

Ground Tire Rubber: Field Project Experiences & Lessons Learned – Part 2



Matthew Corrigan, P.E.

Amir Golalipour, Ph.D.

Asphalt Binder ETG meeting - September 12, 2016



Team members

- Chuck Paugh
- Dr. Ray Bonaquist
- Satish Belagutti
- Butch Heidler

Their efforts on the projects and presentation are greatly appreciated.



FHWA MATT Program

- Mobile Asphalt Testing Trailer (MATT)
- AASHTO Accredited
- Superpave™ Technology
 - Test
 - Evaluate
 - Refine
 - Improve
 - Implement



Challenges

- National discussions of GTR modified binder testing ongoing challenges
 - Aging: RTFO & Long Term conditioning
 - Solubility
 - Separation
 - DSR testing: Different gap sizes, Concentric Cylinder testing
 - Low temperature specimen preparation

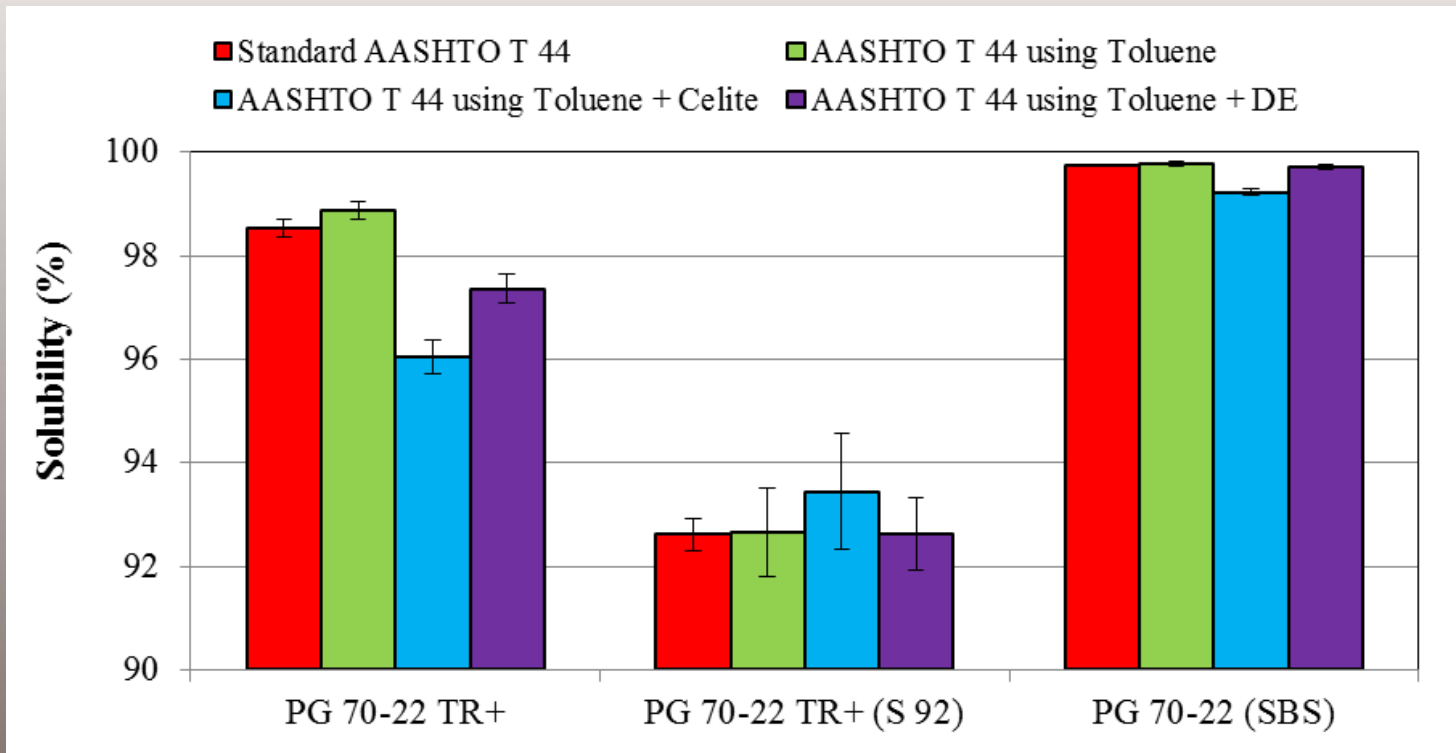


Project Description – AZ 2015

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



Solubility



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



Separation

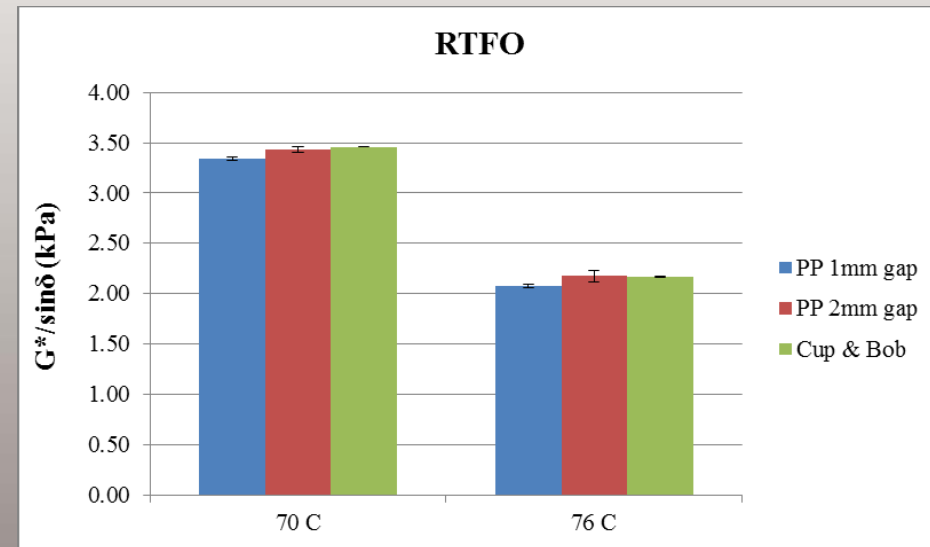
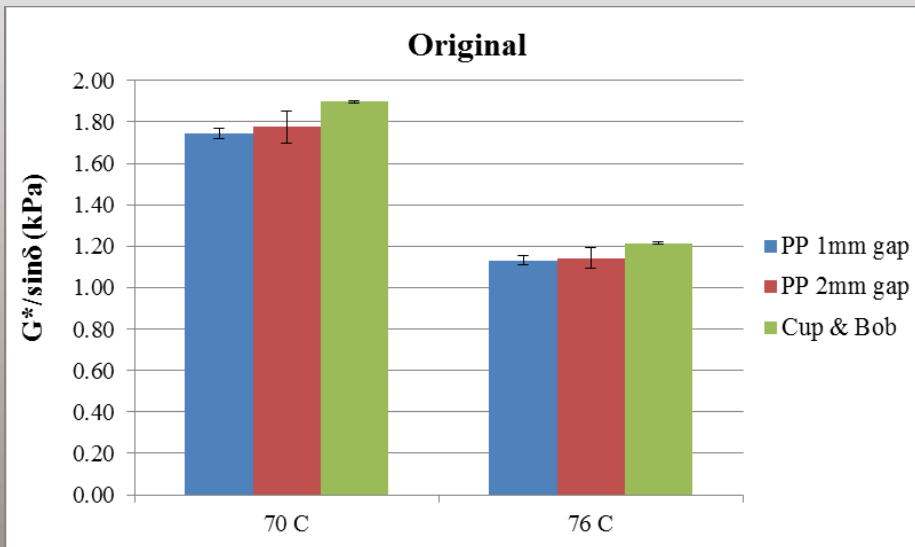
Binder	Continuous High Temperature Grade for Top Specimen, (°C)	Continuous High Temperature Grade for Bottom Specimen, (°C)	Continuous High Temperature Grade Difference Top-Bottom, (°C)
PG 70-22 TR+	80.7	81.0	-0.3
PG 70-22 TR+ (S 92)	78.2	96.6	-18.4
PG 70-22 (SBS)	76.7	78.3	-1.5

