

# Laboratory Evaluation: Wax Additives in Warm-Mix Asphalt Binder



**ETG WARM MIX TASK GROUP:**  
**GAYLON BAUMGARDNER**  
**GAYLE KING**  
**GERALD REINKE**  
**MATT CORRIGAN**  
**CHRIS ABADIE**

# Objective



**Evaluate the effect of wax additives on physical properties and characteristics of asphalt binders and their subsequent performance in mixtures.**

# Materials



- **Asphalt – One (1)**
  - Lion Oil PG64-22 Eldorado, AR Refinery (Saudi)
- **Wax Additives – Nine (9)**
  - Non-Paraffin Wax Additives
- **Aggregates**
  - Vulcan Barin Quarry Granite, Columbus, GA (Aggregate used on the NCAT Test Track)
- **Mix Design**
  - 12.5mm Dense Graded SuperPave™ Gyratory
    - ✦ ~5.5% Binder
    - ✦ ~7.0% Air Voids

# Paraffin and Non-Paraffin Waxes

## Paraffin Wax

Size of molecule  $< C_{45}$   
Melting point  $< 70\text{ }^{\circ}\text{C}$

## Non-Paraffin Wax

Size of molecule  $> C_{45}$   
Melting point  $> 70\text{ }^{\circ}\text{C}$

natural waxes

animal  
(e.g. beeswax)

vegetable  
(e.g. Carnaubawax)

modified  
natural waxes

brown coal-  
derivative

mineral oil-  
derivative

partial synthetic  
waxes

acid waxes

ester waxes

amid waxes

alcohol waxes

full synthetic  
waxes

Fischer-Tropsch-  
waxes

polyethylene-  
waxes

⋮

⋮

⋮

⋮

# Selected Additives



- **Paraffin Waxes:**
  - **Microcrystalline**
    - Astra 3816 Refined Paraffin
- **Non-Paraffin Waxes:**
  - **Modified Natural**
    - Romonta Normal - Montan
    - Romonta Asphaltan A
    - Romonta Asphaltan B
  - **Partial Synthetic**
    - Clariant Licomont BS100 – N,N'-ethylenebisstearamide
    - Luxco Pitch – stearic acid pitch
    - Ester Wax - TBD
  - **Synthetic**
    - Sasobit – Fischer-Tropsch
    - Allied - Polyethylene

