

Asphalt Expert Task Group Update and Emerging Topics



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U.S. DOT | Federal Highway Administration
Preconstruction, Construction, and Pavements



U.S. Department of Transportation
Federal Highway Administration

October 2017

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 in Bozeman on Sept 20-21, 2017
 - POC – Matthew Corrigan
- Asphalt Binder ETG
 - Last meeting in Bozeman on Sept 19-20, 2017
 - POC – Matthew Corrigan
- Sustainable Pavements TWG
 - POC – Gina Ahlstrom



Open Meetings
All are Welcome!



www.AsphaltETGs.org

EXPERT TASK GROUPS ASPHALT MIX & ASPHALT BINDER

WWW.ASPHALTETGS.ORG

Upcoming ETG Meetings

To Be Announced

(Next tentative- week of April 23, 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
 - Balanced Mix Design
 - MSCR Binder Grading
 - Ground Tire Rubber
- Asphalt Binder Replacement
- Performance Related/Based Specifications
- ΔT_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
 - T 378-17 for Dynamic Modulus $|E^*|$ and Flow Number (F_n)
 - R 84-17 for developing $|E^*|$ master curves
 - TP 107-14(2016) for Cyclic Fatigue (cracking)
 - and draft TP XX for Stress Sweep Rutting



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



Why AMPT Cyclic Fatigue Test?

- 1.* Heritage and “pedigree” of the theory – aerospace industry application for solid rocket propellant
2. Need for a performance test that would be defensible, not 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



Why AMPT Cyclic Fatigue Test?

5. The test tells you a lot about your mix!!!
 - 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
6. Connect mix design, construction, and acceptance by means of distress and performance prediction
 - not just a pass/fail test



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 ($P_{bR\text{AP}}$), 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 blended binder:

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

ΔT_c = Stiffness critical temp (S) – the Relaxation critical temp (m-value)

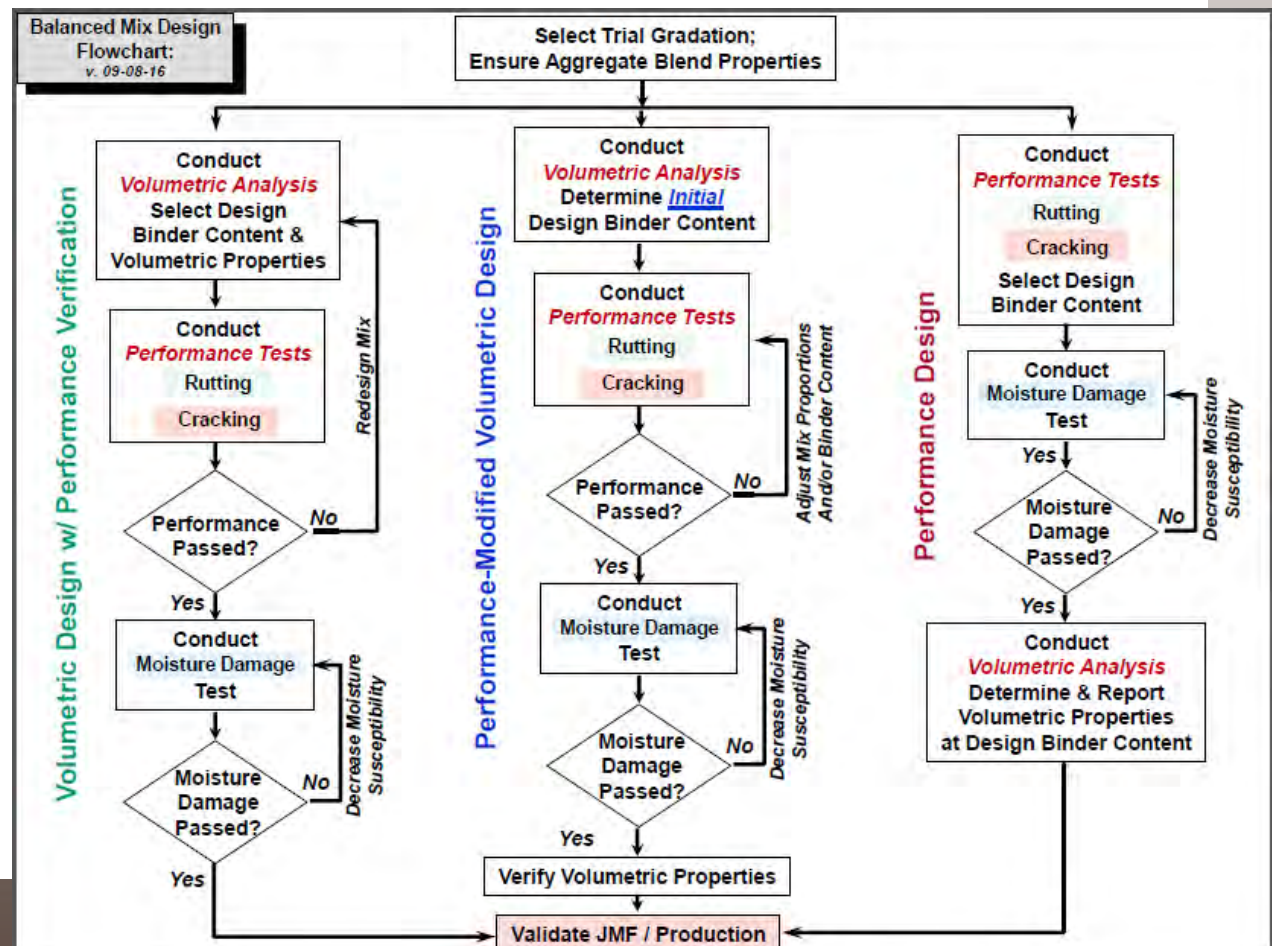
- Previous work by M. Anderson, T. Bennert, G. Reinke indicates that when $\Delta T_c < -5^\circ\text{C}$ there is a significant loss of cracking resistance.