- 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

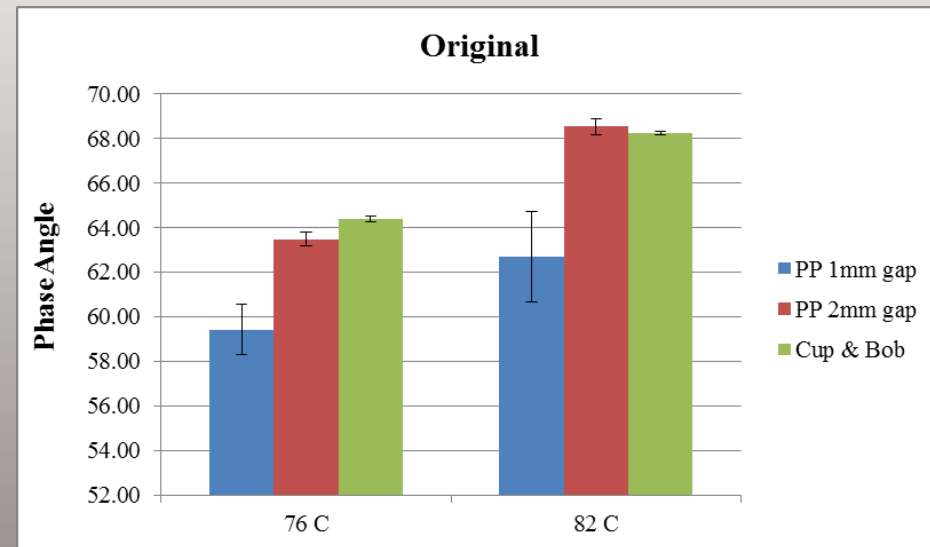
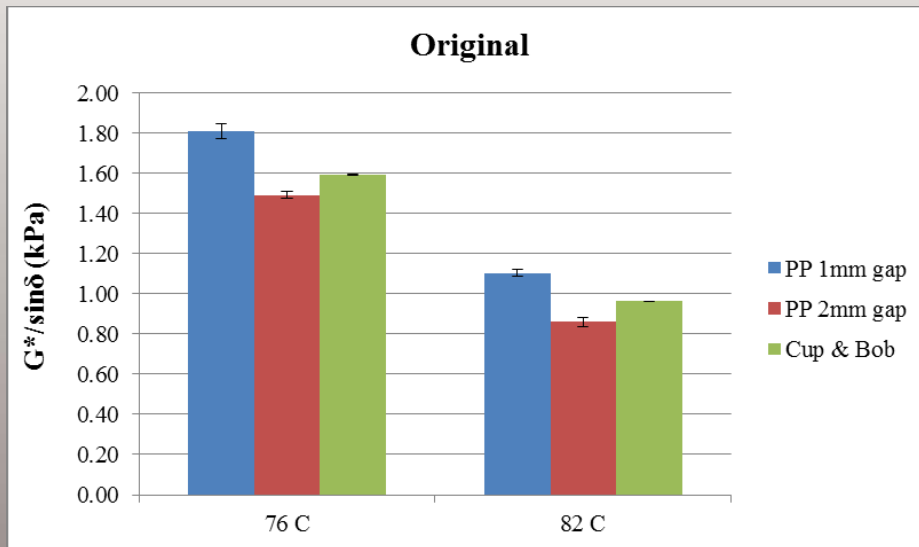


- Same PG grade
- Cup & Bob (CC 17) slightly higher $G^*/\sin\delta$ value: perhaps due to shelf-aging of material
- Cup & Bob: smallest values of standard deviation



