



**Florida Department of Transportation**

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**AFD40(2) Monthly Web Meeting:  
FDOT APT Update**

**Jamie Greene**

**May 2014**

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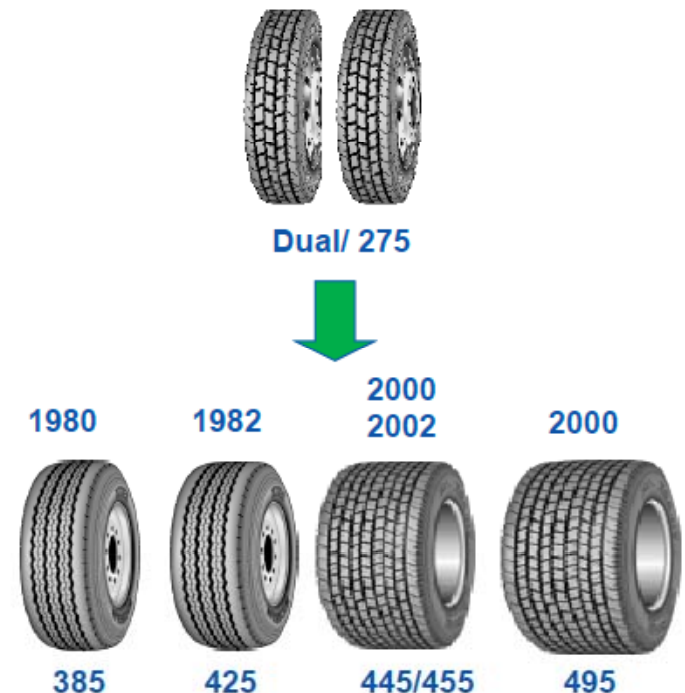
# Topics

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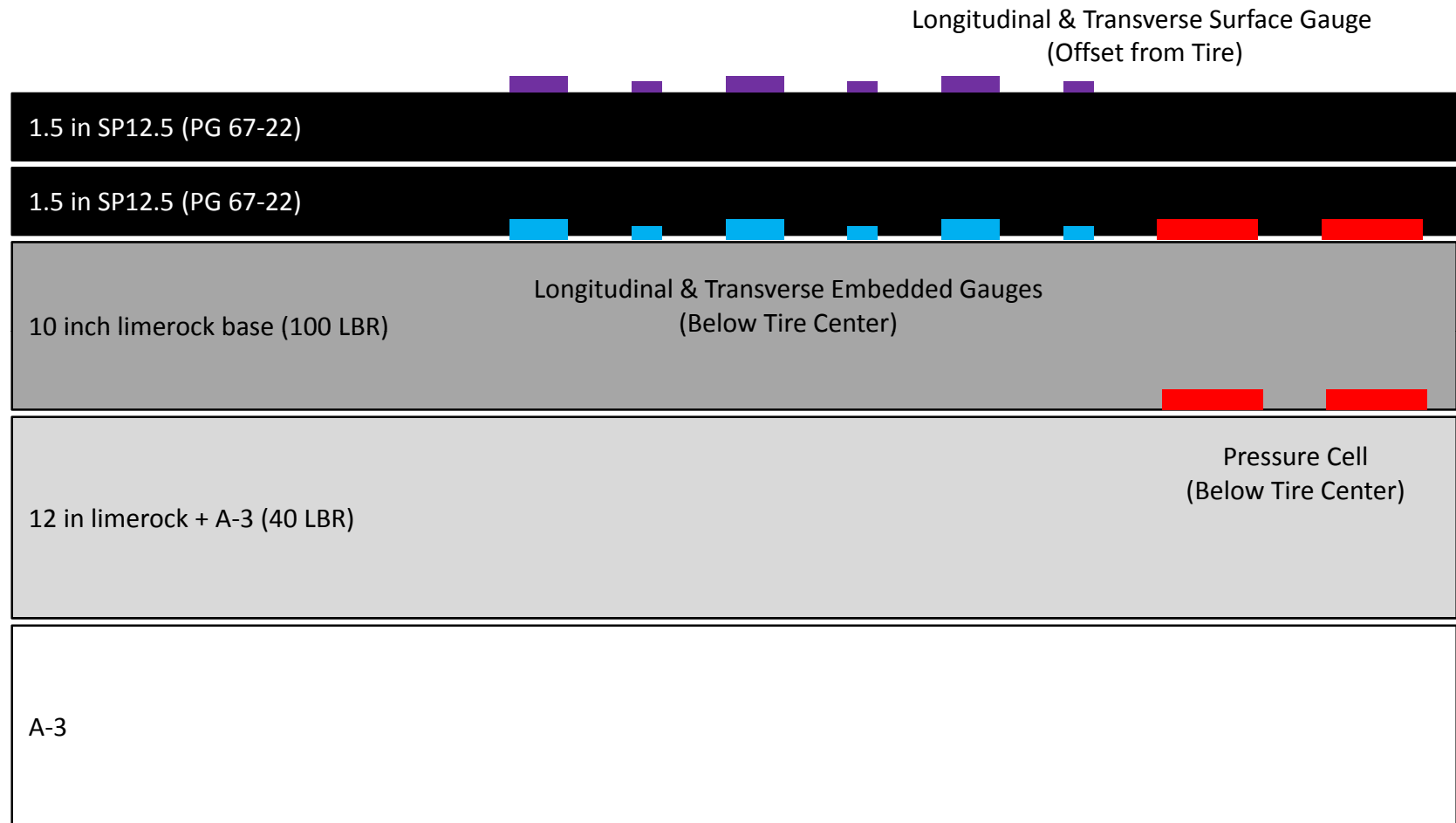
- Current APT research (2013 to present)
  - Impact of wide-base tires on pavement damage
  - Fiber reinforced polymer bridge deck
  - Benefit of using a prime coat
  - 4.75 mm mixture as a preservation treatment
  - Florida's concrete test road
  - PG 76-22 asphalt rubber binder
    - Sanghyun Chun presenter

