# Asphalt Expert Task Group Update and Emerging Topics



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U.S. DOT | Federal Highway Administration Asset Management, Pavement, and Construction

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# Asphalt Expert Task Groups

- Forum for Government, Industry, and Academia
- Discussion of ongoing asphalt binder and mixture technology
- Provide technical input for current and future research, development, and specifications.



# Asphalt Expert Task Groups

- Asphalt Mixture & Construction ETG
  - Last meeting on Sept 20-21, 2017
  - POC Matthew Corrigan
- Asphalt Binder ETG
  - Last meeting on Sept 19-20, 2017
  - POC Matthew Corrigan
- Sustainable Pavements TWG
  - POC Heather Dylla



Open Meetings All are Welcome!

# www.AsphaltETGs.org



Upcoming ETG Meetings To Be Announced

(Next tentative: 8-10 May 2018)

Past ETG Meetings September 2017 — Bozeman, MT May 2017 — Ames, IA September 2016 — Fall River, MA April 2016 — Salt Lake City, UT September 2015 — Oklahoma City, OK April 2015 — Fall River, MA September 2014 — Baton Rouge, LA

## **Current Asphalt ETG - Activities**

- Asphalt Mixture Performance Tester (AMPT)
- Performance Tests for Cracking/Fatigue
- RAP & RAS Asphalt Binder Replacement

- PEMD
- MSCR Binder Grading
- Ground Tire Rubber
- Performance Related/Based Specifications
- $\Delta T_c$  and related rheological parameters
- Provide technical input to AASHTO Committee on Materials & Pavements (COMP) & assist improvement, revision, and update of standards and specifications



# Asphalt Mix Performance Tester (AMPT)

www.fhwa.dot.gov/pavement/asphalt/tester.cfm

- Results used for ME Design and PRS/PBS inputs
- Adopted AASHTO Standards (2017):
  - R 83-17 for preparation of AMPT test specimens
    Draft small scale fabrication simplifies testing, reduces mix quantity, and allows evaluation of in service pavements
  - T 378-17 for Dynamic Modulus |E\*| and Flow Number (F<sub>n</sub>)
  - R 84-17 for developing |E\*| master curves
  - TP 107-14(2016) for Cyclic Fatigue (cracking)
  - and draft TP XX for Stress Sweep Rutting



Already invested in AMPT equipment for PavementME ... the AMPT can do much more than just |E\*| testing!!



# Why AMPT Cyclic Fatigue Test?

- 1<sup>\*</sup> Heritage and "pedigree" of the theory aerospace industry application for solid rocket propellant
- 2. Need for a performance test that would be defensible, <u>not</u> empirical correlations
- **3.** AASHTO TP 107-14 (2016) Determining the Damage Characteristic Curve of Asphalt Mixture from Direct Tension Cyclic Fatigue Tests
- 4. Connect mix design, construction, and acceptance by means of distress and performance prediction

- not just a pass/fail test



\*Refer to ETG presentation at previous 2016 AMAP meeting for significantly more details

# Why AMPT Cyclic Fatigue Test?

- 5. <u>The test tells you a lot about your mix!!!</u>
  - Response under multiple strains:
    STRUCTURE/TRAFFIC
  - Response under multiple load rates: TRAFFIC
  - Response under multiple temperatures: SEASONAL
  - More information gained from this test protocol and analysis than from other single tests at a single rate/temperature



# Reclaimed Asphalt Pavement (RAP) Reclaimed Asphalt Shingles (RAS)

#### RAP/RAS Task Force within ETG:

- AASHTO PP 78-17 Design Considerations for RAS
- Improvements to M 323 Superpave Design
  - Table 2 vs Table 3 requirements and limits
  - Definitions (P<sub>bRAP</sub>), references (MSCR & LTPPBind), appendices, editorial, and organization
  - RAP binder ratio (RAPBR) emphasis with binder grade adjustment guidelines
  - Evaluate blended binder properties to align with PP 78 recommendations
  - Future goal to incorporate both combined RAP & RAS materials together in guidance



# ETG RAP/RAS Task Force

Focus on the brittleness of the <u>blended</u> binder:

• Estimate brittleness of the blended binder with the Bending Beam Rheometer (BBR)

 $\Delta T_c$  = Stiffness critical temp (S) – the Relaxation critical temp (m-value)

• Previous work by M. Anderson, T. Bennert, G. Reinke indicates that when  $\Delta T_c < -5^{\circ}C$  there is a significant loss of cracking resistance.



Performance Engineered Mixture Design "Balanced Mix Design" Task Force

Approaches identified for potential use with emphasis on performance & engineered

mixtures:

For additional information refer to 2017 AMAP .ppt



Performance Related Specifications the evolution & next generation of QA specifications

> "QA specifications that describe the desired levels of <u>key materials and construction</u> <u>quality characteristics</u> that have been found to <u>correlate with fundamental</u> <u>engineering properties that predict</u> <u>performance</u>"

> > Transportation Research Circular Number E-C137 Glossary of Highway Quality Assurance Terms



# Many PRS Benefits!

Only a few highlighted here.