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

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



- 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

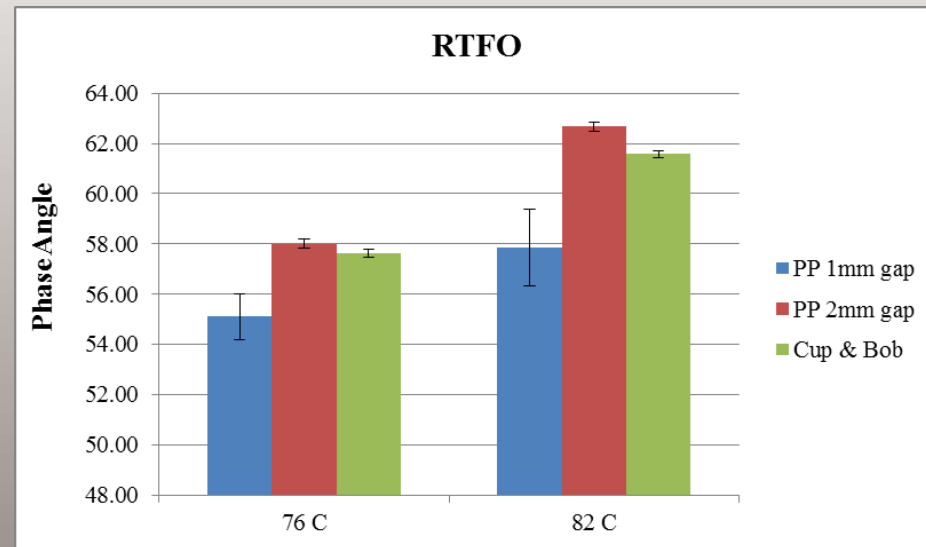
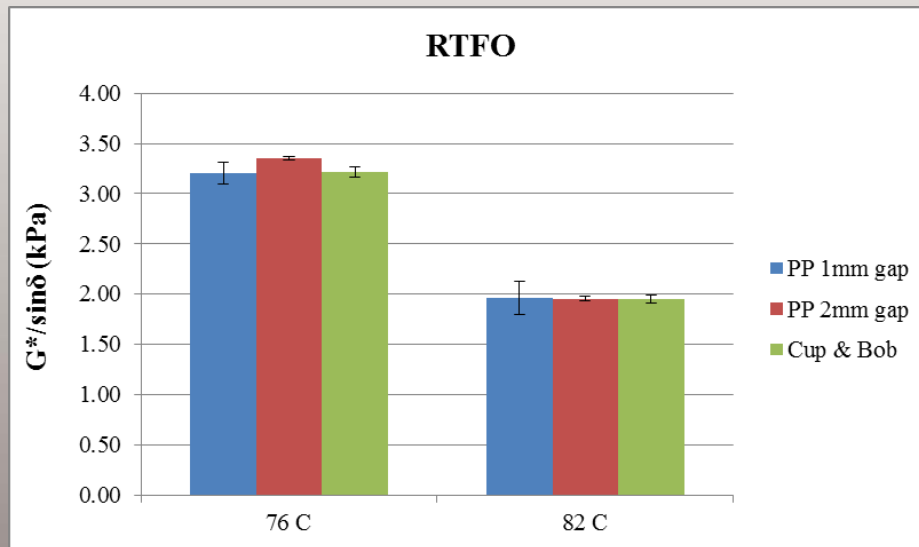
Item	1 mm gap Complex Modulus, (kPa)	1 mm gap Phase Angle, (°)	2 mm gap Complex Modulus, (kPa)	2 mm gap Phase Angle, (°)
Replicate 1	1.52	58.6	1.34	63.3
Replicate 2	1.59	60.2	1.34	63.3
Replicate 3	NA	NA	1.32	63.8
Average	1.55	59.4	1.33	63.5
Standard Deviation	0.05	1.17	0.01	0.26

- 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 $G^*/\sin\delta$ and phase angle for 1mm