# Experimental



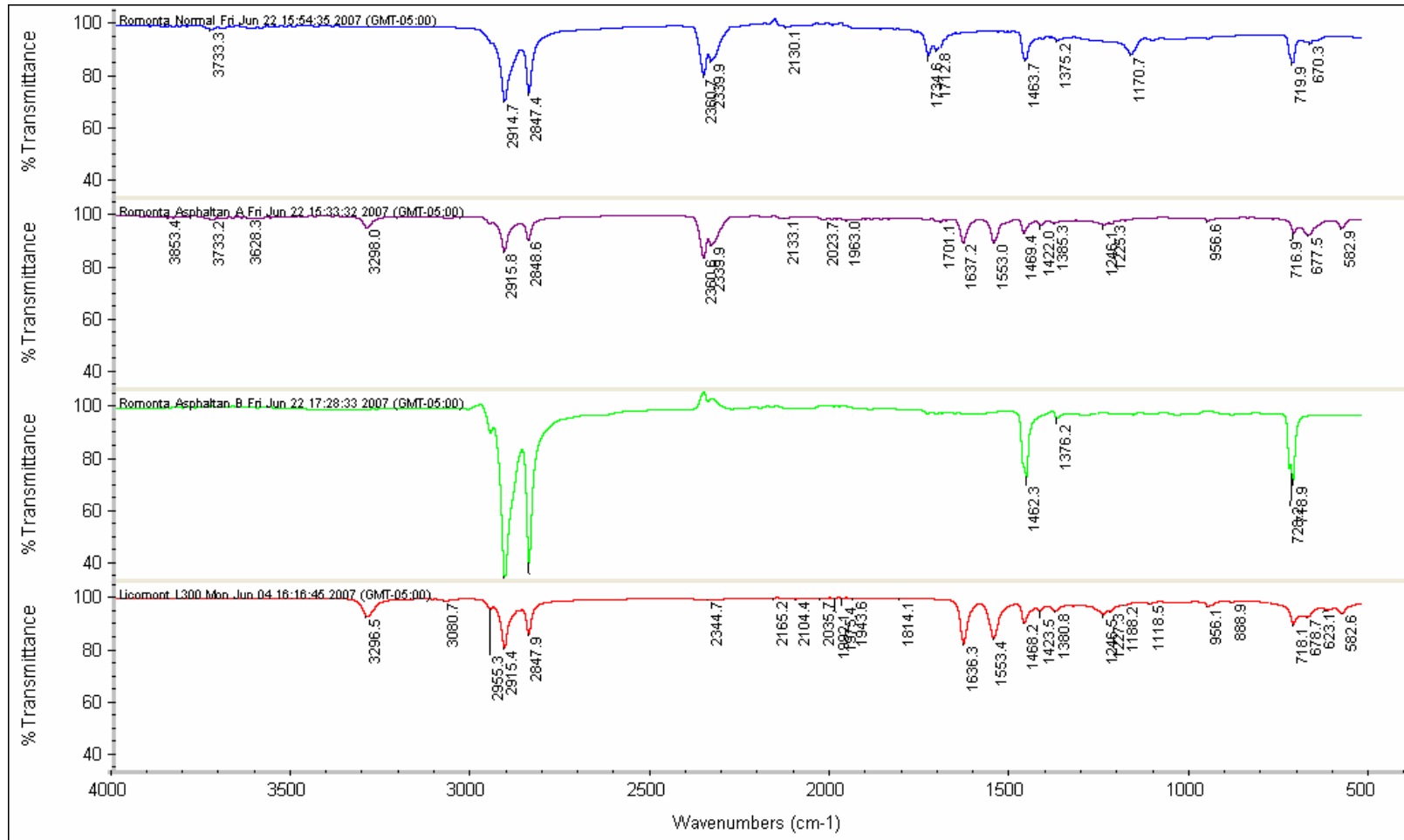
- **Proposed Testing Completed Cooperatively**
  - Paragon Technical Services, Inc. (PTSi)
  - Mathy Technology and Engineering, Inc. (MTE)
  - Anderson Asphalt (Dr. Dave Anderson)
  - Western Research Institute (WRI)
  - Louisiana State University (LSU)
  - Federal Highways (FHWA)
  - Kraton Polymers (KP)

# Experimental – Additive Testing



- **Fourier Transform Infra-Red Spectroscopy (FTIR) – WRI**
- **Gel Permeation Chromatography (GPC) – WRI/PTSi/KP**
  - High Temp GPC – KP
- **Glass Transition (T<sub>g</sub>)**
  - Modulated Differential Scanning Calorimetry (MDSC) – WRI/MTE
- **Branching**
  - Nuclear Magnetic Resonance (NMR) – WRI
  - Atomic Force Microscopy (AFM) - WRI
  - Mass Spectroscopy (MS) – WRI
  - X-Ray - LSU

# Fourier Transform Infra-Red Spectroscopy (FTIR)



# Experimental – Binder Testing



- **Ten (10) Binders (Control PG64-22 and Nine (9) Wax Modified Binders**

*Note: Testing other than Tribo-Rheometry and Binder True Grade to be Performed on PAV Aged Binders*

- Master Curve Development (DSR) – PTSi
- SuperPave™ True Grade (Through DTT) – PTSi
- Tribo-Rheometry – PTSi/MTE
- Physical Hardening (32 days saturation at -12°C) Bending Beam Rheometry (BBR) - PTSi
- Testing at 1,2,4,8,16 and 32 Days Concurrent with Binder
- Multi-Step Creep Recovery (MSCR) – FHWA
- Binder Stress Sweep Fatigue (Bahia UW Method) – PTSi/MTE