Balanced Mix Design Task Force

- Three main approaches were identified for potential use:

For details, refer to the 18 Oct 2017 NEAUPG .ppt provided by Shane Buchanan



Balanced Mix Design Task Force

Current Activities

- Information Outreach
 - Present BMD concepts
 - Highlight the benefit of BMD concepts
- Field Acceptance
 - Define various approaches for acceptance protocols within a BMD approach



Performance Related Specifications

“QA specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance”

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



Pavement
Design

How PRS Works

Planning

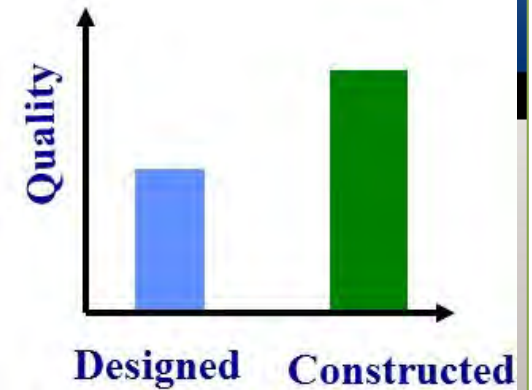


Establish Performance
Criteria



Identify AQC's and
Target Values

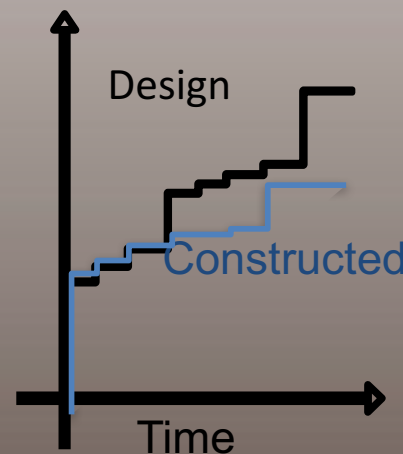
SOFTWARE



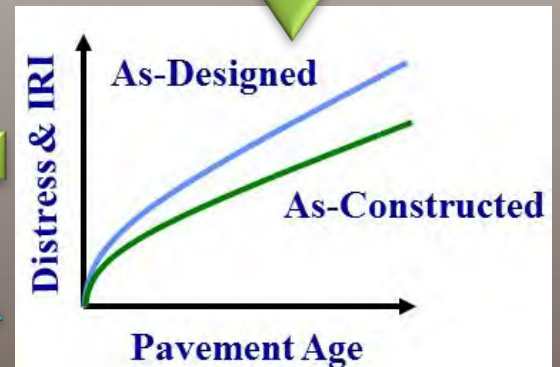
Design AQC vs.
As-Constructed AQC



Pay Factor



Compare As-Built
and As-Designed



Model
Performance

Value of
Performance?



Benefits of PRS

- Long term pavement performance predicted from fundamental engineering properties
- Incentives and disincentives justified through reduction or increase in pavement life
- Allow contractors flexibility to be innovative and competitive

YES!