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

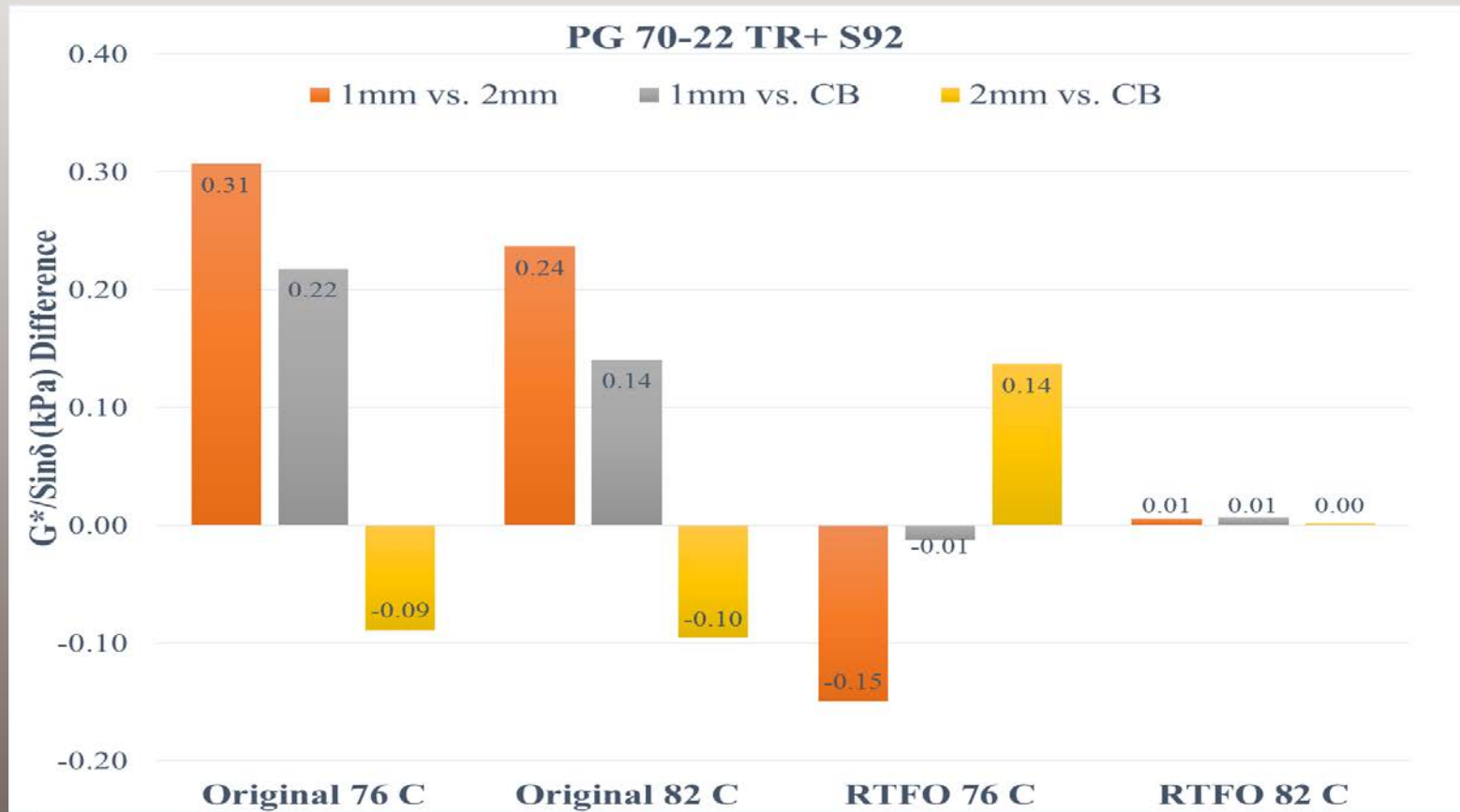
1 & 2 mm gap vs. Cup and Bob - RTFO



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



DSR PG Results: PG 70-22 TR+ (S 92)



