Mobile Asphalt Testing Trailer Program (MATT): Recent Experience in Arizona

All images FHWA unless otherwise noted.

Arizona Pavements/Materials Conference
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U.S. Department of Transportation
Federal Highway Administration
Office of Infrastructure

Amir Golalipour, Ph.D.
David J. Mensching, Ph.D., P.E.

Office of Preconstruction, Construction, and Pavements

Agenda

- FHWA Pavement and Materials
- Binder Activities
- Asphalt Mixture Performance Tester (AMPT)
- Arizona Project Results & Discussions
- Questions

Acronyms

- AASHTO: American Association of State Highway and Transportation Officials
- ABCD: Asphalt Binder Cracking Device
- ABTL: Asphalt Binder Testing Laboratory
- AIMS: Aggregate Imaging System
- AMPT: Asphalt Mixture Performance Tester
- BBR: Bending Beam Rheometer
- CAA: Coarse Aggregate Angularity
- CC: Concentric Cylinders
- DSR: Dynamic Shear Rheometer
- DTT: Direct Tension Tester
- ETG: Expert Task Group
- Gmb: Bulk Specific Gravity
- GTR: Ground tire rubber
- HMA: Hot mix asphalt
- HQ: Headquarters
- MATT: Mobile Asphalt Testing Trailer
- MSCR: Multiple Stress Creep and Recovery
- PAV: Pressure Aging Vessel
- PEMD: Performance-Engineered Mixture Design
- PG: Performance Grading
- PRS: Performance Related Specification
- QA: Quality Assurance
- RAP/RAS: Reclaimed Asphalt Pavement/Reclaimed Asphalt Shingles
- RTFO: Rolling Thin-film Oven
- RV: Rotational Viscometer
- SSR: Stress Sweep Rutting
- TFHRC: Turner-Fairbank Highway Research Center
- WMA: Warm Mix Asphalt

Note: FHWA does not endorse products or manufacturers. Trade or manufacturers' names appear in this presentation solely for informational purposes.

Pavement & Materials Discipline

- Program Office
  - Office of Preconstruction, Construction, and Pavements (FHWA HQ, Washington, DC)
    - Mobile Asphalt Testing Trailer (MATT)
    - Asphalt Binder Testing Laboratory (ABTL)
- Research and Development
  - TFHRC (McLean, VA)
- Technical Services
  - Resource Center
- Divisions

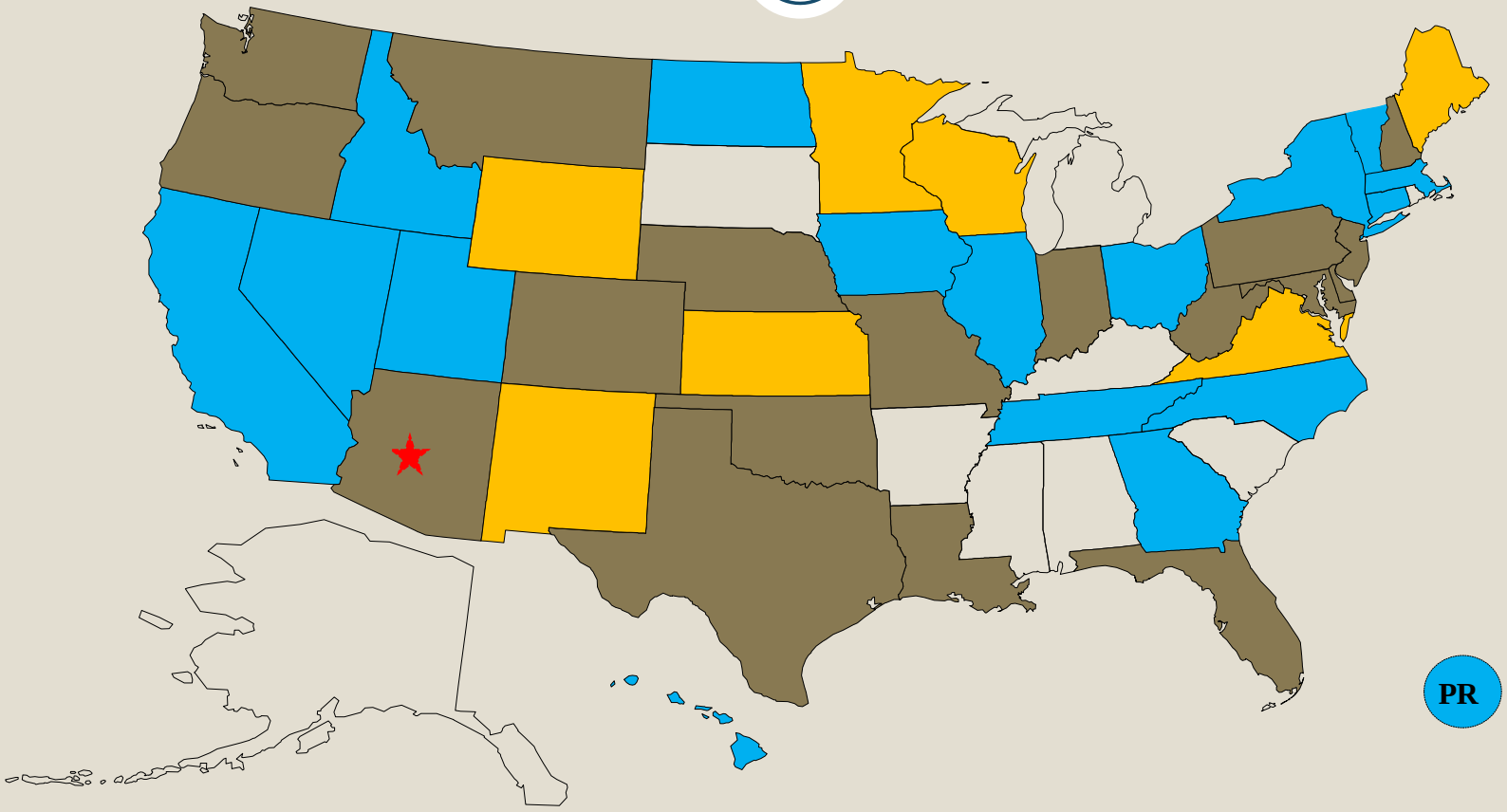
Program Objective

- Provide Support to National Initiatives
  - Performance-Engineered Mixture Design (PEMD)
  - Increased Pavement Density
  - Development of New QA Concepts for HMA
  - Understanding Asphalt Rubber Testing
  - Binder Performance Testing
- Provide Assistance with State-specific Issues
  - Technical Guidance
  - Forensics

MATT Program History

- Projects began in 1988
  - Demonstration Project 74: Field Management of Asphalt Mixes Using Volumetric Quality Control
- Transition to Superpave implementation
  - Early 1990s
  - Classroom and hands-on training
- Transition to performance-related specifications
  - Shadow testing
  - AMPT user since 2003
- Innovative materials and practices
  - WMA, SMA, GTR, RAP/RAS, increased density