PRS Initiative

- Use of fundamental tests to capture variance between as-designed and as-built AQC's
- Asphalt Mixture Performance Tester (AMPT) used in mixture design
- Performance volumetric relationships used in construction
- Structural response model (stresses and strains)



PRS Initiative

- Fundamental



FHWA PRS

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



FlexMAT™ and FlexPAVE™ Available

- FlexMAT™ – Excel spreadsheet
 - Analyzes cyclic fatigue, $|E^*|$, and SSR data
 - Import files directly
 - Output → FlexPAVE™
- FlexPAVE™ – performance prediction tool
 - PEMD through acceptance
 - Simulate as-design and as-built performance



FlexMAT™ and FlexPAVE™ Available

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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

temperature superposition

THIS IS THE KEY DIFFERENCE WHEN COMPARED TO OTHER AVAILABLE METHODS!

- Fundamental describe bending conditions
- Allows for direct incorporation of pavement structure into prediction



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
 - www.fhwa.dot.gov/pavement/asphalt/index.cfm
- Resources posted on AI's website
 - www.asphaltinstitute.org/public/engineering/mscr-information.dot

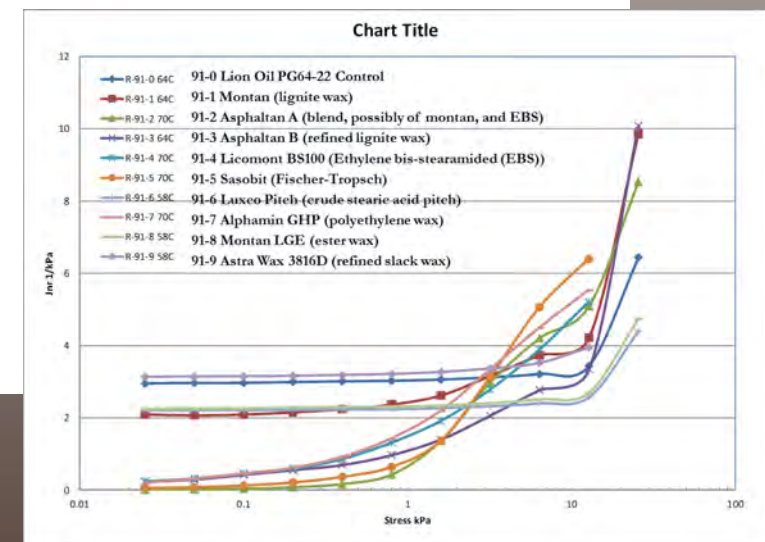


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MSCR $J_{nr\text{diff}}$ Task Force

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



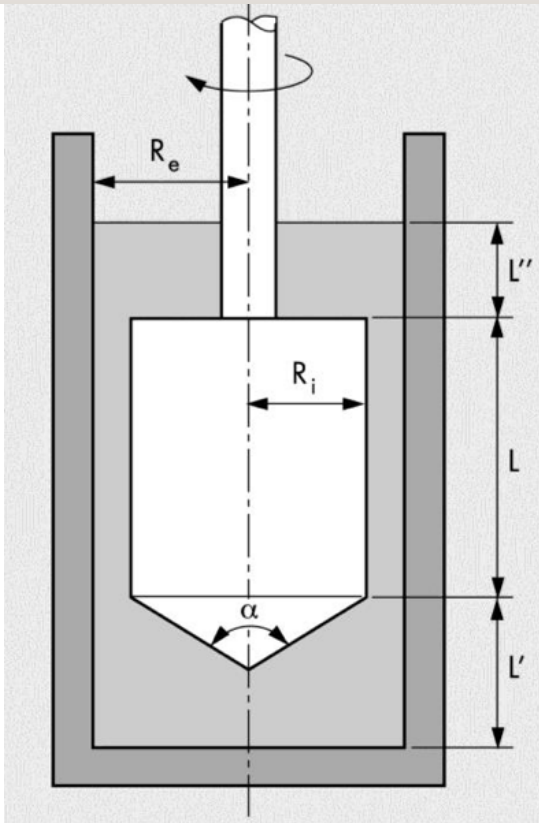
DSR Concentric Cylinder (CC) Task Force

- 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 ... concentric cylinder geometry also called “Cup & Bob” geometry
 - “required to enable good rheology!” ... “Gap size matters!”