# Wide-Base Tires

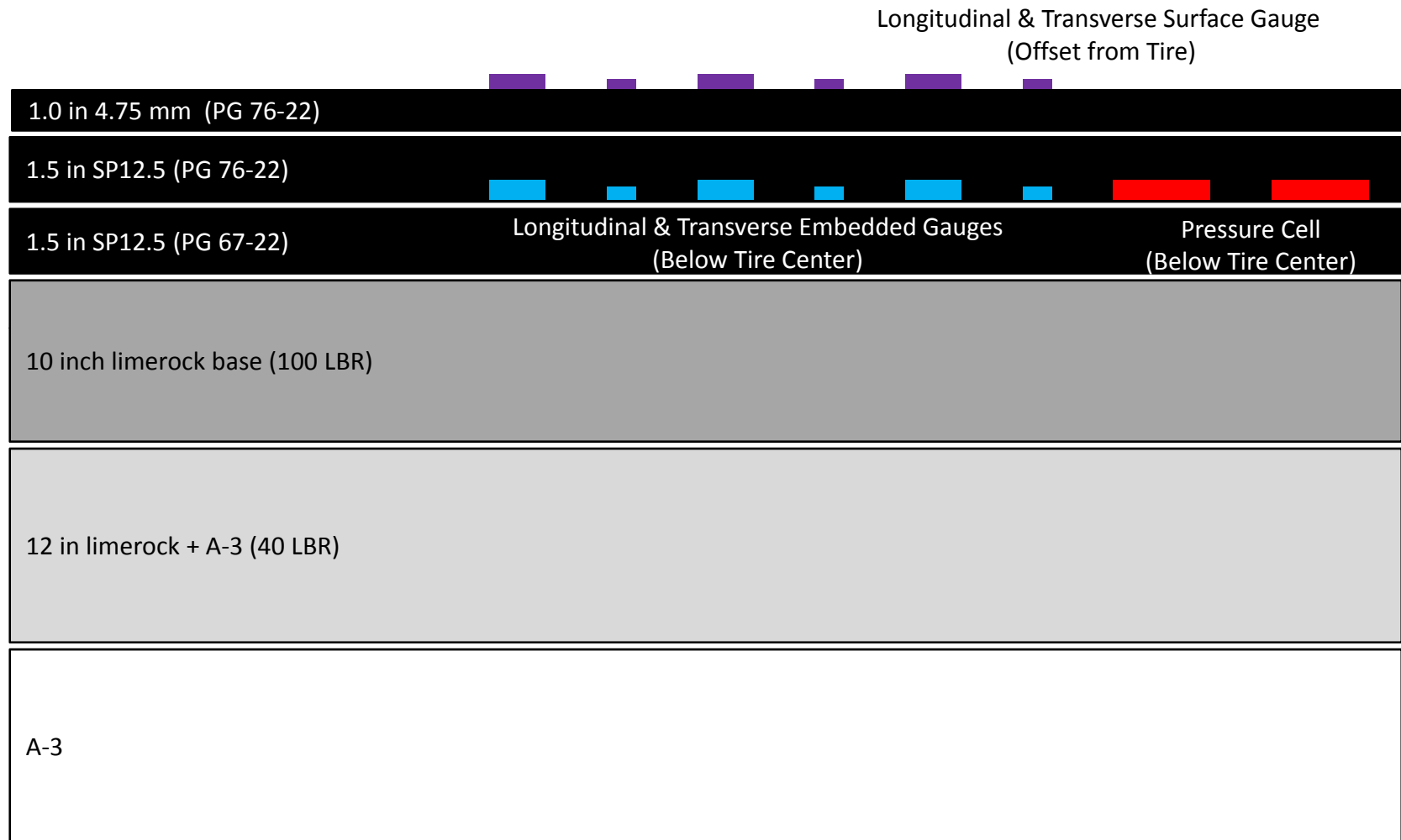
- TPF-5(197), The Impact of Wide-Base Tires on Pavement – A National Study
- **Objective:** Quantify the impact of WBT on pavement damage utilizing advanced theoretical modeling and validate results using full-scale testing
- **Scope:**
  - University of Illinois, Principal Investigator
  - Contact stress measurements, CSIR
  - Instrumented pavement sections
    - ✓ FDOT
    - ✓ UC-Davis
    - ✓ Ohio University
  - Modeling effort
    - ✓ University of Illinois
    - ✓ Delft University of Technology