- 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

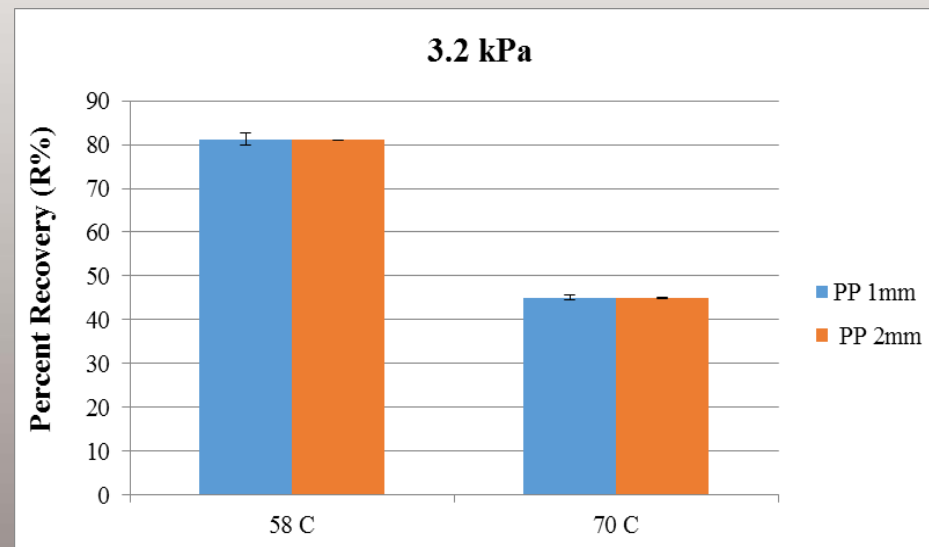
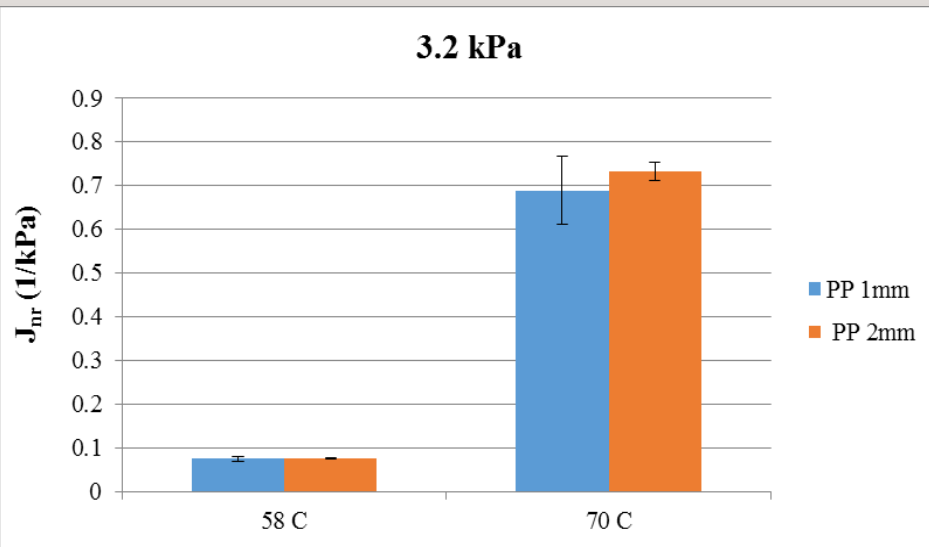
Binder	Original Complex Modulus	RTFOT Complex Modulus	Original Phase Angle	RTFOT Phase Angle
PG 70-22 TR+	Increases 0.04 kPa Not significant	Increases 0.07 kPa Significant	Increases 0.63° Not significant	Zero difference Not significant
PG 70-22 TR+ (S 92)	Decreases 0.22 kPa Significant	Increases 0.22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



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

1 vs. 2 mm gap - RTFO



- J_{nr} differences are increased with increasing temperatures
- PP 1mm: possible particle interactions with plates -> *lower permanent deformation*
- Percent recovery (R%) : very similar results



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.



Project Description – FL 2015

- Project Location:
 - Florida
- Hot mix asphalt (HMA) produced with an asphalt rubber binder (ARB):
 - **FDOT revised Section 916-1**
 - ARB must contain at least contain at least 7% GTR by weight of asphalt binder.
 - No Solubility required
 - Separation & **DSR PP with 2mm gap**
 - **Binder: PG 76-22 ARB**