- Allow contractors to be more <u>innovative</u> and more <u>competitive</u>
- Long term pavement performance determined from more <u>fundamental</u> <u>engineering properties</u>
- Connect & align <u>design with construction</u>
- Incentives & disincentives justified through reduction or increase in expected pavement life



# **PRS** Initiative

- Use of fundamental tests to capture variance between as-designed and asbuilt Acceptance Quality Characteristics (AQC)
- Asphalt Mixture Performance Tester (AMPT) used in mixture design
- Performance volumetric relationships used in construction
- Structural response model

- (stresses and strains, temperature and loading)



# **PRS** Initiative

Fundamental

FHWA PRS

- How much distress? How much life?
- Stresses and strains
- Material properties (i.e., modulus)
- Use with structural response model (i.e. FlexPAVE)
- Many temperature/loading conditions represented
- Index-Based
  - Go/no-go: correlation-based
  - Some engineering properties, some empirical
    - More tied to a local material database
  - Not used with structural response model
  - Only a few temperature/loading conditions represented

U.S. Department of Transportation Federal Highway Administration Cost-efficient way to account for relevant distress!!

## FlexMAT<sup>™</sup> and FlexPAVE<sup>™</sup> Available

- FlexMAT<sup>TM</sup> Excel spreadsheet
  - Analyzes cyclic fatigue, |E\*|, and SSR data
  - Import files directly
  - Output  $\rightarrow$  FlexPAVE<sup>TM</sup>
- FlexPAVE<sup>™</sup> performance prediction tool
  - PEMD through acceptance
  - Simulate as-design and as-built performance



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# Predicts Performance!!

# Material Behavior Across All Loading Conditions

- Time-temperature superposition
  - Major benefit
  - Reduces testing time
  - Enables robustness of models
- Fundamental properties required to describe behavior across wide-range of conditions
- Allows for direct incorporation of pavement structure into predictions

# Material Behavior Across All Loading Conditions

- THIS IS A KEY DIFFERENCE WHEN COMPARED pavement structure into predict

# Multiple Stress Creep Recovery (MSCR)

FHWA is working with the Asphalt Institute to assist States to effectively understand and implement MSCR.

• Technical Brief FHWA-HIF-11-038



• Resources posted on Al's website

 www.asphaltinstitute.org/public/engineering/ mscr-information.dot





mum

# MSCR J<sub>nrdiff</sub> Task Force

- AASHTO T 350-14 and M 332-14
- Emphasis on determining J<sub>nrdiff</sub>
  - $J_{nr}$  change with stress increase
  - Impact of stress selection on J<sub>nr</sub> while staying within the binder's linear range
  - $-J_{nr}$  slope determination
  - E grade J<sub>nrdiff</sub> waiver





# DSR Concentric Cylinder (CC) Task Force

- Extensive development work conducted on rubber modified binder with CC geometry
  - Reveals the practical and rheological challenges
  - Suitable measuring geometry for PG measurements of ground tire rubber modified asphalt binders
  - Finalized tool dimensions and requirements
- DSR ... CC geometry also called "Cup & Bob" geometry
  - "required to enable good rheology!" ... "Gap size matters!"



# Small cylinder inside a big cylinder enables the use of large gaps



# DSR Concentric Cylinder (CC) Task Force

### Draft AASHTO test standard development

- TP XX-YY Determining the Rheological Properties of Asphalt Binder Containing Ground Tire Rubber Particulates Using Concentric Cylinder Geometry in the Dynamic Shear Rheometer (DSR)
  - PG High temperature characterization
  - Procedure to calibrate/verify torque and temperature
- Future
  - RTFO aging and BBR testing



# Re-refined Engine Oil Bottoms (REOB) Vacuum Tower Asphalt Extender (VTAE)

## Task Force within ETG

- Draft white paper finalized (to be published)
- Which rheological parameter
  - critical temperature change ( $\Delta T_c$ )
  - Glover-Rowe (GR)
  - rheological index (R value)
  - cross over frequency ( $\omega_c$ ) and temp ( $T_{\omega c}$ )
- All of these parameters can be interrelated from understanding the relationship between loading time (or frequency) and temperature.