# Test Pit Instrumented Section



# Test Track Instrumented Section



# HVS Test Matrix

180  
Combinations

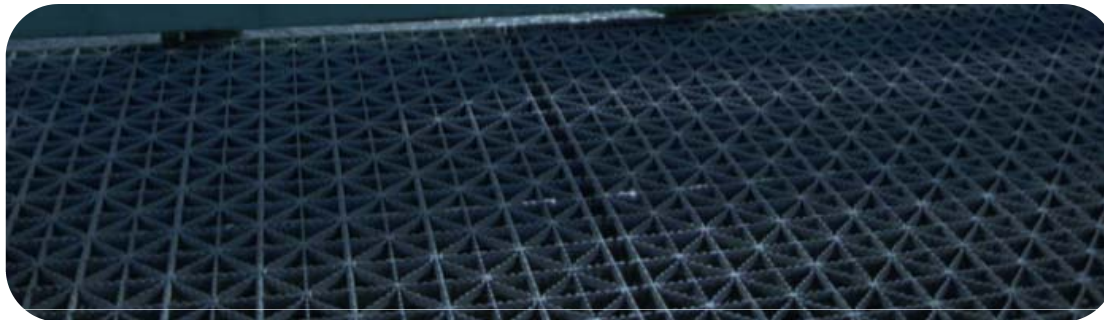
Tire Type	Inflation Pressure (psi)	Tire Loading (kips)				
		6	8	10	14	18
NGWB and Dual	80	6	8	10	14	18
NGWB and Dual	100	6	8	10	14	18
NGWB and Dual	110	6	8	10	14	18
NGWB and Dual	125	6	8	10	14	18
Dual Only	60/110	6	8	10	14	18
Dual Only	80/110	6	8	10	14	18
Tests at 25°C, 40°C, and 55°C						

