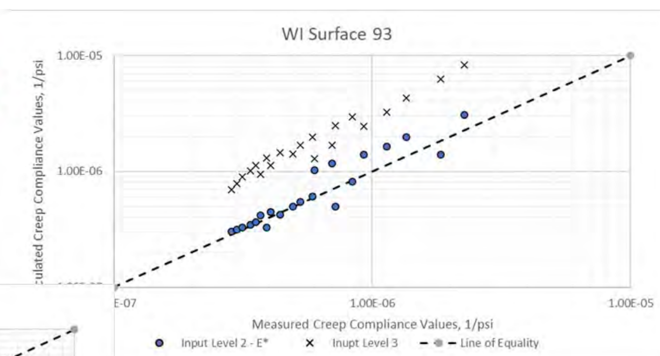
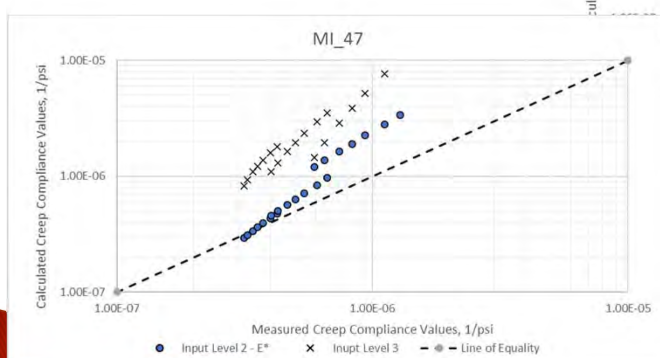
Comparison of Creep Compliance Input Levels; some individual examples





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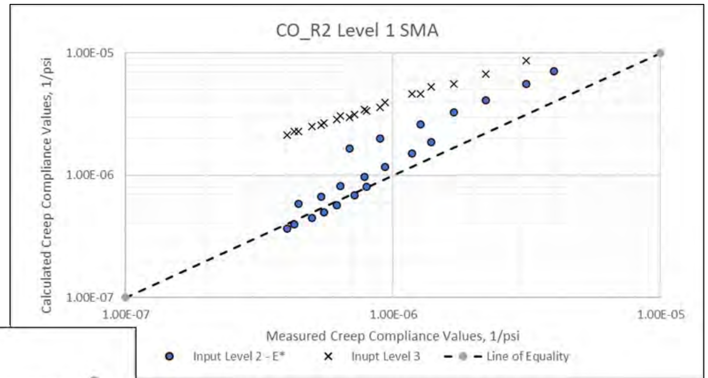
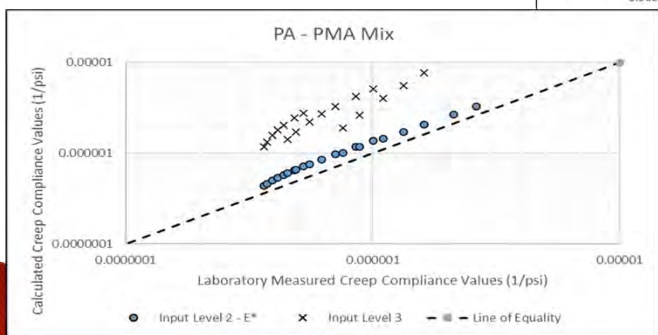
Comparison of Creep Compliance Input Levels; some individual examples