MATT visits since 2007

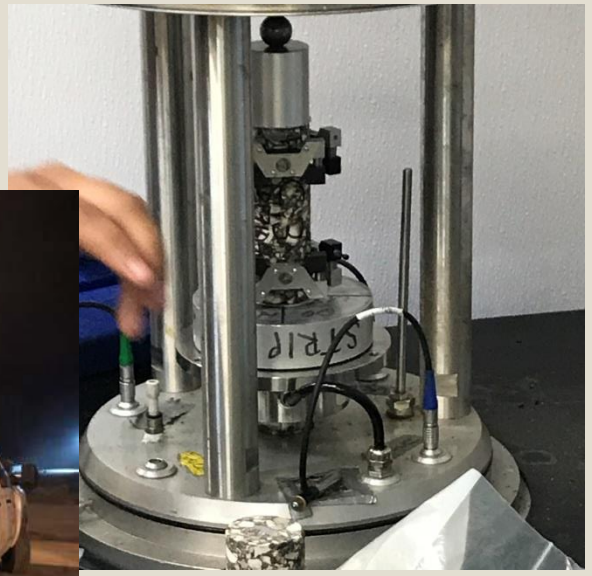


Technical Workshops

Training

Training for the Maryland State Highway Administration staff

Field visits



Other MATT Activities

- Conferences
- Expert task group support
- NCHRP panels and project participation
- Division Office rotational assignments
- Academic journal papers and presentations

Deployment Status: Asphalt Rubber

- Seven projects between 2013 to 2015
- Collaboration with four State DOTs to evaluate their specifications based on project results
- Working with FHWA ETG to develop AASHTO standard for asphalt rubber testing

Binder Activities

Binder Characterization

TEST PROCEDURES

- Performance Grading
  - AASHTO M 320
  - AASHTO M 332 (MSCR)
  - AASHTO R 49 (Low Temperature PG)
- Solubility & Separation
  - AASHTO T 44
  - ASTM D7173

EQUIPMENT

- RV
- DSR
- RTFO
- PAV
- Vacuum Degassing Oven
- BBR
- DTT
- ABCD (AASHTO TP 92)
- Torsional bar testing

MSCR Criteria: AASHTO M 332 - J_{nr}

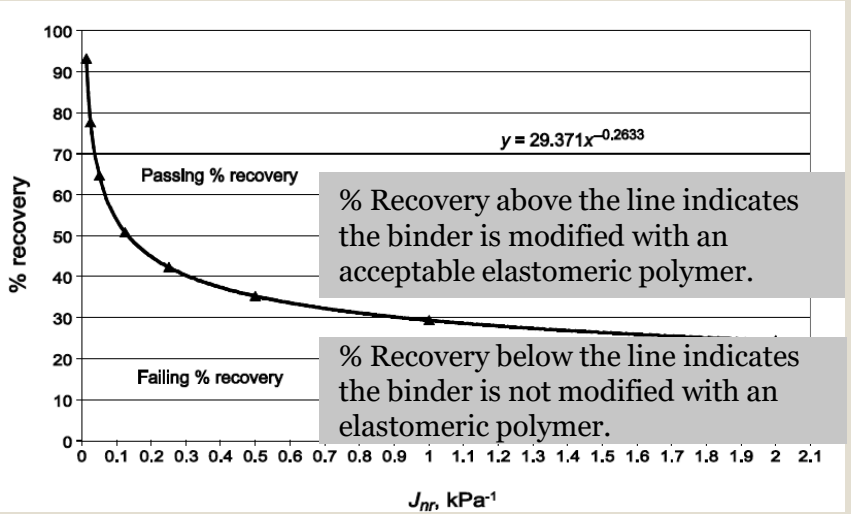
- Boundaries for J_{nr} values are established based upon traffic level.
- As traffic level increases, lower J_{nr} value is required -> basically stiffer binder.

Traffic Loading	$J_{nr3.2}$ (1/kPa)	J_{nrdiff} (Percent)	Recommended Traffic Levels
Standard Traffic (S)	≤ 4.5	Maximum 75%	< 10 million ESALs or Traffic Speed >70 km/h
Heavy Traffic (H)	≤ 2.0	Maximum 75%	10 to 30 million ESALs or Traffic Speed 20 to 70 km/h
Very Heavy Traffic (V)	≤ 1.0	Maximum 75%	> 30 million ESALs or Traffic Speed < 20 km/h
Extremely Heavy Traffic (E)	≤ 0.5	Maximum 75%	> 30 million ESALs and Standing Traffic (Toll plaza or Port)

MSCR Criteria: AASHTO R 92 - R%

- % Recovery is plotted vs. J_{nr}.
- Boundaries are established based upon measured J_{nr} values at 3.2 kPa.
- A simple above the line/below the line criteria provides the needed validation of polymer modification.

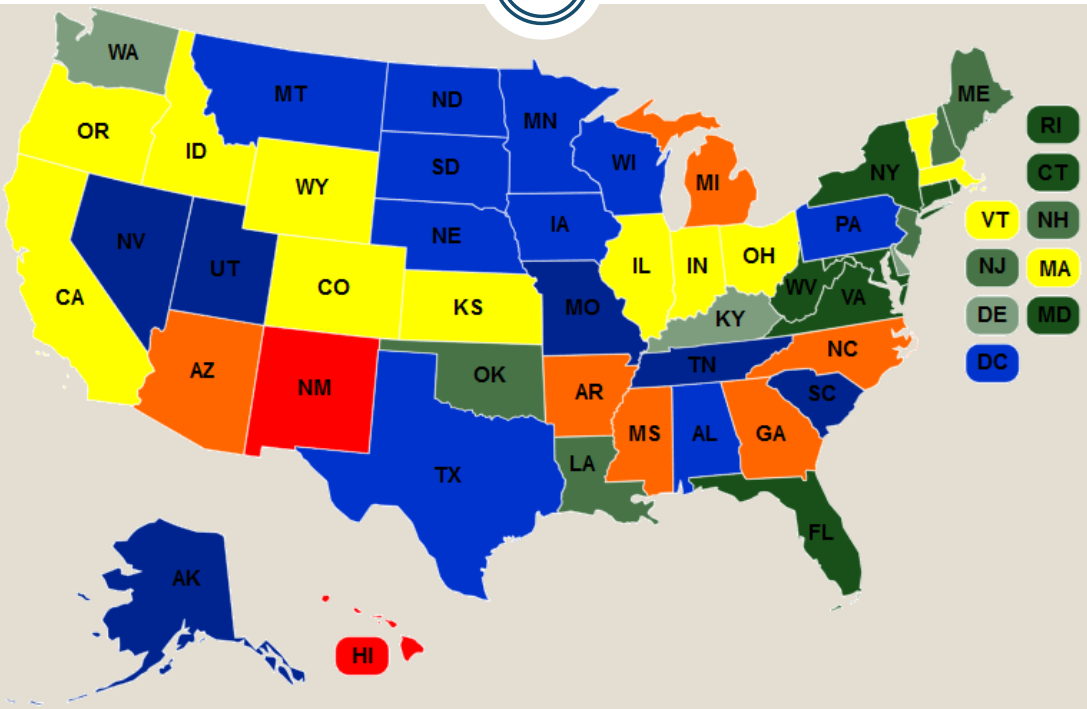
Minimum % Recovery for Measured J_{nr} values	
J_{nr} @ 3.2 kPa	Minimum % Recovery
2.0 - 1.01	30%
1.0 - 0.51	35%
0.50 - 0.251	45%
0.25 - 0.125	50%



Source: Asphalt Institute

Good agreement has been established between **elastomeric polymer modification** and rutting resistance.