Testing completed...  
Final report should be published later this year

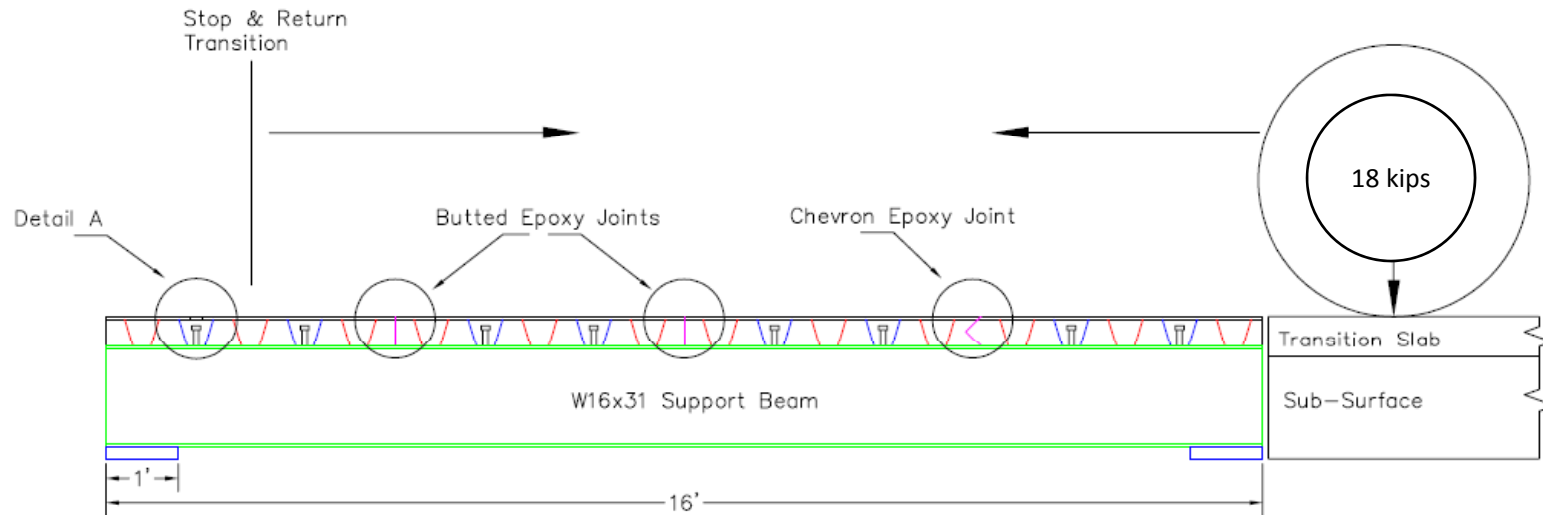
# FRP Bridge Deck

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- **Objective:** Investigate alternative to open grid steel decks
  - Must have a solid riding surface, weigh less than 25 lb/ft<sup>2</sup>, have a low profile (5 in depth), and low noise
- **Background:** Florida has the largest inventory of movable bridges in the US, most of which use open grid steel decks
  - High noise & vibration levels, costly maintenance



# FRP Bridge Deck

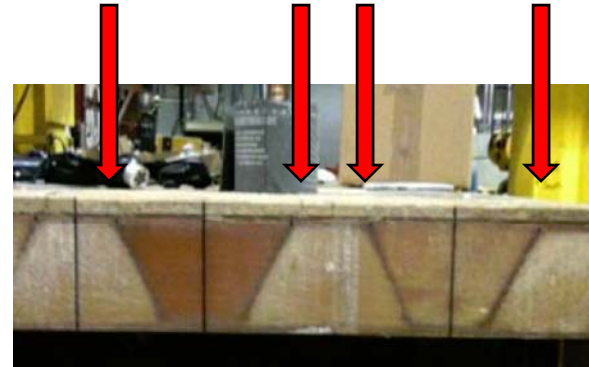




# FRP Bridge Deck

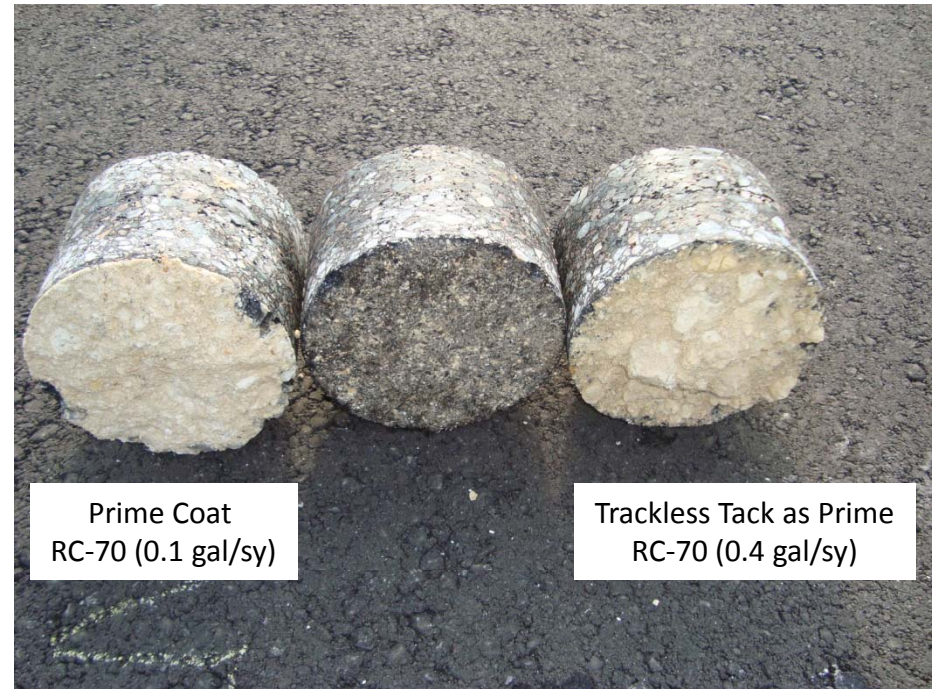
- Applied more than 300,000 passes
- Significant system deflection ( $> 0.5$  inches) in center of deck
- Surface cracks initiated after  $< 5000$  passes
- No catastrophic failures of joints or panels

Structures Research Group interested in testing new design this fall/winter



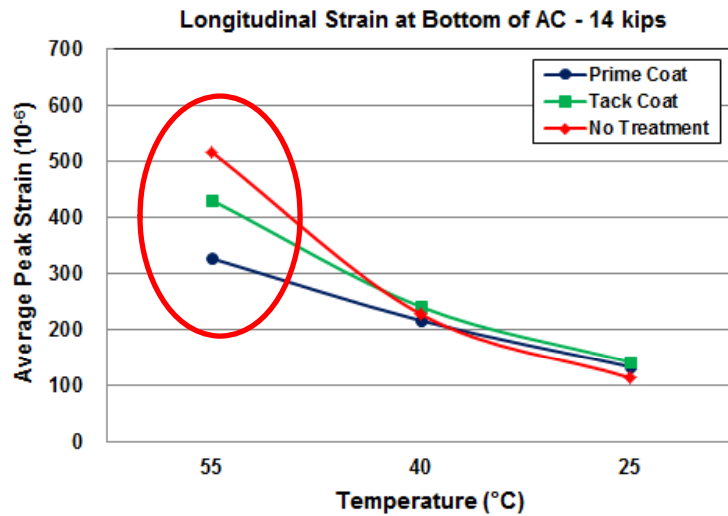
# Prime Coat Benefit

- **Objective:** Investigate structural benefit of prime coat
- **Scope:** Construct and instrument three sections with different base surface preparations: One with standard prime coat, one with a trackless tack coat, and one with no surface preparation.