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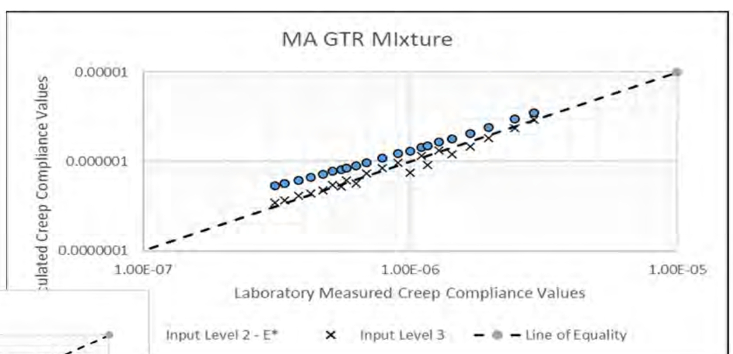
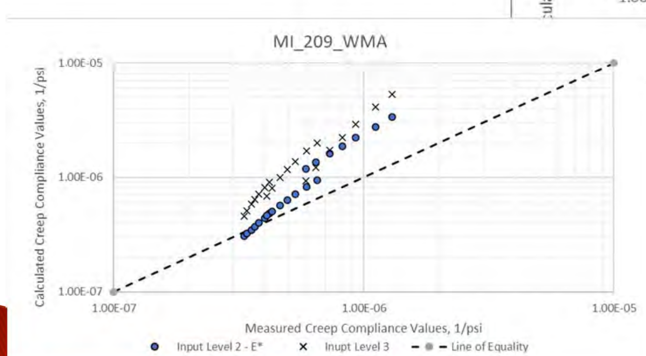
Comparison of Creep Compliance Input Levels; some individual examples





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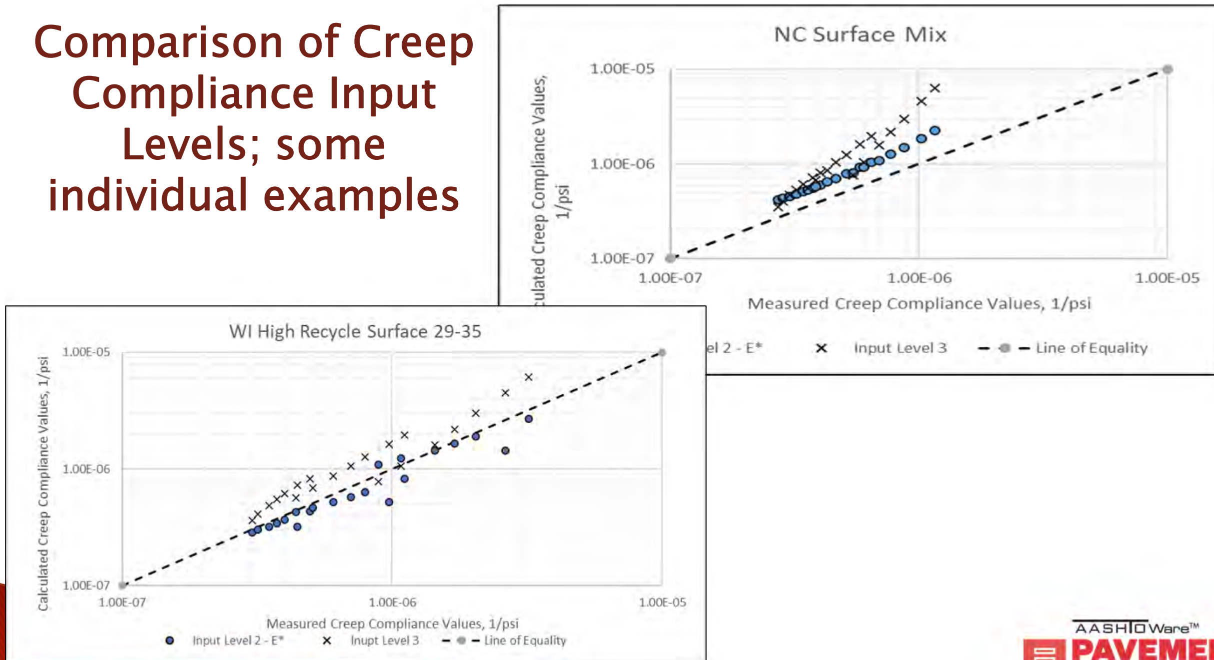
Comparison of Creep Compliance Input Levels; some individual examples