MSCR Implementation



State Color Key

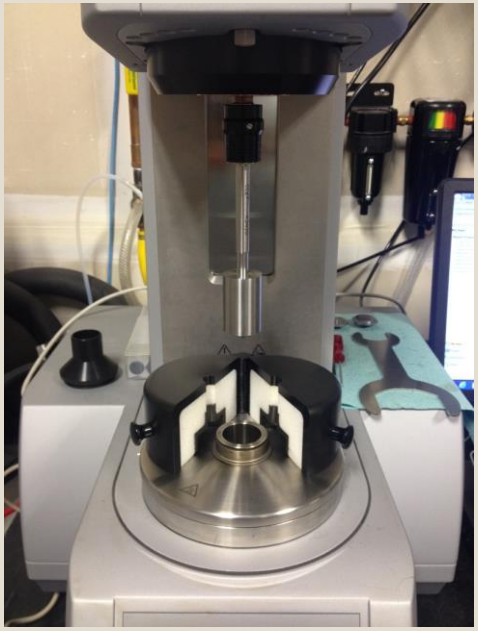
- Full Implementation
- Full Implementation Modified Grades Only
- Planned Full Implementation (12 months)
- Partial Implementation
- Planned Partial Implementation (12 months)
- Considering Implementation (No TIme Frame)
- Testing/Evaluation
- No Activity
- To Be Posted Soon

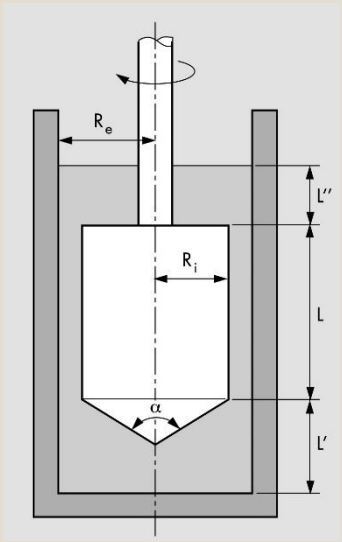
Source: Asphalt Institute

DSR Testing Alternative: Asphalt Rubber Binder

- Can it fit within existing PG grading system?
- DSR Testing Geometry
  - Caltrans, University of California Pavement Research Center, Anton Paar, etc.
  - Concentric cylinder (CC) development testing evaluation looks promising.
  - CC test geometry may overcome specimen preparation limitations of PP geometry.
  - Draft AASHTO standard in development.

Concentric Cylinder Geometry





- Advantages
  - GTR modified asphalt can be measured with particle sizes up to 2 mm.
  - No trimming problems and filling problems.
  - No edge effects.

Low Temperature BBR Test:
Binder New Parameter (ΔTc)

- ΔTc has been identified as an important parameter related to asphalt binder durability.
  - ΔTc = S critical temp - m critical temp.
- As an asphalt binder ages, ΔTc value becomes more negative.
  - Indicating a loss of relaxation properties.
- Threshold of -5 °C being evaluated as a cracking criteria.

Mixture Activities

Performance Testing

- AASHTO T 378 (former TP 79)
  - Dynamic Modulus
    - Mixture Stiffness
    - Rutting
    - Fatigue Cracking
  - Flow Number
    - Rutting
- AASHTO TP 107
  - Cyclic Fatigue
- AASHTO TP XX
  - Stress Sweep Rutting (SSR)

Small Specimen Testing

- Proposed to enable field core testing
- To improve the efficiency of laboratory specimen fabrication