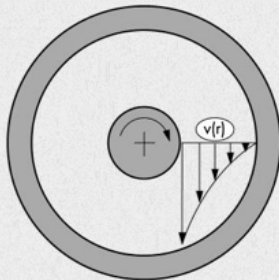
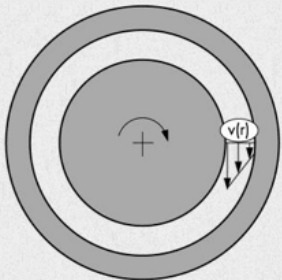
Small cylinder inside a big cylinder enables the use of large gaps

Courtesy of Anton Paar



Absolute

Relative



CC17SP

Gap ≈ 6.2 mm

Suitable for neat and RTFO
asphalt binder
(high PG temperatures)



CC10SP

Gap ≈ 9.5 mm

Suitable for PAV asphalt
binder (intermediate
PG temperatures)

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 (ΔT_c)
 - Glover-Rowe (GR)
 - rheological index (R value)
 - cross over frequency (ω_c)
- All of these parameters can be interrelated from understanding the relationship between loading time (or frequency) and temperature.



ΔT_c and related rheological parameters

Focus on the brittleness of the blended binder:

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

ΔT_c = Stiffness critical temp (S) – the Relaxation critical temp (m-value)

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



ΔT_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 ΔT_c from difference between:
 - Rate of change: original binder to RTFOT to 20 hour PAV



ΔT_c and related rheological parameters

- Other parameters that provide similar info?
 - Aging decreases ΔT_c , increases R-value, decreases crossover frequency, and increases crossover temperature
- Relationship between ΔT_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)