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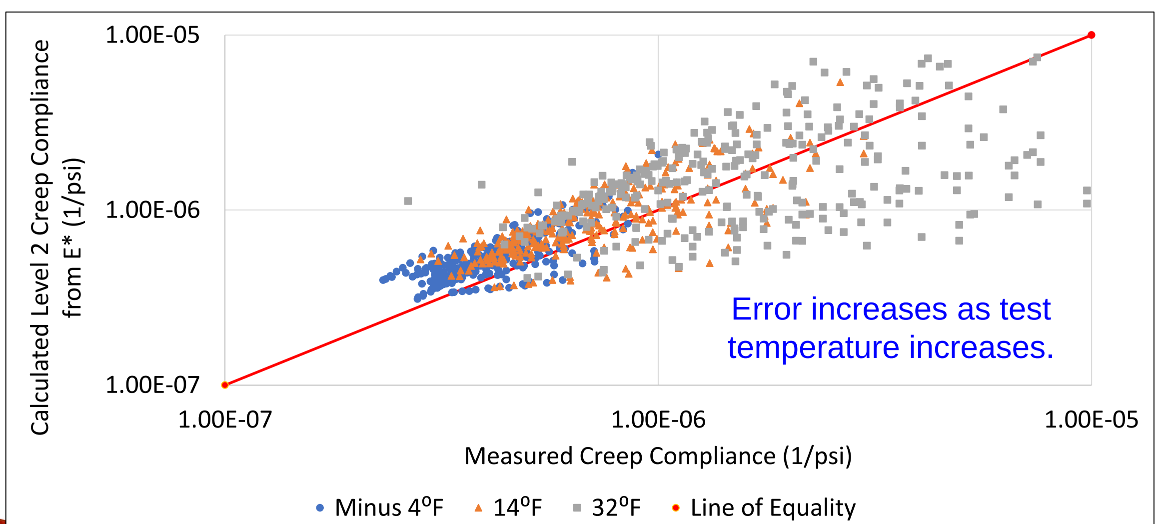
Comparison of Creep Compliance Input Levels



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Comparison of Creep Compliance Input Levels

Analysis of variance completed to identify factors related to the residual errors. Test Temperature found to be the most significant.

Source of Variation	SS	df	MS	F	p-value	p eta-sq
A (Binder Grade)	7.5E-11	4	1.87E-11	33.25	1.70E-24	0.22
B (RAP Content)	1.15E-11	2	5.75E-12	10.19	4.62E-05	0.04
C (Temperature)	1.68E-10	2	8.4E-11	149.03	4.50E-51	0.38
A x B	1.27E-10	8	1.59E-11	28.21	5.25E-36	0.32
A x C	-3.8E-11	8	-4.7E-12	-8.42	-	-0.16
B x C	-4.8E-11	4	-1.2E-11	-21.48	-	-0.22
A x B x C	3.96E-10	16	2.48E-11	43.94	2.52E-83	0.59
Within	2.71E-10	480	5.64E-13			
Total	9.62E-10	524	1.84E-12			

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Comparison of Creep Compliance Input Levels

- The asphalt mixtures used to compare input levels 1 and 2 were selected based on what was available from different sources.
- A sampling matrix or factorial was not used to ensure statistical significance of mixture variables.
- Thus, decision made to only use test temperature to reduce bias.

Source of Variation	SS	df	MS	F	p-value	p eta-sq
A (Binder Grade)	7.5E-11	4	1.87E-11	33.25	1.70E-24	0.22
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A x B x C	3.96E-10	16	2.48E-11	43.94	2.52E-83	0.59
Within	2.71E-10	480	5.64E-13			
Total	9.62E-10	524	1.84E-12			