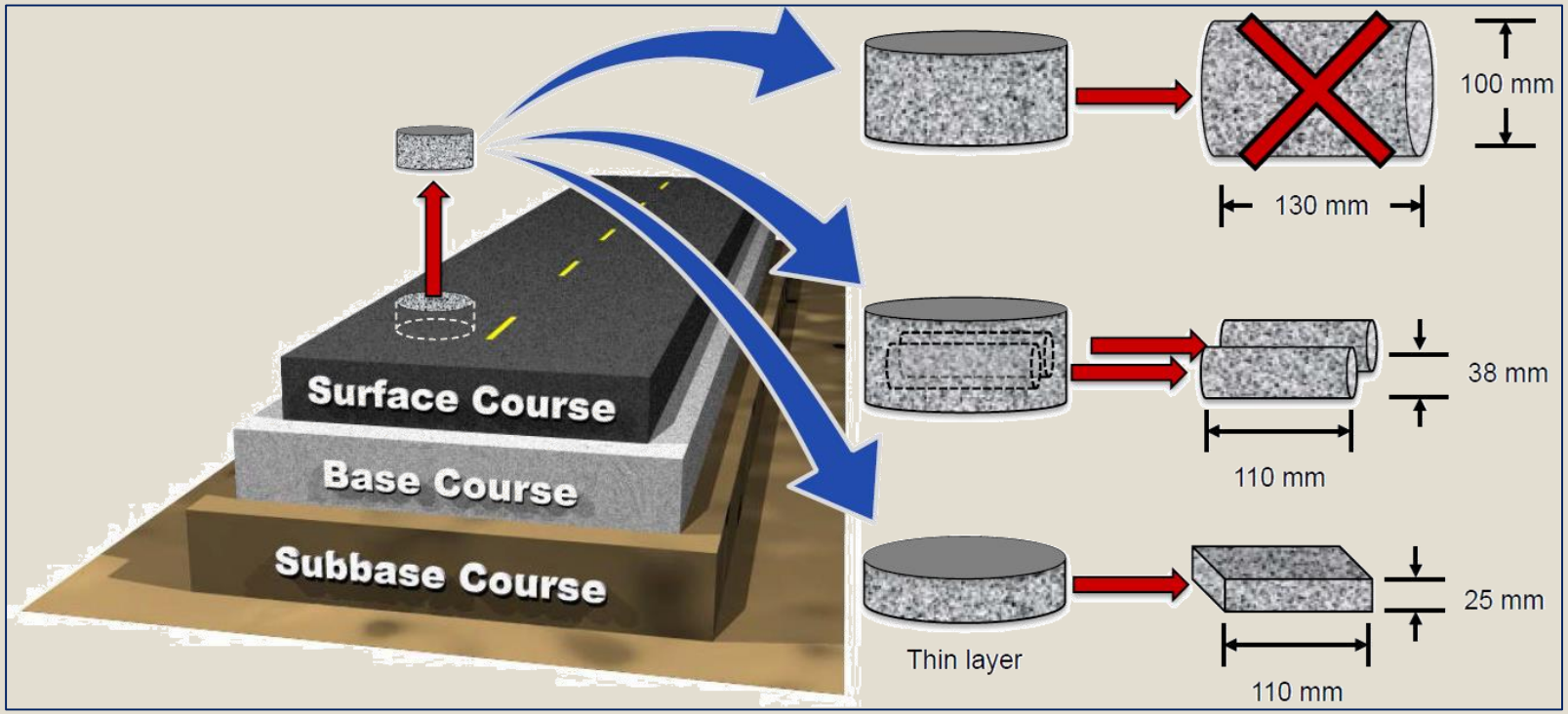


Image: North Carolina State University

Small Specimen Geometry

- Need less material to complete testing matrix

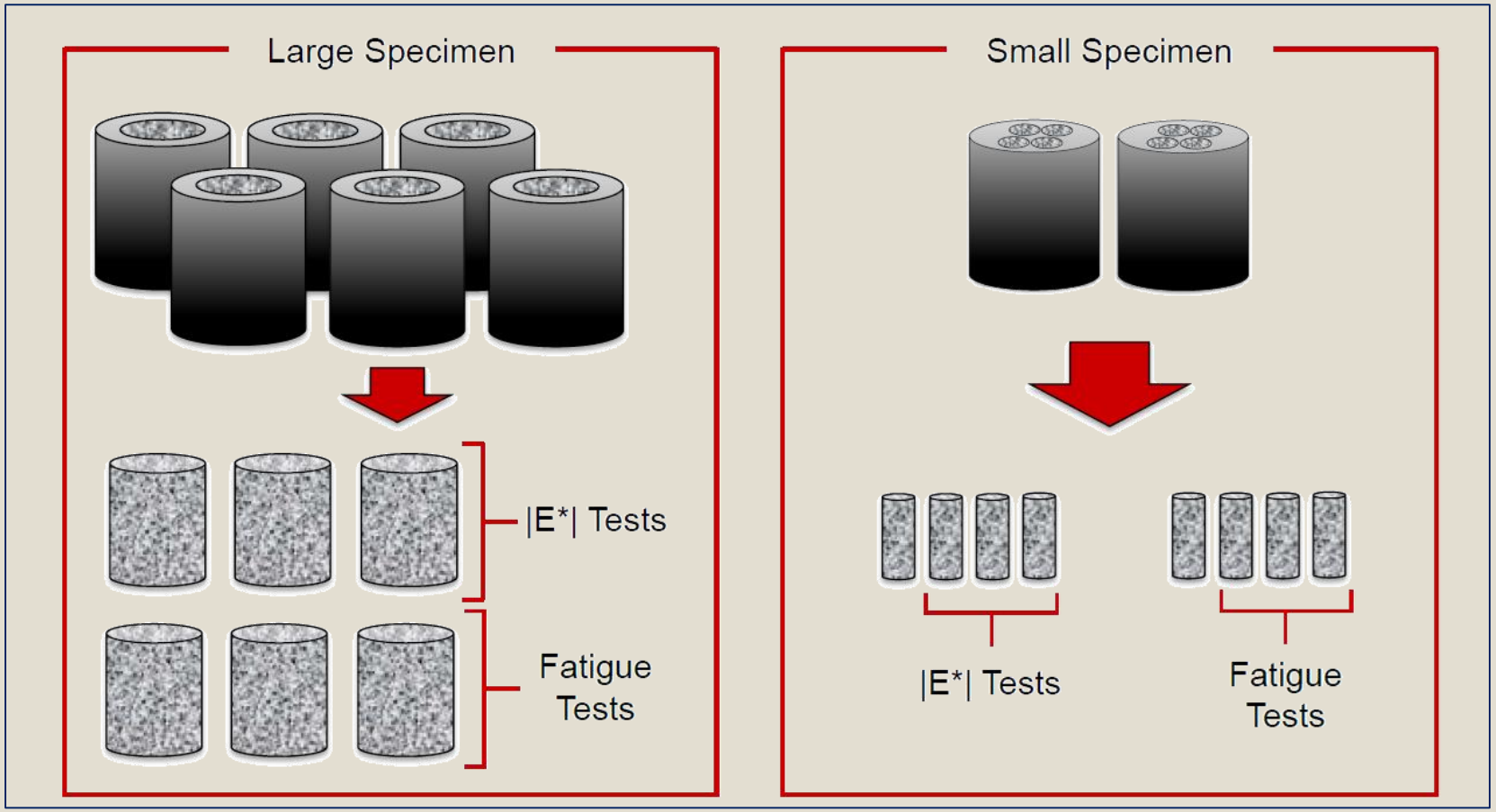
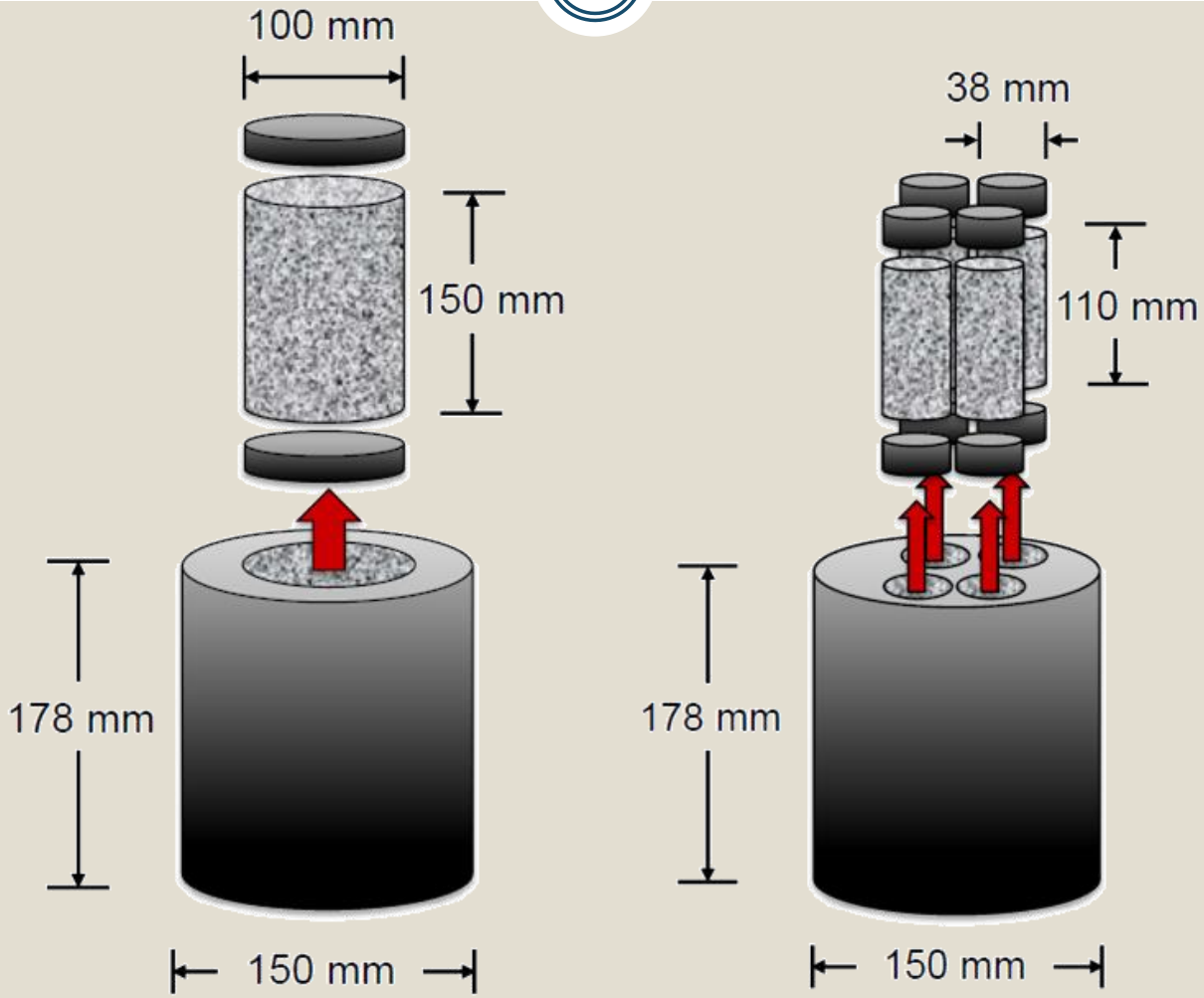