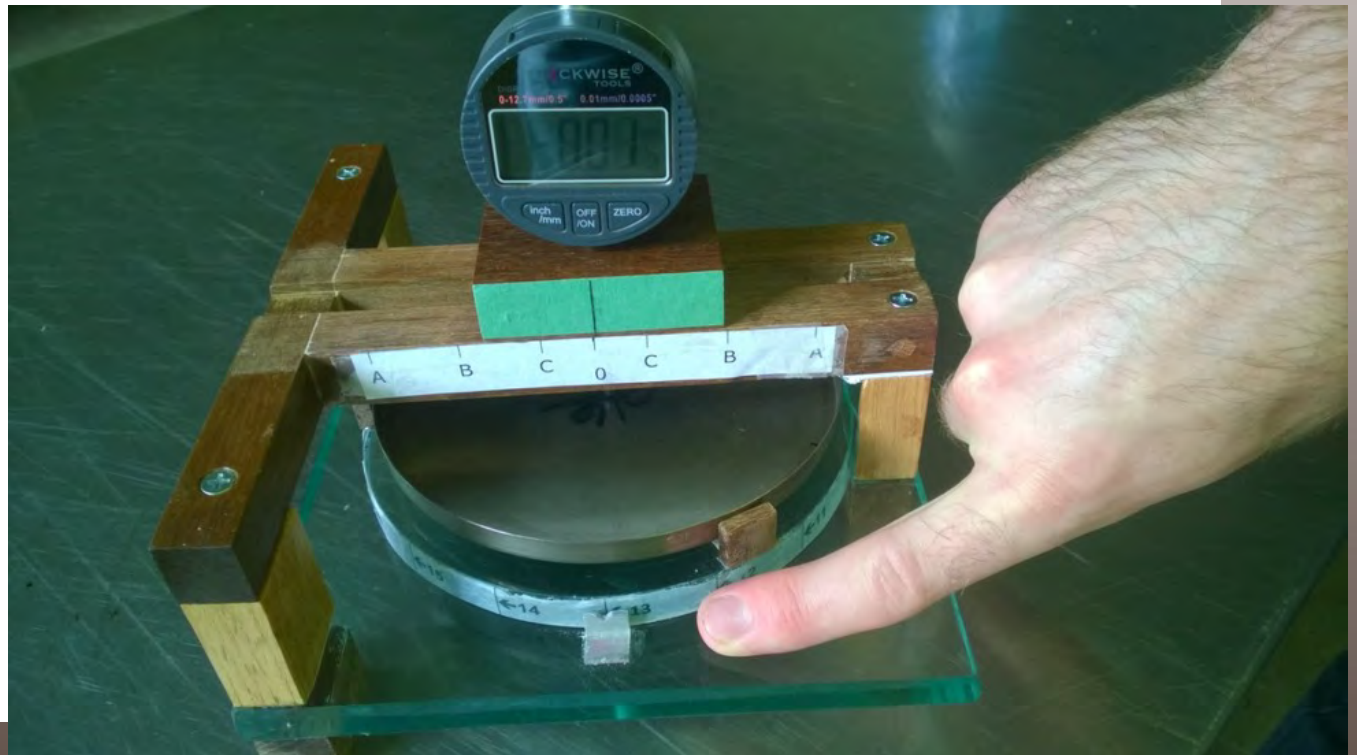
PAV Pan Warping

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



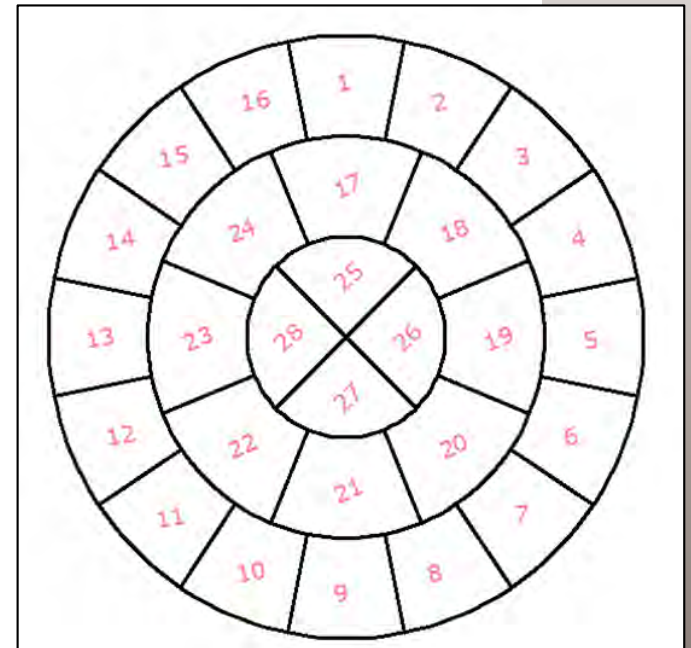