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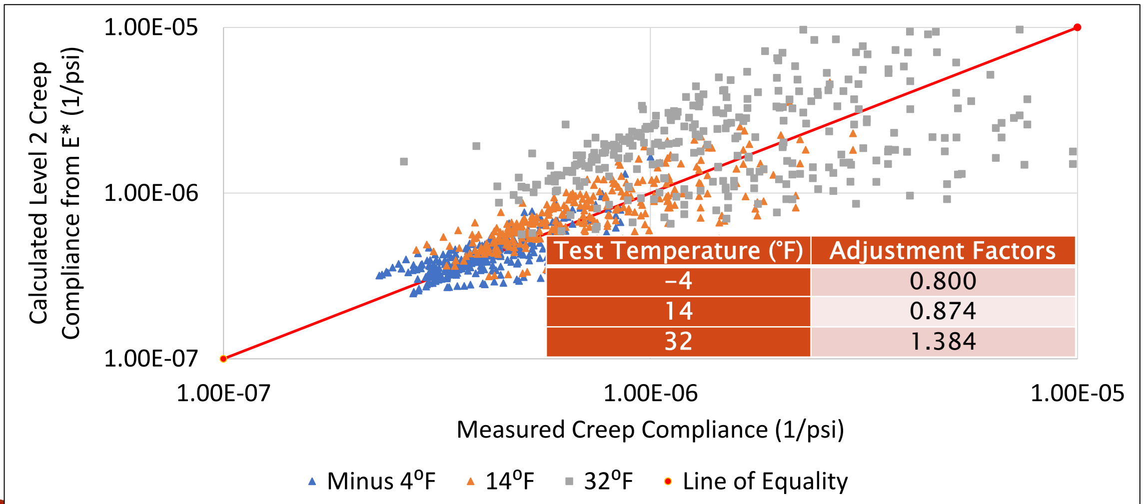
Comparison of Creep Compliance Input Levels



Test Temperature (°F)	Adjustment Factors
-4	0.800
14	0.874
32	1.384

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FY 2024, Webinar #2: Creep Compliance Input Level 2

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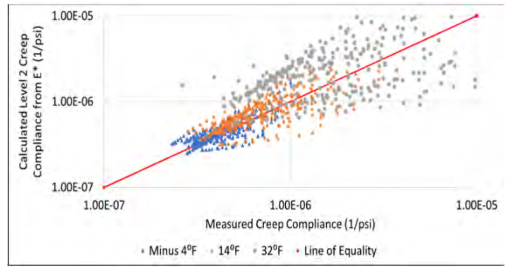
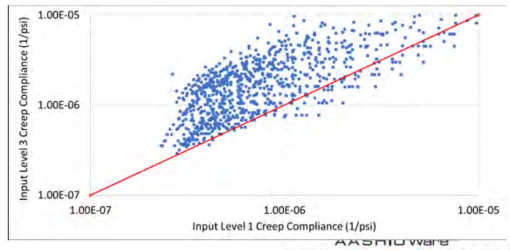
Calibration Coefficients

Does the new input level 2 approach have an impact on the global and local calibration coefficients?

- The outcome in predicted transverse cracks using input level 1 and 2 are statistically the same – ***THE CALIBRATION COEFFICIENTS SHOULD BE THE SAME***.
- However, the calibration coefficients will be different for using input level 3, because of the bias between input levels 1 and 3.





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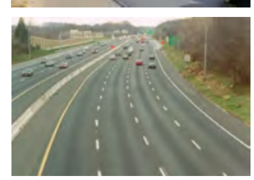
Calibration Coefficients

Points to remember, as related to calibration coefficients for transverse cracks?

- **Aging differences**: Dynamic modulus test specimens are short-term aged, while creep compliance specimens were initially long-term aged specimens.
  - With input level 2 both test specimens represent the same aging condition, short-term aged using plant produced, laboratory compacted specimens.
  - Assumption used for the input level 2 method: short-term aged specimens can be used to predict the response of long-term aged specimens.
  - The bias is consistent so it is an easy adjustment related to calibration between predicted and measured transverse cracks.



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Calibration Coefficients

Points to remember, as related to calibration coefficients for transverse cracks?

- Confinement differences: Dynamic modulus test specimens can be confined or unconfined as per AASHTO T 378.
  - The use of a confined test specimen to measure the dynamic modulus will impact the test results and thus impact the creep compliance values for input level 2.
  - Most, if not all, of the data used to prepare input level 2 method was based on input level 1 dynamic modulus measured on uniaxial or unconfined test specimens.