Image: North Carolina State University

Small Specimen Geometry



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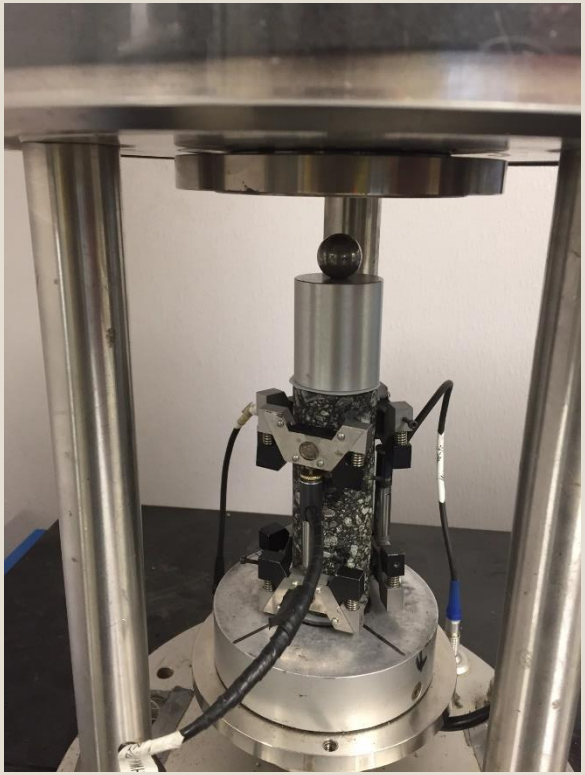
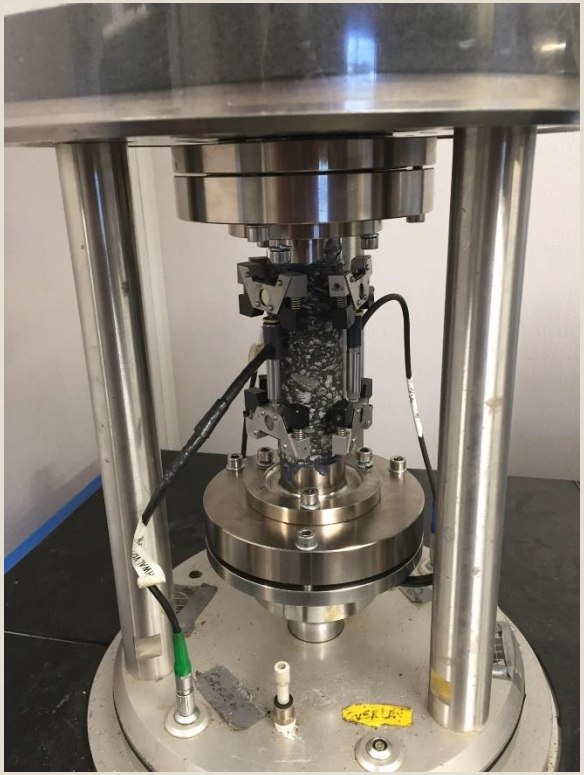
Types of Small Specimen Testing

Small Scale Dynamic Modulus



Small Scale Cyclic Fatigue



AMPT Small Specimen Advantages

- Field core testing
- Reduced sampling and material requirements for testing
- Same data output generated from small scale testing as full scale testing

Arizona Project

Arizona Project Description - 2015

- Open Graded Friction Course (OGFC) mixtures
- Three different Terminal blended Asphalt Rubbers
- Hybrid Binders:
  - PG70-22 TR+
    (8 % GTR + 2 % SBS; solubility limit of 97%)
  - PG70-22 TR+ S92
    (8 % GTR + 2 % SBS; solubility limit of 92%)
  - PG70-22 (contains only SBS)

Study Plans

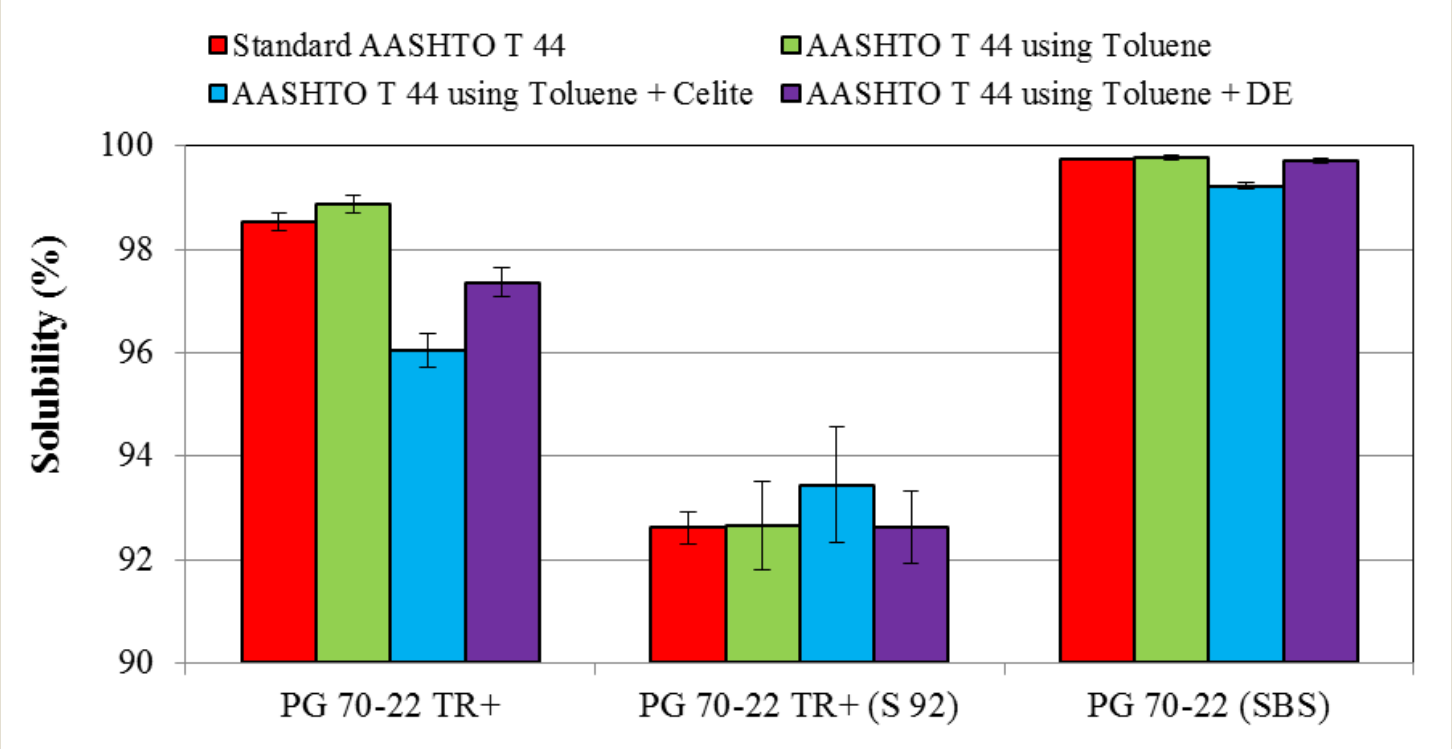
- Topics investigated in this project
  - Solubility
  - Separation
  - DSR testing: gap size effect
  - Long term conditioning