PPAV Pan Warping

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

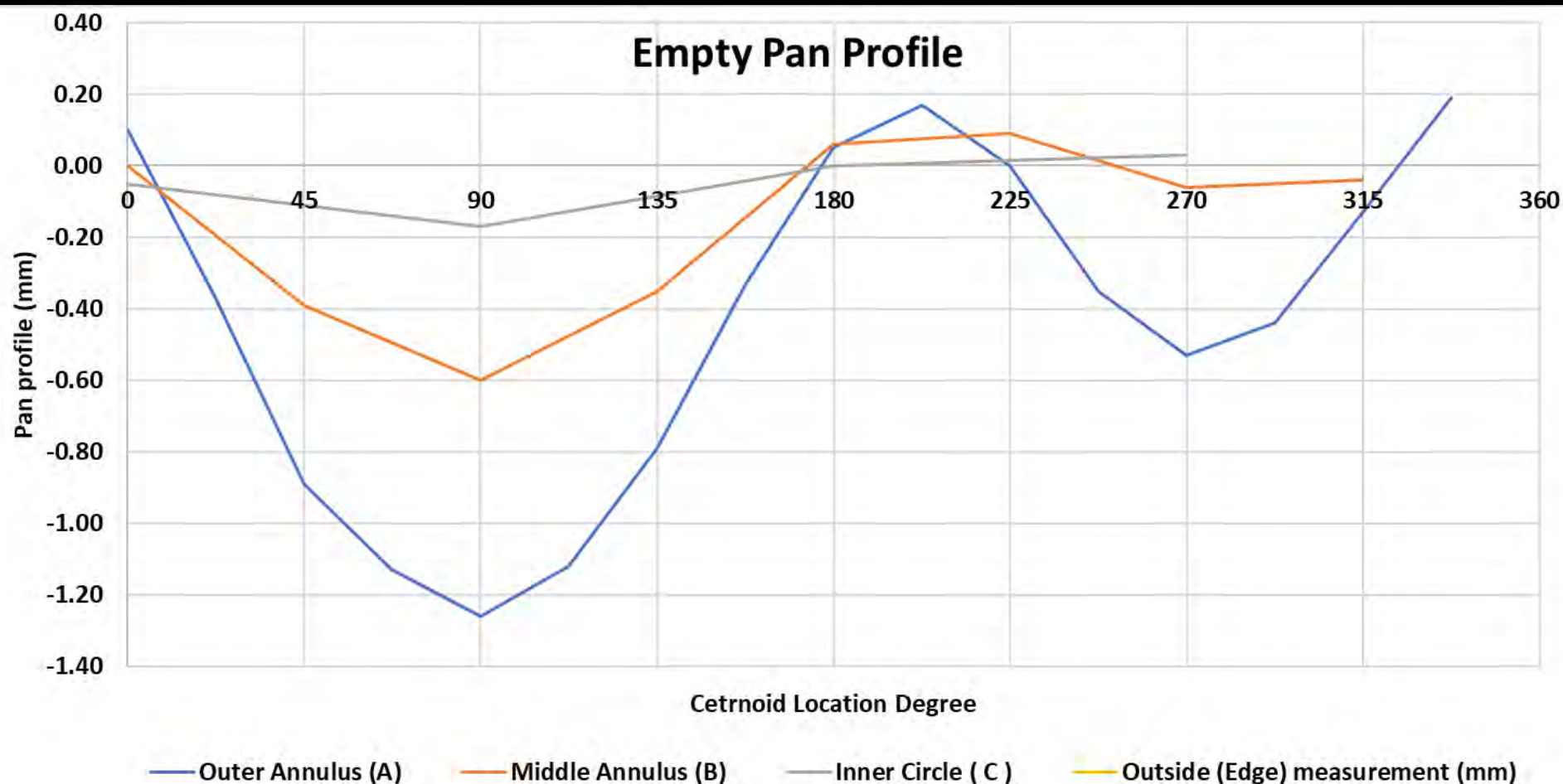


Profiling and Calculated Effect