## $\Delta T_c$ and related rheological parameters

Focus on the brittleness of the <u>blended</u> binder:

• Estimate brittleness of the blended binder with the Bending Beam Rheometer (BBR)

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# $\Delta T_c$ and related rheological parameters

- Current 20 hour PAV does not represent enough aging to identify critical conditions or to match field aging by pavements
- 40 hour PAV correlated with performance
- Options for achieving additional aging are being explored
  - Thinner asphalt films
    - PAV or USAT (Universal Simple Aging Test)
  - Predicted  $\Delta T_c$  from difference between:
    - Rate of change: original binder to RTFOT to 20 hour PAV



## $\Delta T_c$ and related rheological parameters

- Other parameters that provide similar info?
  - Aging decreases  $\Delta T_c$ , increases R-value, decreases crossover frequency, and increases crossover temperature
- Relationship between  $\Delta T_c$  and  $T_{\omega c}$ 
  - Cross over temperature ( $T_{\omega c}$ ) measured at 10 radians/sec where the phase angle is 45° or tan  $\delta$ = 1
  - $T_{\omega c}$  is easy to measure on RTFO aged binder



# PAV Degassing

- Laboratories routinely confuse barometric pressure with the barometric pressure reported by the local weather station
  - Barometric pressure reported by local weather station is corrected to sea level
    - Useless for our purposes!
  - Absolute vacuum gage should be specified
  - Tie vacuum level to elevation



# PAV Degassing - Proposal

When using a vacuum gage to control the degassing pressure, the gauge readings given by Eq. 4 calculated using the laboratory elevation to the nearest 100 feet shall be used to control and report the vacuum during the degassing cycle. Equation 4 accounts for changes in atmospheric pressure with elevation. No additional corrections for laboratory barometric pressure, temperature, humidity, etc. shall be applied to the vacuum gage reading regardless of instructions supplied by any vendors, instrument software, or other source. The vacuum gage reading shall be reported and controlled to the nearest 0.5 in Hg (0.2 kPa).



# PAV Degassing - Proposal

- The absolute pressure calculated in accordance with Eq. 4 shall be 5.0 ± 0.50 inches of mercury (17 ± 1.7 kPa).
- As a minimum the gage shall be read and reported to the nearest 0.5 inches Hg (2 kPa)



# PAV Pan Warping

1. How can we measure pan flatness?

a. Current techniques are not satisfactory

2. How do we obtain direct measure of flatness?

a. Profile is needed

3. How do typical pan flatness errors affect test results?

- a. If flatness and property vs. thickness data are available, it can be estimated
- b. Determined experimentally by using warped pans

# PAV Pan Warping

- 4. How can we measure pan flatness in specification scenario?
- 5. What are realistic limits for specifying pan

flatness?





Measuring jig and photo provided by Dr. David Anderson

# **Profiling and Calculated Effect**

- Pan divided into 28 segments
- Profile measured at centroid of each profile
- Properties for each segment can be weighted as long as effect of thickness on properties is known



 Can also estimate effect of pan and vessel levelness



# Profiling and Calculated Effect





Courtesy of Dr. David Anderson

Enhanced Durability through Increased In-Place Pavement Density

- Assumption Pavement density can be increased with a minimum of additional cost.
- Long-Term Objective States will increase their in-place asphalt pavement density requirements resulting in increased pavement life.



# Enhanced Durability through Increased In-Place Pavement Density

- A 1% increase in field density (1% less air voids) is can increase asphalt pavement service-life 10+%! (conservatively)
- Today's compaction target is typically 92% of maximum (G<sub>mm</sub>) (8% air voids), with varying requirements for the area near the longitudinal joint

Increased Density Pavements target a 1-2% increase across the entire pavement! — Just 1% more... makes a huge difference!



### Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density



#### Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density



# Next Steps

- Field experiment Phase 1
  - 10 states selected
  - Projects completed in 2016
- Extend field experiment Phase 2
  - 9 states selected
  - Projects constructed in 2017 and early 2018
- Extend field experiment Phase 3
  - Proposals due end of Jan for 2018 projects
- FHWA's best practices communication
  - Summary document
  - Tech Brief
  - Additional workshops (funding dependent)

# Summary Document

### NCAT Report 17-05

"Demonstration Project for Enhanced Durability of Asphalt Pavements through Increased In-place Pavement Density" - July 2017



U.S. Department of Transportation Federal Highway Administration

http://eng.auburn.edu/research/centers/ncat/files/technicalreports/rep17-05.pdf

# Can we achieve increased density?



Test sections had increased % TMD:

- 8 of 10 states achieved > 1.0% increase
- 7 of 10 states achieved > 94.0% G<sub>mm</sub>
- 6 of 10 states achieved > 95.0% G<sub>mm</sub>
  Will there be changes?
- 7 of 10 states are changing specifications



# FHWA Field Support Mobile Asphalt Testing Trailer (MATT)

- Mobile Asphalt Pavement Materials Lab
  - Site Visits & Shadow Projects
  - Field Data/Testing/Evaluation
  - Use/Demo Emerging Innovations
  - POC: David Mensching

#### or Matthew Corrigan



# Thank You!!

#### Discussion / Comments / Questions





FHWA's Mobile Asphalt Testing Trailer Office of Asset Management, Pavement, and Construction



U.S. Department of Transportation Federal Highway Administration

www.fhwa.dot.gov/pavement/asphalt