# Experimental – Binder Testing (Contd.)

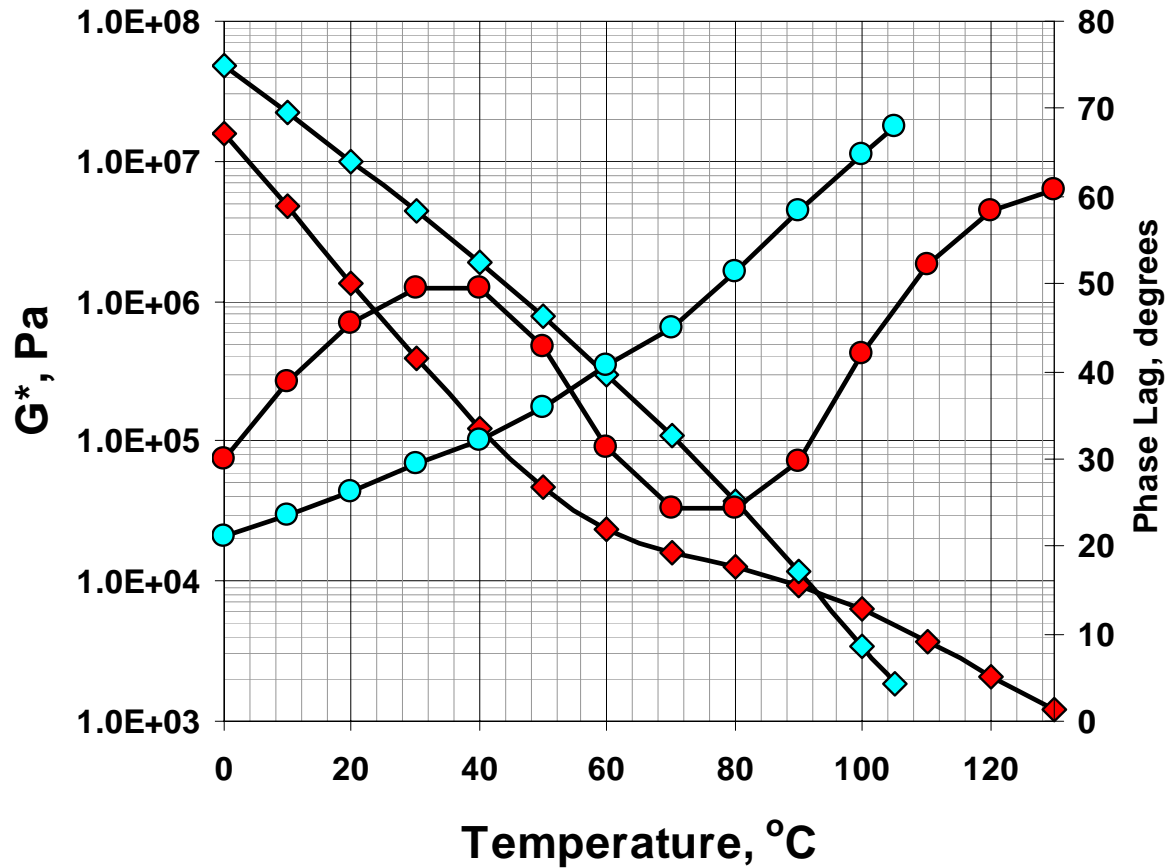


- **Ten (10) Binders (Control PG64-22 and Nine (9) Wax Modified Binders**

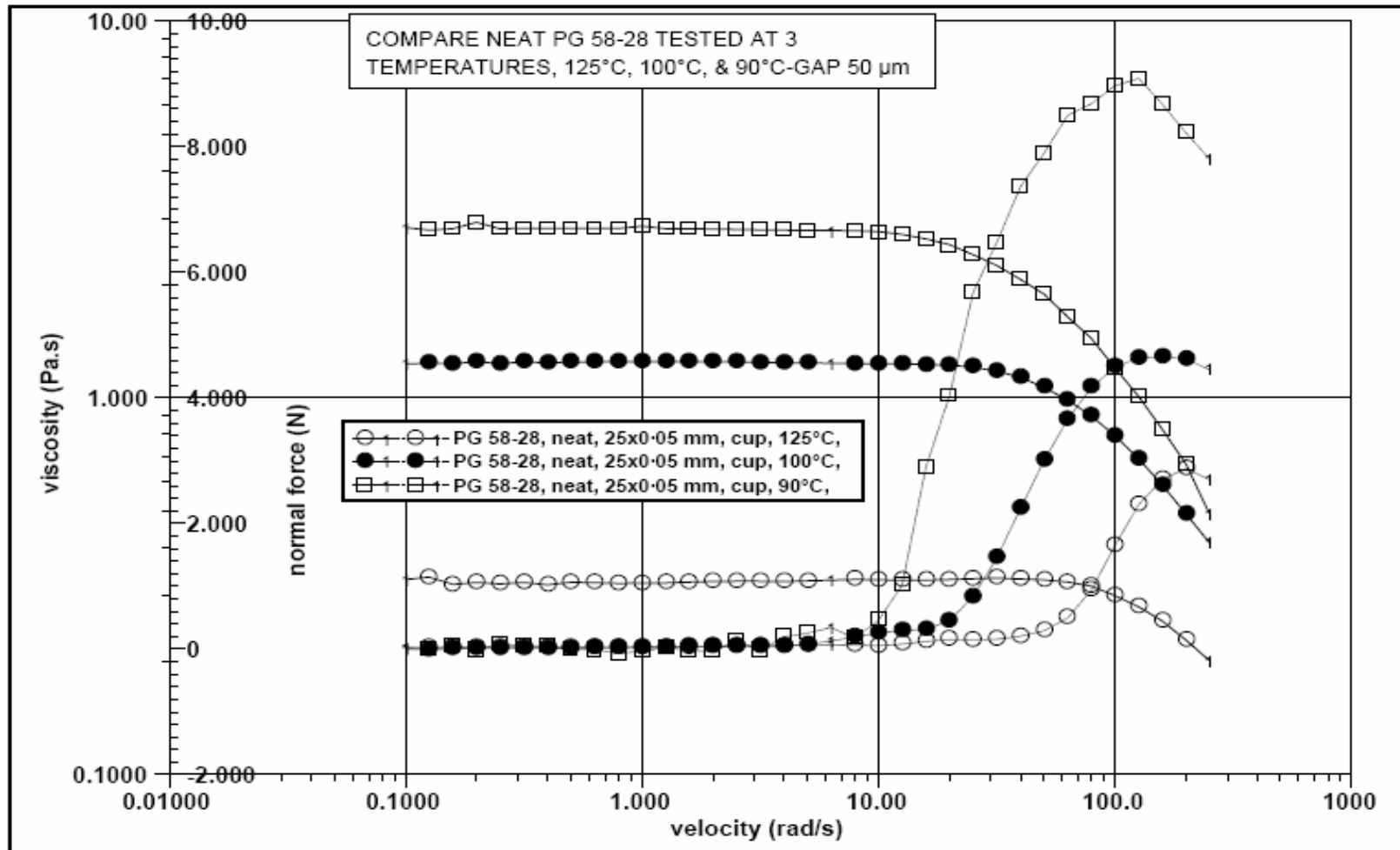
*Note: Testing other than Tribo-Rheometry and Binder True Grade to be Performed on PAV Aged Binders*

- **Glass Transition Tg**
- **Modulated DSC (MDSC) – WRI/MTE/Anderson Asphalt**
- **Dilatometric Analysis - Anderson Asphalt**
- **Fracture Testing – Anderson Asphalt**
- **Atomic Force Microscopy (AFM) - WRI**
- **Solid State NMR –(WRI**
- **X-Ray – LSU**
- **High Pressure Liquid Chromatography/Gel Permeation Chromatography/Mass Spectroscopy – (HPLC/GPC/MS) – WRI/LSU**