Separation

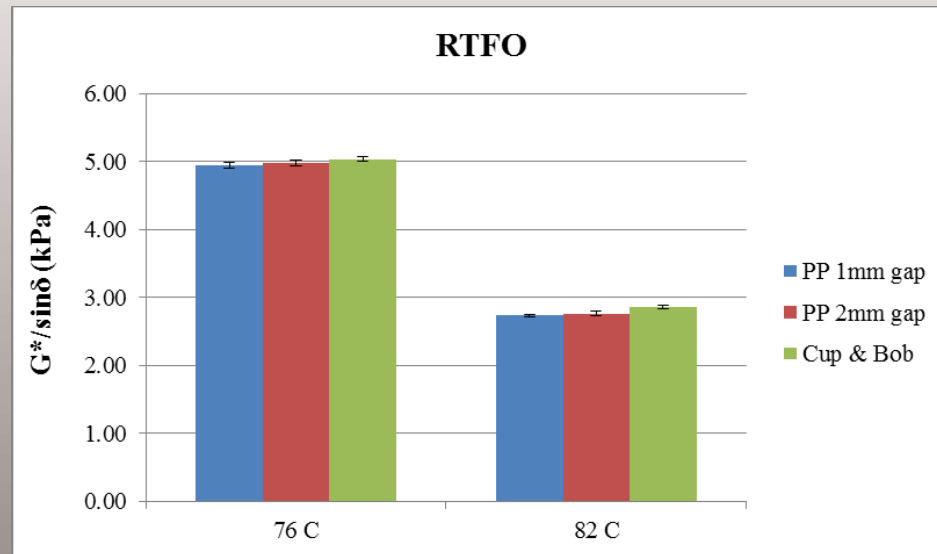
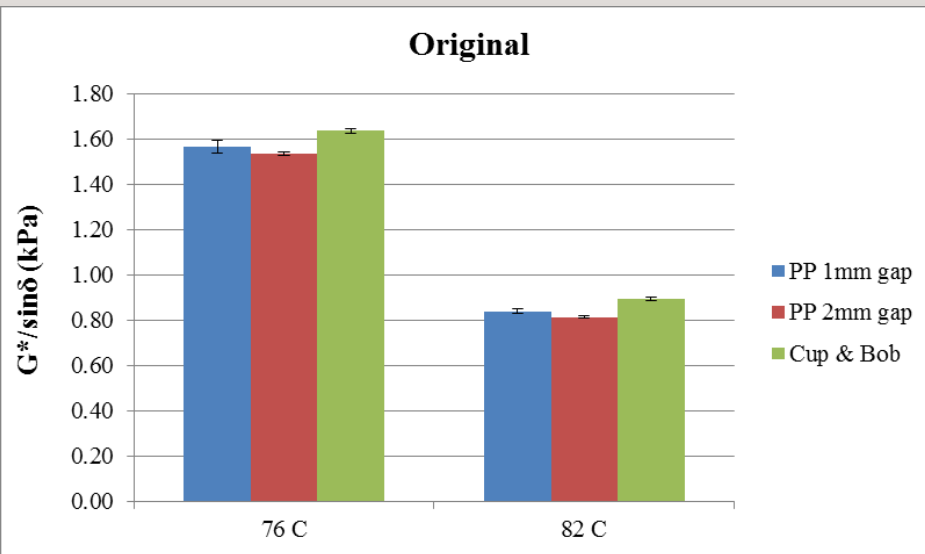
Binder	Continuous High Temperature Grade for Top Specimen, (°C)	Continuous High Temperature Grade for Bottom Specimen, (°C)	Continuous High Temperature Grade Difference Top-Bottom, (°C)
PG 76-22 ARB	80.0	86.5	-6.5

- Separation tests conducted following ASTM D7173
- 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 76-22 ARB

1 & 2 mm gap vs. Cup and Bob



- Same PG grade
- Cup & Bob slightly higher $G^*/\sin\delta$ value
- No indication of significant particle interaction with plates: due to finer mesh size & low percentage of rubber
- Very similar results overall