Solubility – AASHTO T 44

- UW-Madison MARC have proposed changes to the standard
  - Use of toluene as the solvent
  - The addition of an analytical filter:
    To increase the filter area and reduce the potential for the fiberglass filter to become clogged during testing

- Analytical Filters used in this study
  - Celite
  - Diatomaceous Earth (DE)

Solubility Results



- Use of toluene as the solvent
- The addition of an analytical filter
- Some differences in solubility

Solubility Results:
Analysis of Variance

Solubility Test Variation	PG 70-22 TR+	70-22 TR+ (S 92)	PG 70-22 (SBS)
Toluene	Not significant	Not significant	Not significant
Toluene + Celite 505	2.47 % lower	Not significant	0.52 % lower
Toluene + Diatomaceous Earth	1.16 % lower	Not significant	Not significant

- Compared to Standard Method, AASHTO T 44.
- Not a statistically significant difference using toluene compared to trichloroethylene.
- The differences in solubility when using an analytical filter aid were 0.5 to 2.5 percent: significant considering solubility is normally specified to the nearest 0.1 percent !

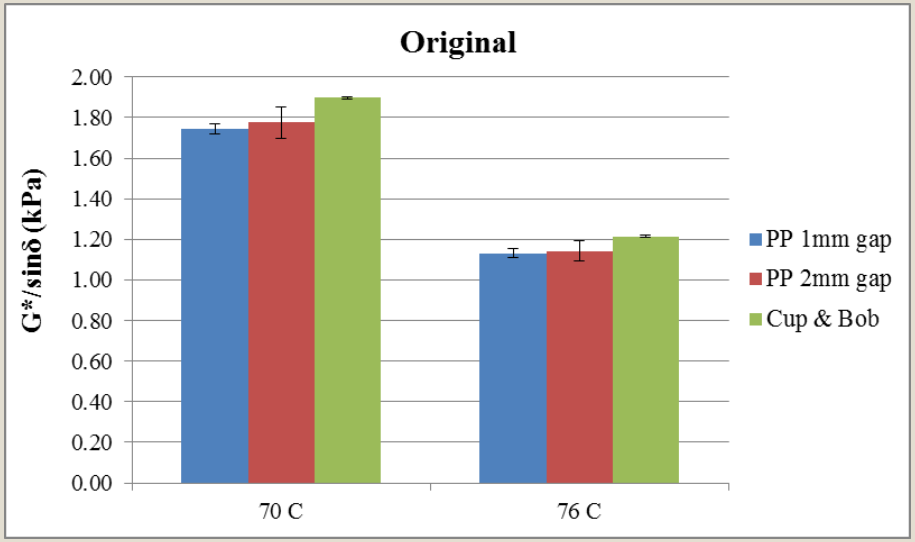
Separation Results

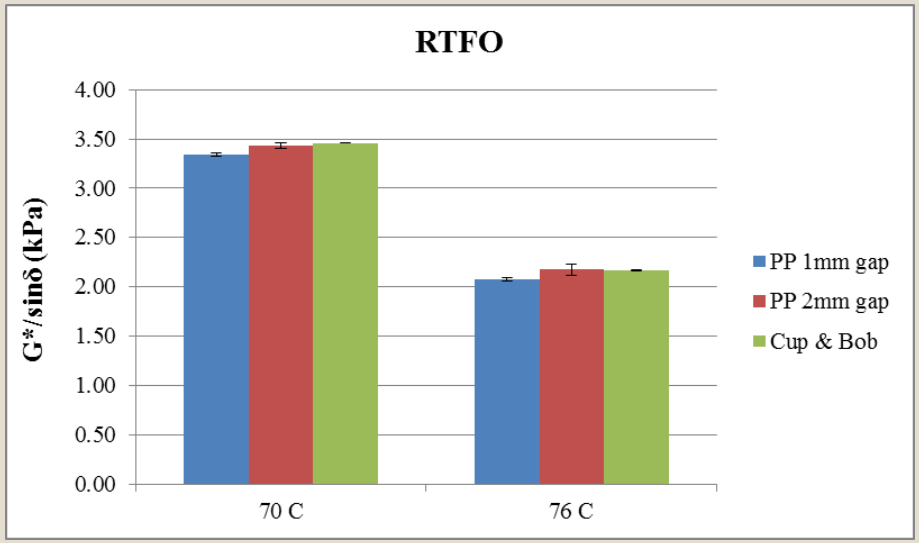
Binder	Continuous High Temperature Grade for Top Specimen, (°C)	Continuous High Temperature Grade for Bottom Specimen, (°C)	Continuous High Temperature Grade Difference Top-Bottom, (°C)
PG 70-22 TR+	80.7	81.0	-0.3
PG 70-22 TR+ (S 92)	78.2	96.6	**-18.4**
PG 70-22 (SBS)	76.7	78.3	-1.5

- Separation tests conducted following ASTM D7173: samples are stored in vertical tubes in an oven at 163 °C for 48 hours
- Test specimens taken from the top and bottom of the vertical storage tube are measured using AASHTO T 315
- GTR is separating and sinking to the bottom of the separation tube.