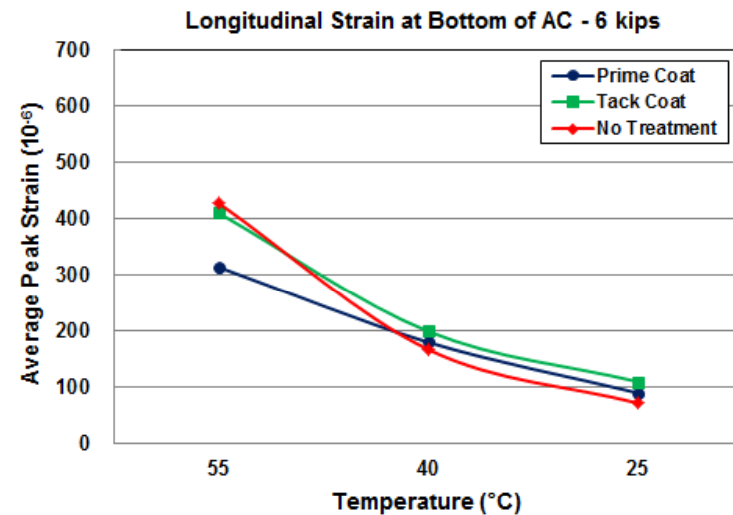
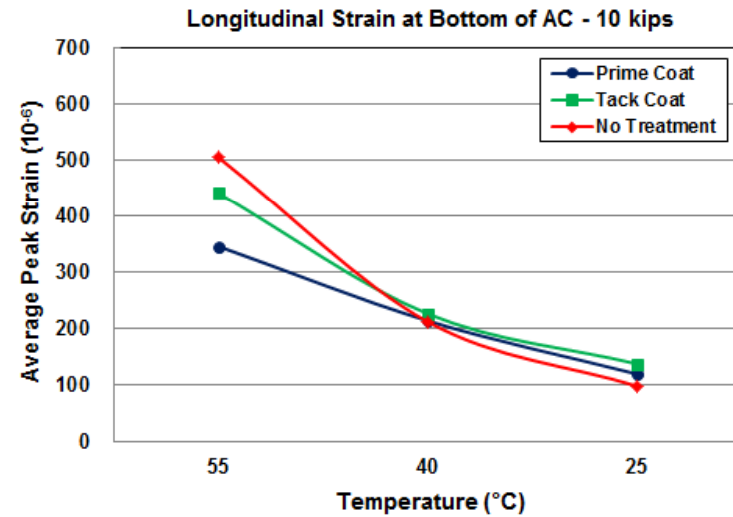


# Longitudinal Strain at AC Bottom

(Preliminary Data)