# Master Curve Development



# Tribo-Rheometry



# Experimental – Mixture Testing

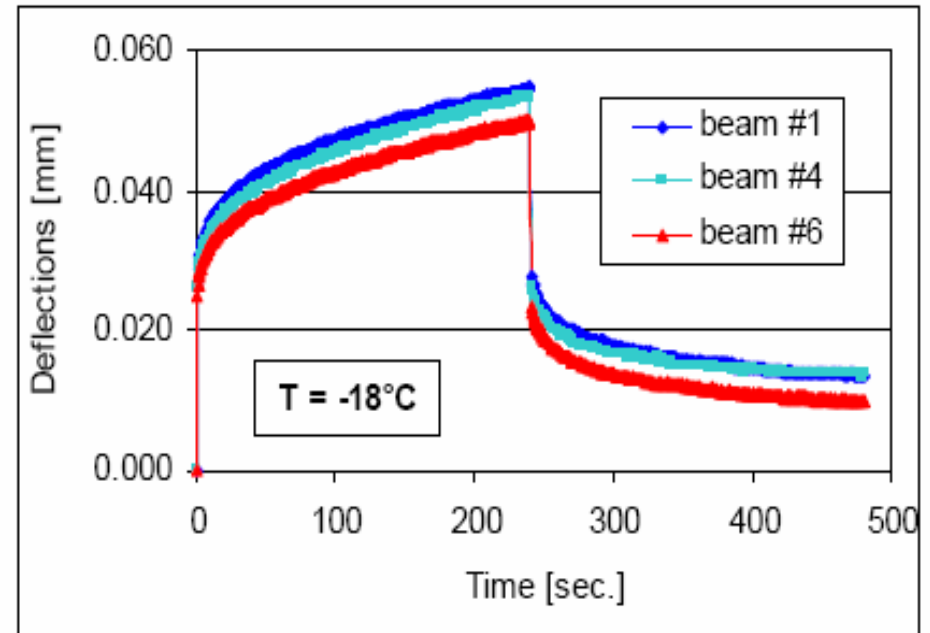
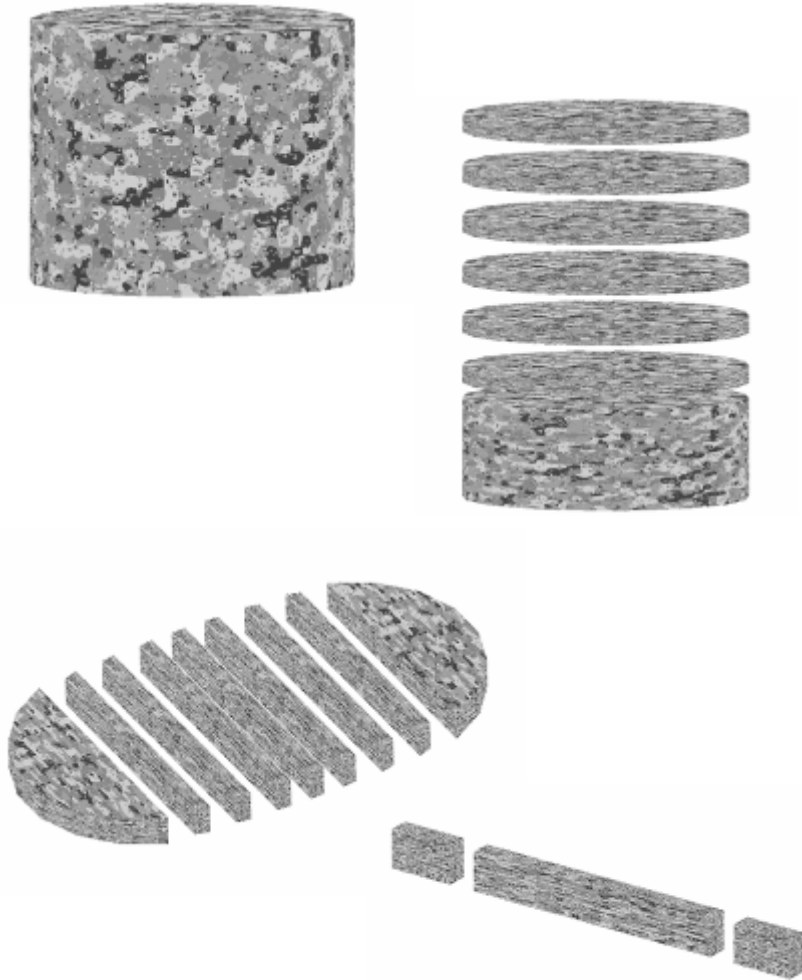


- **Ten (10) Mixtures (Control and Nine (9) Modified)**

Dense Graded SuperPave™ Gyrotory Specimens

- **Physical Hardening (32 days saturation at -12°C)  
Bending Beam Rheometry (Marasteanu UM  
Method) (BBR) - PTSi**
- Testing at 1,2,4,8,16 and 32 Days Concurrent with Binder
- **Sand Cylinder Fatigue (SCF) – MTE**
- **Glass Transition (Tg) (MTE Method) – MTE**
- **Fracture Testing – Anderson Asphalt**

# Physical Hardening - BBR



# Questions?



What's Over the Hill  
for Warm Mix?