PG Results: PG 70-22 TR+ (S97)

1 & 2 mm gap vs. Cup and Bob

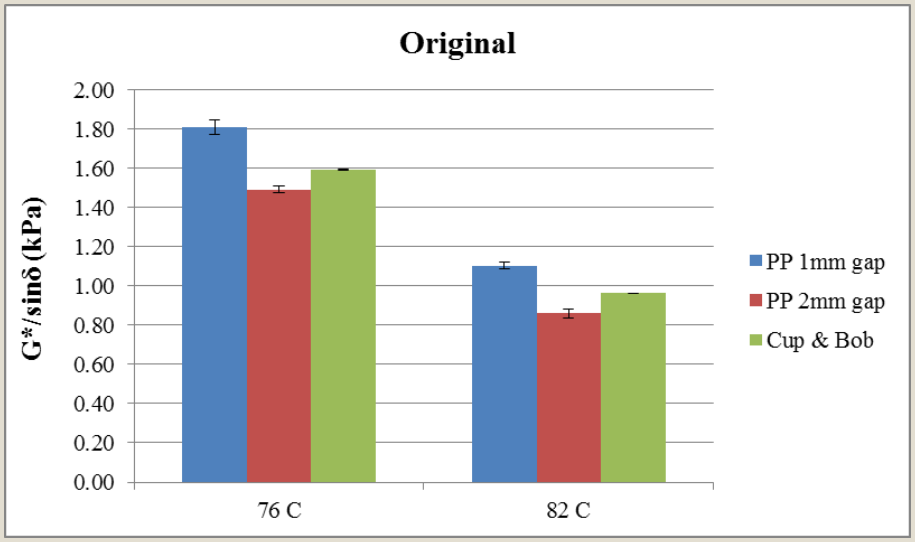


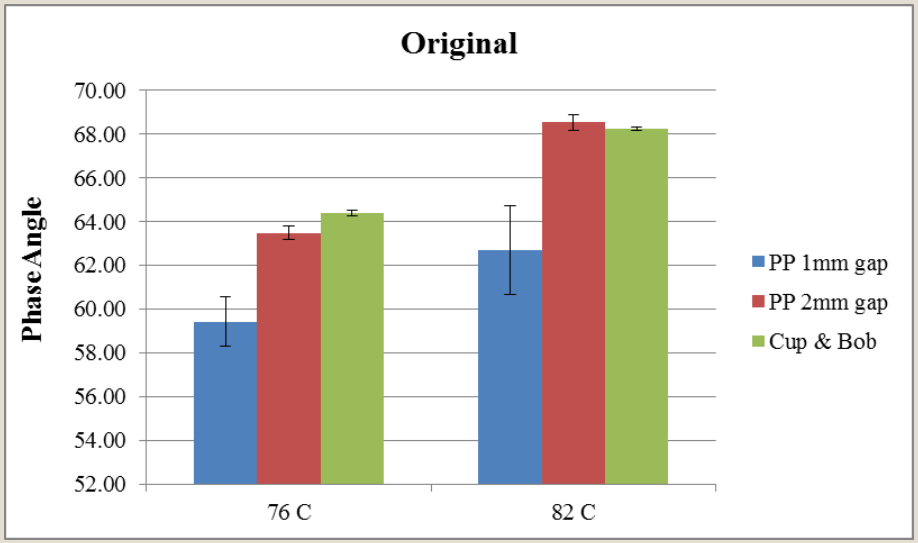


- Same PG grade
- Cup & Bob (CC 17) slightly higher G*/sinδ value: perhaps due to trimming or shelf-aging of material
- Cup & Bob: smallest values of standard deviation

PG Results: PG 70-22 TR+ (S92)

1 & 2 mm gap vs. Cup and Bob - Unaged





- PP 1mm shows different material behavior
- PP 1mm: possible particle interactions with plates -> *higher stiffness & more elastic type behavior*
- Similar results for PP 2mm and Cup & Bob

DSR PG Results: 1 vs. 2 mm gap

PG 70-22 TR+ (S 92) – Original binder at 76 °C

Item	1 mm gap Complex Modulus, (kPa)	1 mm gap Phase Angle, (°)	2 mm gap Complex Modulus, (kPa)	2 mm gap Phase Angle, (°)
Replicate 1	1.52	58.6	1.34	63.3
Replicate 2	1.59	60.2	1.34	63.3
Replicate 3	NA	NA	1.32	63.8
Average	1.55	59.4	1.33	63.5
Standard Deviation	0.05	1.17	0.01	0.26

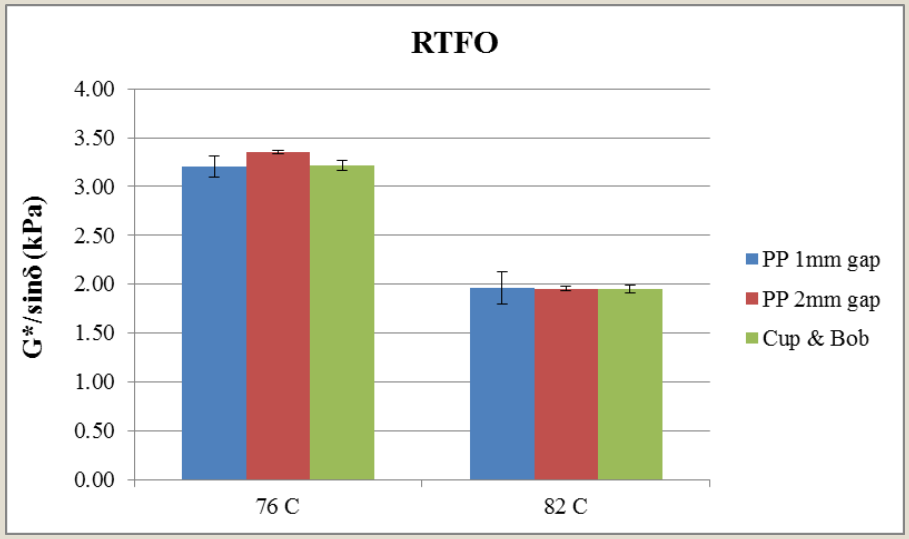
- For gap sizes of 1 to 2 mm: when there is an interaction of the rubber particles with the testing plates ->

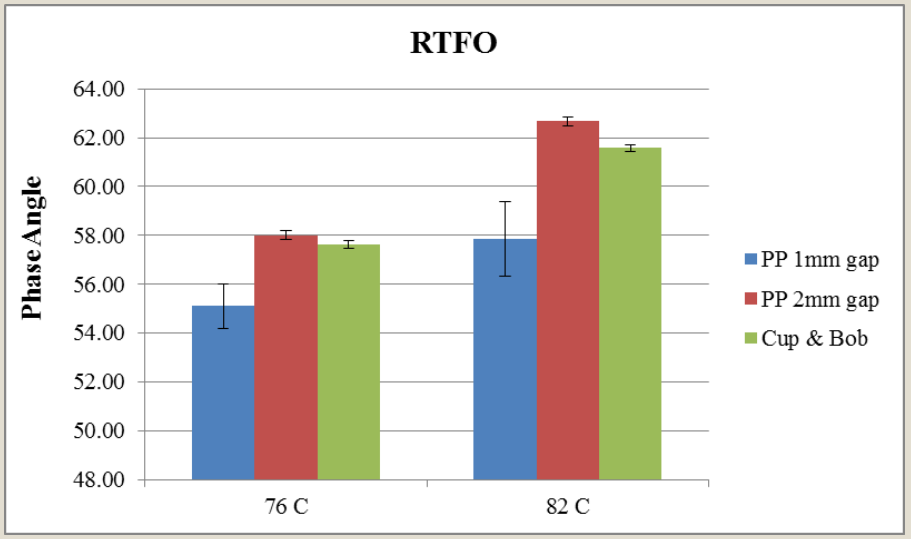
  ↑ gap : ↓ variability, ↓ the complex modulus, ↑ the phase angle.