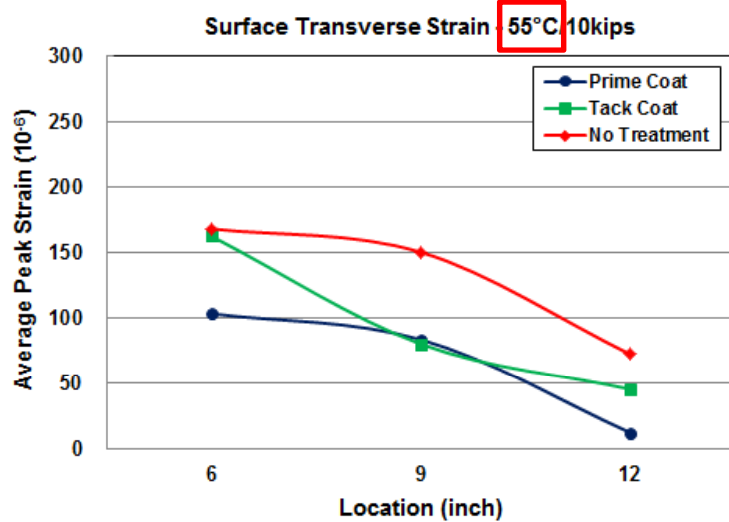


Strain in untreated section increases at elevated temperatures

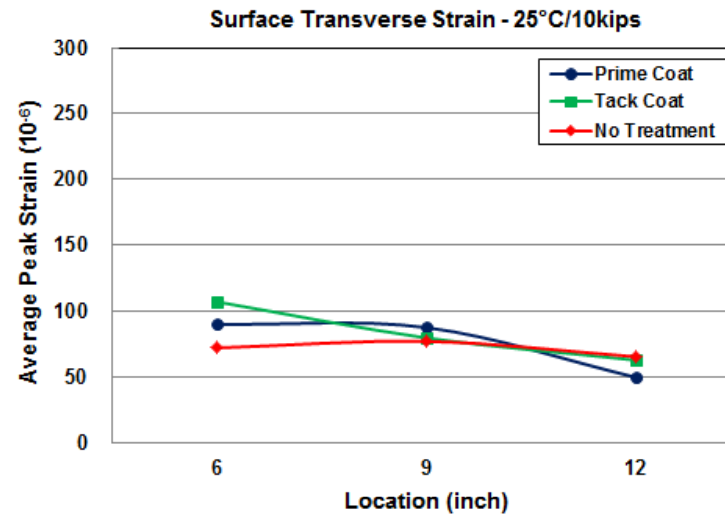
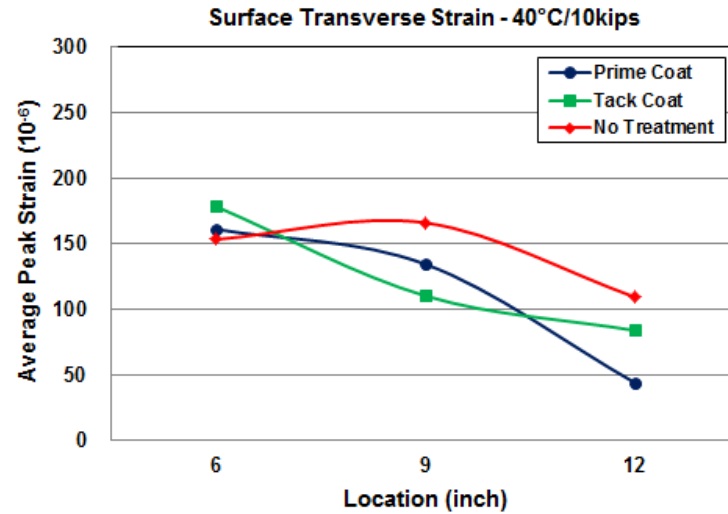


# Transverse Strain at AC Surface

(Preliminary Data)

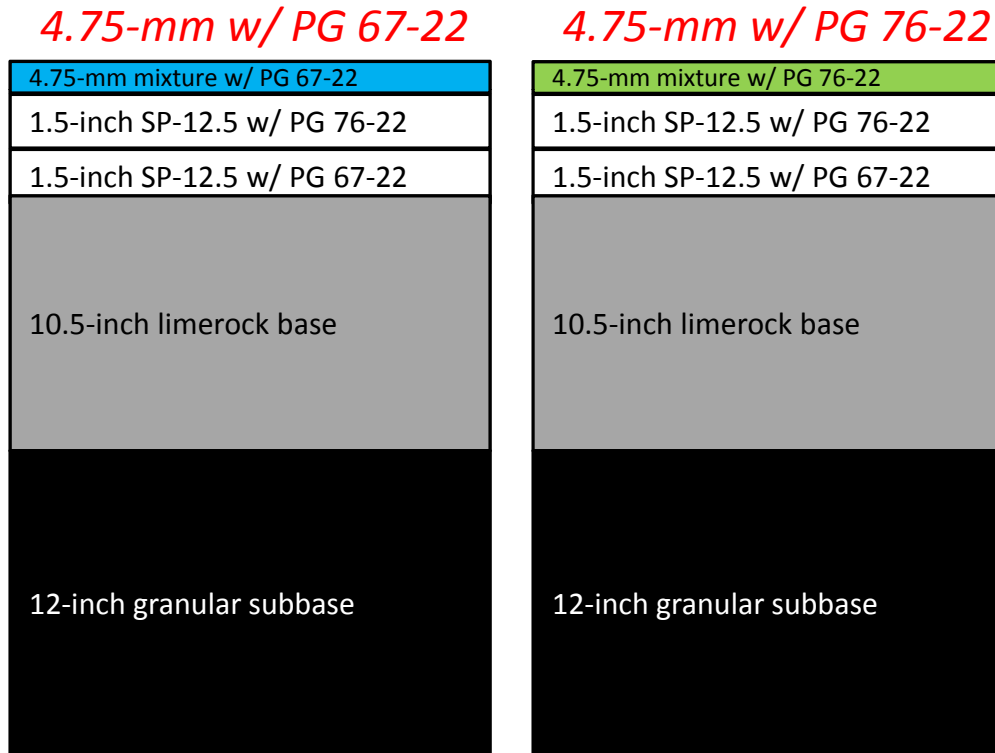


Strain in untreated section increases at elevated temperatures



# 4.75 mm Preservation Treatment

- Objective:** Study use of 4.75 mm mixture for preservation treatment on low-volume roadways and overbuild layer