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Calibration Coefficients

Points to remember, as related to calibration coefficients for transverse cracks?

- Test specimen geometry differences: Dynamic modulus data is measured on compression specimens (uniaxial or triaxial), while the creep compliance data is measured on indirect tensile specimens.
  - There is a difference between mixture response measured on different specimen geometries. Specimen geometry is believed to be the reason for the bias being temperature dependent.

Test Temperature (°F)	Adjustment Factors
-4	0.800
14	0.874
32	1.384

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FY 2024, Webinar #2: Creep Compliance Input Level 2

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Summary and Takeaways

1. Creep compliance is only needed in the PMED software for the asphalt wearing surface.
2. Input level 2 creep compliance is only applicable when input level 1 dynamic modulus data are used.
3. Do not mix the use of input levels 1 or 2 with input level 3. There is a bias so the calibration coefficients will be different.
4. Use uniaxial test specimens, AASHTO T 378, to measure dynamic modulus to be consistent with the data used to develop the input level 2 method.

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Summary and Takeaways

5. The dynamic modulus and creep compliance test specimens represent short-term aged mixtures. So the assumption is short-term agend can be used to predict the response from long-term aged specimens.
6. Remember, there are other asphalt mixture variables that can be used to reduce the error between input levels 1 and 2. This will require the development of a statistically valid sampling matrix or factorial.

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FY 2024 Webinar #2: Creep Compliance Input Level 2

Poll 2: Questions 4, 5, and 6

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4. Is transverse cracking an issue or variable used in designing flexible pavements?
   - ❑ No
   - ❑ Yes

5. In using the PMED software for flexible pavement design, what input level is commonly used for creep compliance?
   - ❑ Do not use PMED for flexible pavement design.
   - ❑ Use input level 3 – default creep compliance values.
   - ❑ Use input level 2 – creep compliance measured at one test temperature.
   - ❑ Use input level 1 – creep compliance measured in accordance with AASHTO T 322 or an XML library based on AASHTO T 322.

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6. How valuable was this webinar to you?
   - ❑ Highly valuable
   - ❑ Moderately valuable
   - ❑ Little value.
   - ❑ No value.

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FY 2024, Webinar #2: Creep Compliance Input Level 2

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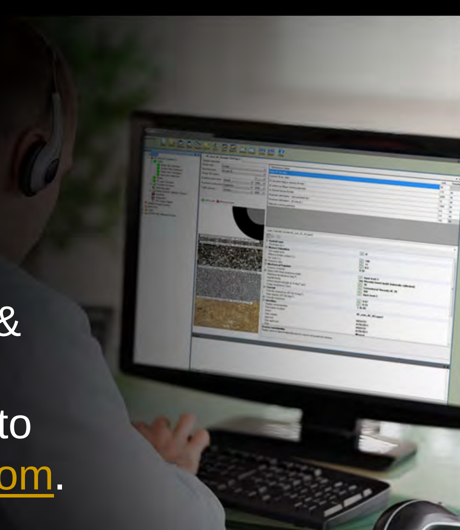
FY 2024 Webinar #2; Creep Compliance Input Level 2

QUESTION AND ANSWER SESSION

We welcome comments & suggestions for future webinars; Send an email to pavementmedesign@ara.com.



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Upcoming Webinars for FY 2024

- Webinars 3 and 4 will be announced in the PMED newsletter after the Task Force meeting in October.
- Reminder:
  - Slides, Q&A, and the recordings for all webinars are and will be posted at:
    - AASHTOWare Pavement ME Design - Webinar Series (me-design.com)

Looking for webinar topics for FY 2025 - Please submit any webinar topic suggestions.

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Upcoming Events for FY 2024

- 2024 Pavement ME Design Fall Task Force Meeting
  - October 11 & 12, 2023, Denver, Colorado

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Thank you for Attending the Webinar!

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ME Design Resource Website:
https://me-design.com/MEDesign/

Pavement ME Design Users Group Contact:
- Ryan Fragapane and Ben Sade

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Webinar is closed.

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