- Lower G*/sinδ and phase angle for 1mm

PG Results: PG 70-22 TR+ (S92)

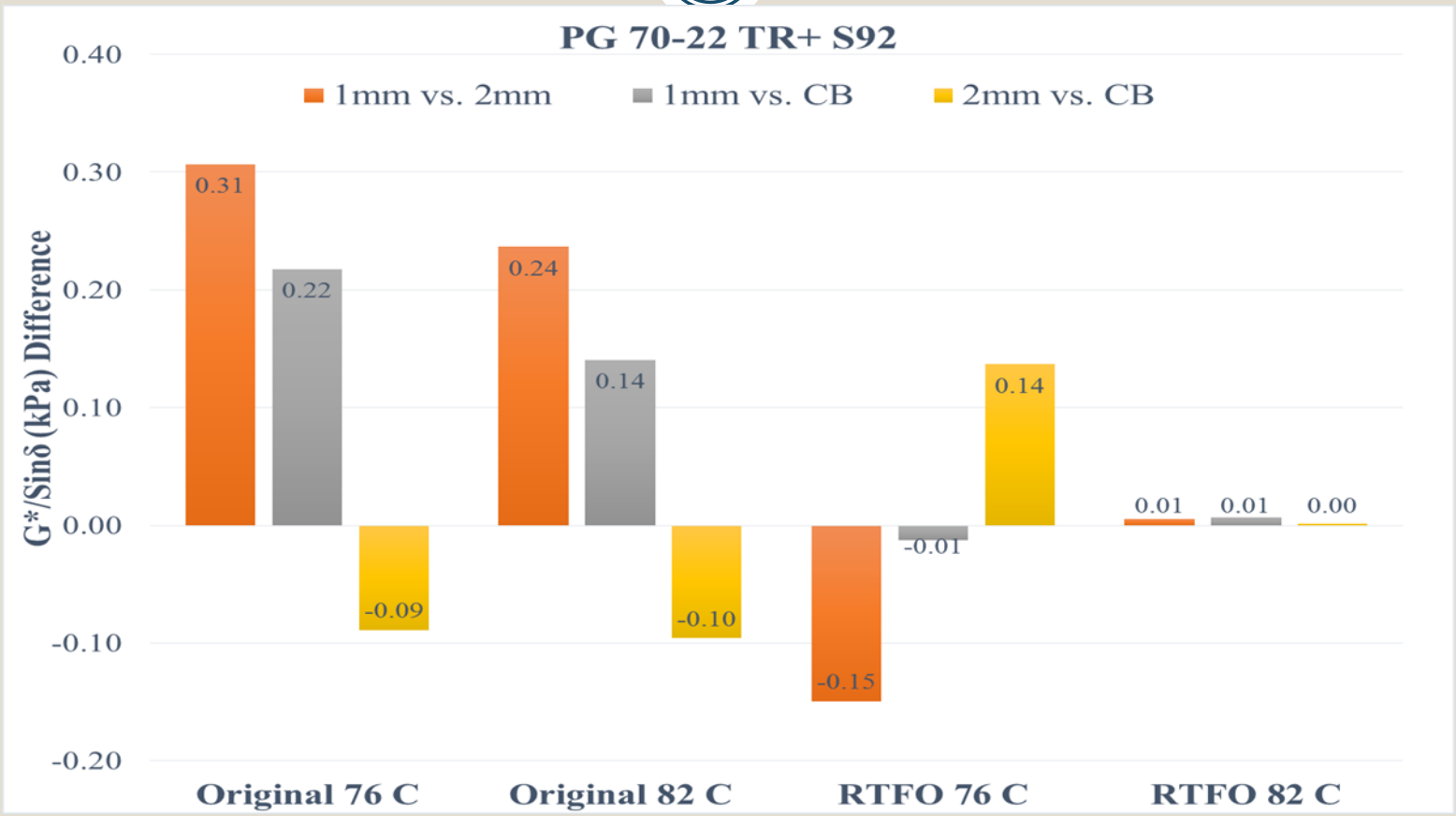
1 & 2 mm gap vs. Cup and Bob - RTFO





- Same PG grade
- PP 1mm: possible particle interactions with plates -> *lower phase angle (more elastic type behavior)*
- Differences decreased after RTFO conditioning

PG Results: PG 70-22 TR+ (S92)



- 2mm vs. Cup & Bob: most similar results
- Differences decreased after RTFO aging …

DSR PG Results: 1 vs. 2 mm gap

Statistical Analysis – Effect of 1mm increase in gap

Binder	Original Complex Modulus	RTFOT Complex Modulus	Original Phase Angle	RTFOT Phase Angle
PG 70-22 TR+	Increases 0.04 kPa Not significant	Increases 0.07 kPa Significant	Increases 0.63° Not significant	Zero difference Not significant
PG 70-22 TR+ (S 92)	Decreases 0.22 kPa Significant	Increases 0.22 kPa Significant	Increases 4.05° Significant	Increases 1.90° Not significant

- Only PG 70-22 TR+ (S 92) original binder show effects consistent with particle interaction.
- When used to test binders modified with GTR, this gap may be too small to accommodate the rubber particles.
- Concentric Cylinder (Cup & Bob) needed as testing geometry for these materials.

Summary of Findings

- Solubility: **Toluene** was found to be an acceptable alternative to Trichloroethylene as a solvent for solubility testing.
- Separation: **GTR**, due to its higher specific gravity than neat asphalt binder, is separating and sinking to the bottom of the separation tube. Separation of TR+ (S 92) binder during non-agitated long-term storage should be expected.
- DSR testing: Results indicate that **particle interaction** with the plates likely occurs when testing the PG 70-22 TR+ (S 92) using the parallel plate geometry.

Takeaway

- Separation: Needs to be considered for Asphalt Rubber Material. (ASTM D7173)

- DSR testing: All Asphalt Rubber Binders are **not** the same ! Some may work with PP and some not. **Cup & Bob** is a scientific & practical solution.

- DSR testing:
  - **PP issues**: trimming, edge effect, particle interactions, rubber swelling, rubber mesh size and percentage, etc.
  - **Cup & Bob**: no trimming, exact volume filling, no edge effect

Technical Assistance

- If you have upcoming projects for which you would like MATT technical assistance, contact:
  - Amir Golalipour, amir.golalipour.ctr@dot.gov, 202.366.3982
  - Dave Mensching, david.mensching@dot.gov, 202.493.3232

https://www.fhwa.dot.gov/pavement/asphalt/trailer/

Thank You – Questions?

- Trailer is parked outside! Come in for a tour!
- We're here to assist! Please stop by anytime for more discussion.