*4.75-mm thickness ranges from ½ to 1 inch*

# Florida's Concrete Test Road

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- Located in Clay County, SR200/US 301
- Route serves as a significant truck connection between northeast and southwest Florida
- Existing 4-lane rural arterial with a 40 ft median, 31% trucks, design speed of 70 mph
- Will consist of 2.5 miles of two-lane roadway adjacent to existing northbound lanes
- A series of concrete test sections (52 total) including replicates

# Florida's Concrete Test Road

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- WIM installation at south end of test sections
- Dedicated weather station
- Northbound traffic will be diverted to parallel test road
- Existing northbound asphalt road will provide alternate traffic lanes during evaluation periods
- 2016, estimated construction cost \$26 million



# *US 301 Looking South*



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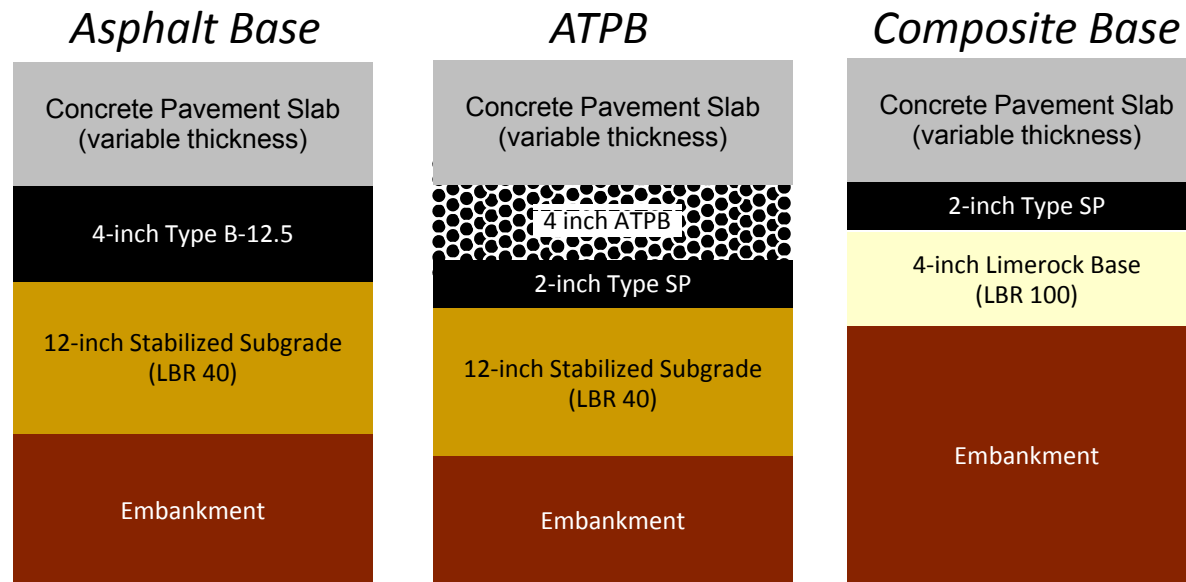
# What Will We Learn?

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- Structural test sections
  - Thickness, base types, recycled materials
  - 4,400 feet total (20 sections)
- Drainage test sections
  - Edge drains, joint sealant
  - 3,600 ft total (16 sections)
- MEPDG calibration test sections
  - Focus on cracking
  - 3,600 ft total (16 sections)