- 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



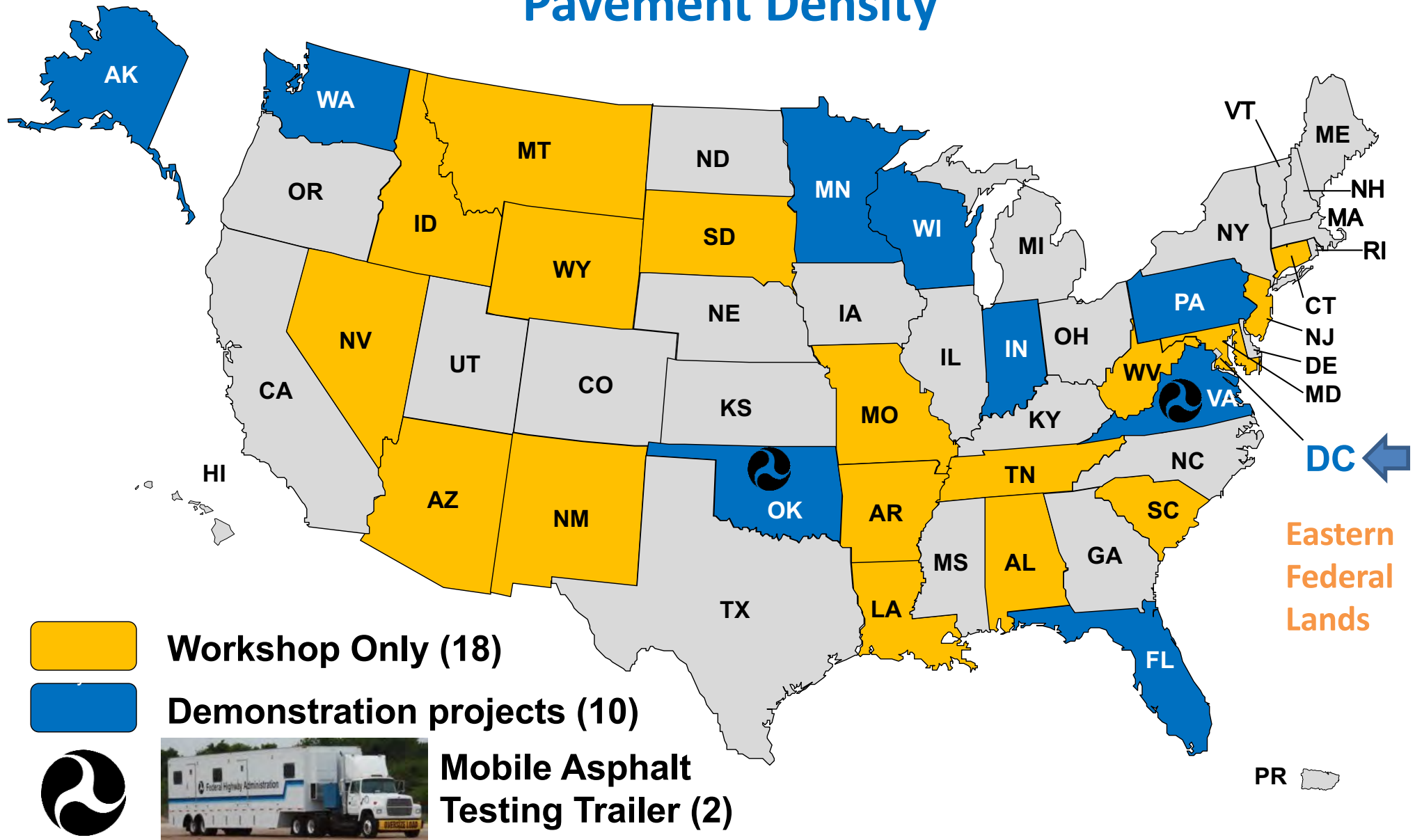
Enhanced Durability through Increased In-Place Pavement Density