Long Term Conditioning

Low Temperature Cracking - PG 76-22 ARB

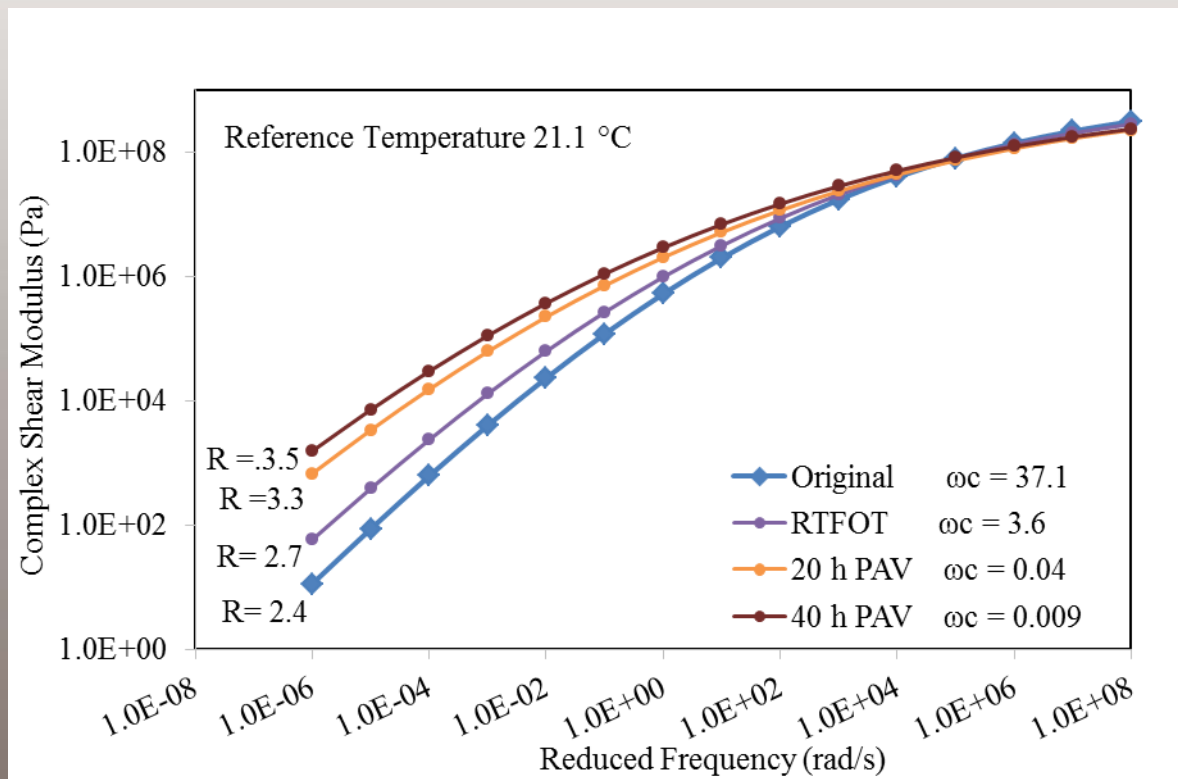
PAV Conditioning Time (h)	AASHTO M 320 Table 1 Intermediate Temperature Continuous Grade (°C)	AASHTO M 320 Table 1 Low Temperature Continuous Grade (°C)	AASHTO M 320 Table 1 ΔT_c (°C)	AASHTO M 320 Table 2 Critical Cracking Temperature (°C)	ABCD Low Temperature Grade (°C)	ABCD AASHTO TP 92 Cracking Temperature (°C)
20	18.5	-27.7	-2.3	-27.7	-28.6	-35.5
40	18.5	-24.5	-5.2	-25.8	-27.7	-34.4

- Reasonable agreement between the three measurements for 20 hours PAV conditioning.
- The ABCD is less sensitive than the other two tests to conditioning time.
- Doubling PAV time:
 - **1.1 °C** ↑ of cracking temp (ABCD)
 - **3.2 °C** ↑ of cracking temp (Table 1)
 - **1.9 °C** ↑ of cracking temp (Table 2)



Long Term Conditioning

Master Curve - PG 76-22 ARB



- More conditioning causes the master curves to become flatter with R increasing and ω_c decreasing.



Summary of Findings

- Separation: Separation of PG 76-22 ARB during non-agitated long-term storage should be expected.
- DSR testing: Results show **no** indication of **particle interaction** with the plates when testing the PG 76-22 ARB using the parallel plate geometry: due to finer mesh size & low percentage of rubber
- For extended PAV conditioning, binder becoming highly **m-value** controlled.
- 40 h PAV conditioning **reveals more information** about material behavior.



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.
- Extended PAV conditioning, may **better differentiate** between different materials in terms of **low temperature cracking**.



Takeaway – Cont'

- RTFO challenges need to be considered: materials creeping out of bottle
- 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
- Low temperature testing (BBR & DDT): specimen preparation, trimming, demolding.
- PAV conditioning ?



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



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