- A 1% increase in field density (1% less air voids) can increase asphalt pavement service-life 10+%! (conservatively)
- Today's compaction target is typically 92% of maximum (G_{mm}) (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

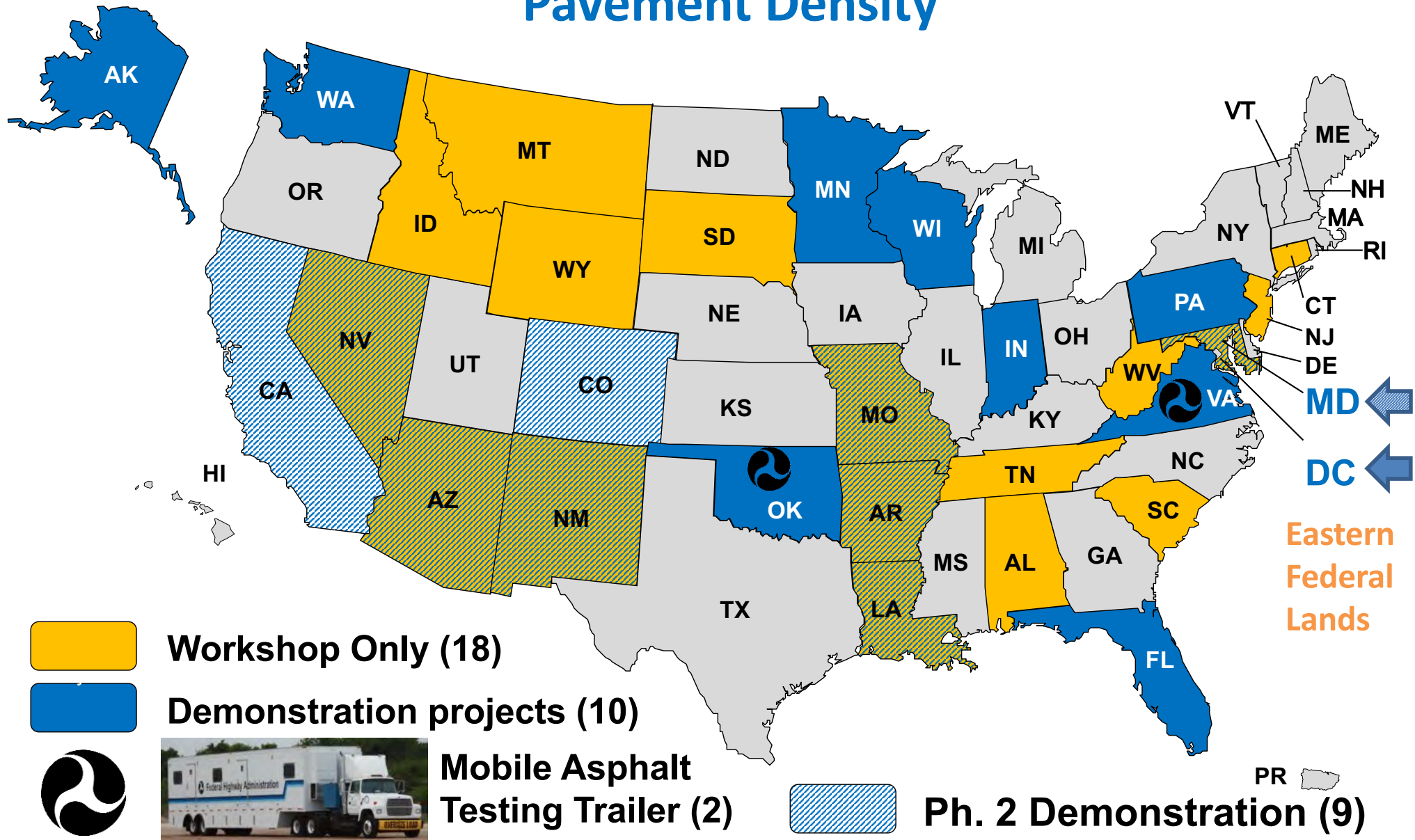


Next Steps

- Field experiment – Phase 1
 - 10 states selected
 - Projects completed in 2016
- Extend field experiment – Phase 2
 - 9 states selected
 - Projects under construction in 2017 and early 2018
- Potential additional field projects in 2018?
- FHWA's best practices communication
 - Summary document
 - Tech Brief
 - Additional workshops (funding dependent)



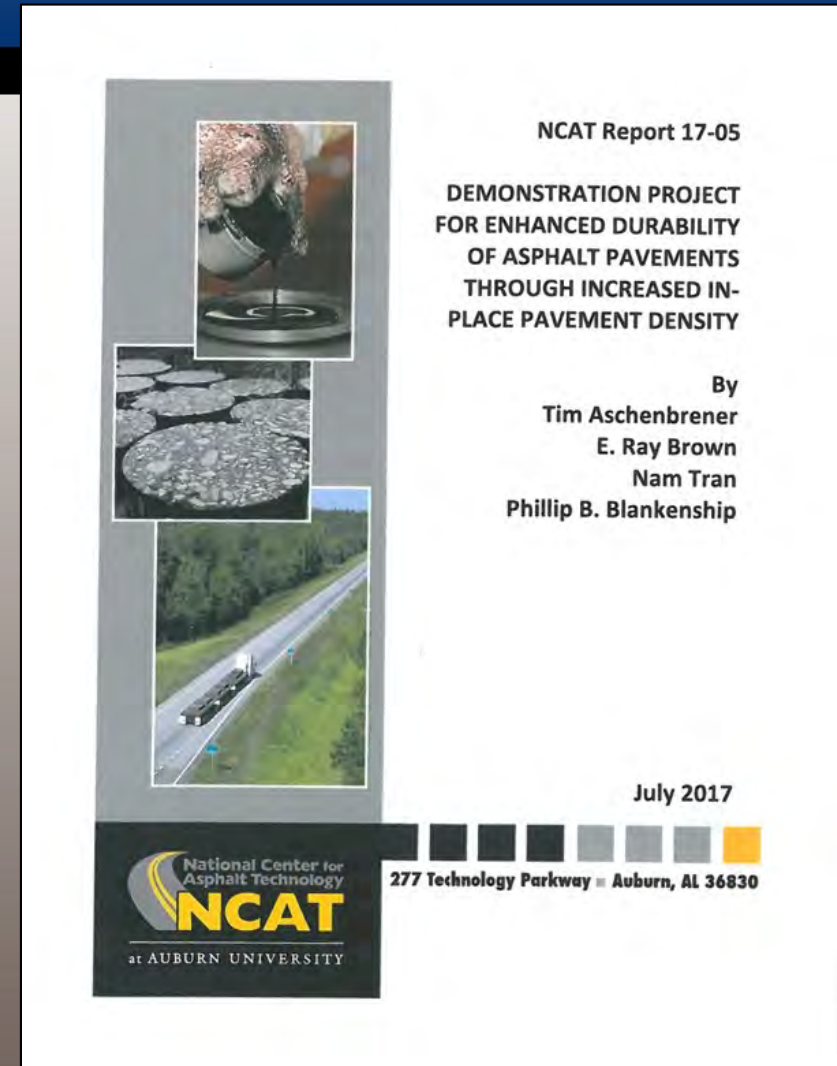
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density



Summary Document

NCAT Report 17-05

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



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<http://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep17-05.pdf>

Can we achieve increased density?

A 3D rendered word "Yes!" in a bright green color, with a slight shadow underneath, giving it a three-dimensional appearance.

Test sections had increased % TMD:

- 8 of 10 states achieved > 1.0% increase
- 7 of 10 states achieved > 94.0% G_{mm}
- 6 of 10 states achieved > 95.0% G_{mm}

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
 - Field Data/Testing/Evaluation
 - Use/Demo Emerging Test Devices
 - POC: Matthew Corrigan and David Mensching



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