# Pavement Structures

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# Current Work

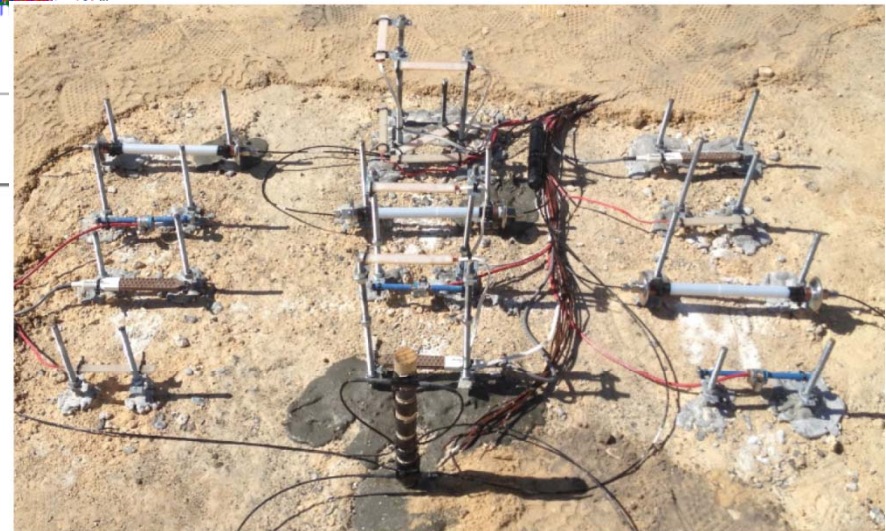
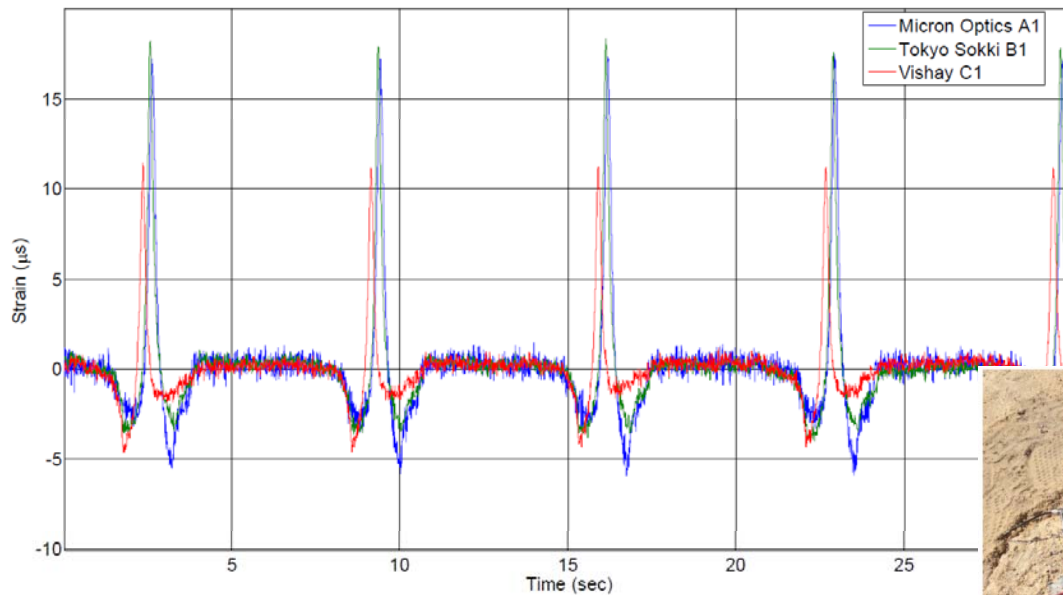
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- Phase III design plans almost complete
- Developing detailed laboratory test plan and long-term monitoring plan
- Designing instrumentation plan
  - Potential use of fiber optic strain gauges
  - Constructability of design
  - Upcoming test sections



# Fiber Optic Strain Gauge Evaluation

- Advantages: Immune to electromagnetic interference (including lightning!), long lead lengths are not a problem, fewer DAQs are required





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## **PG76-22 ARB Study**

**Sanghyun Chun**

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# Contents

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- Introduction
- Accelerated Pavement Testing (APT)
- Laboratory Materials Testing
  - Binder Testing
  - Mixture Testing
- Summary



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# Introduction

# Background

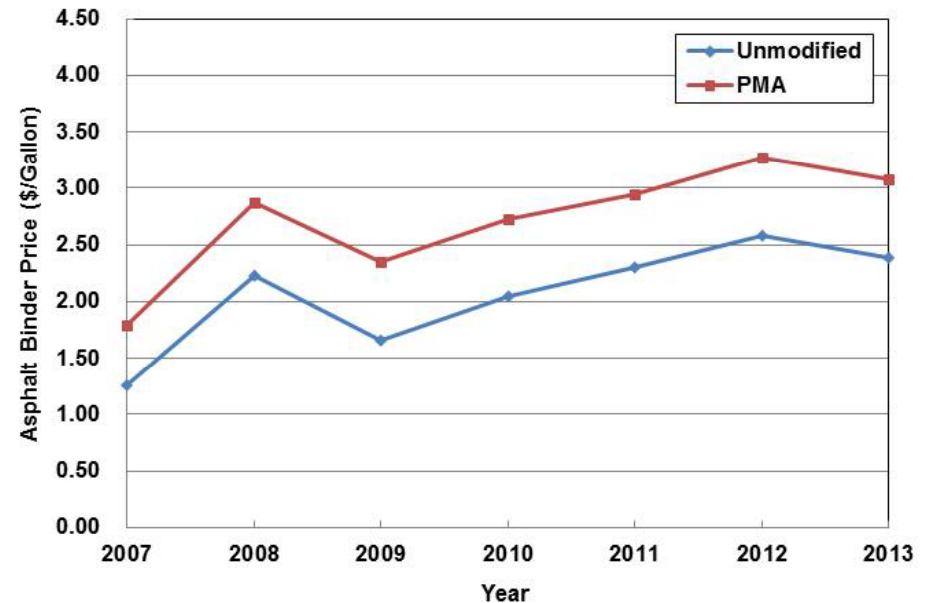
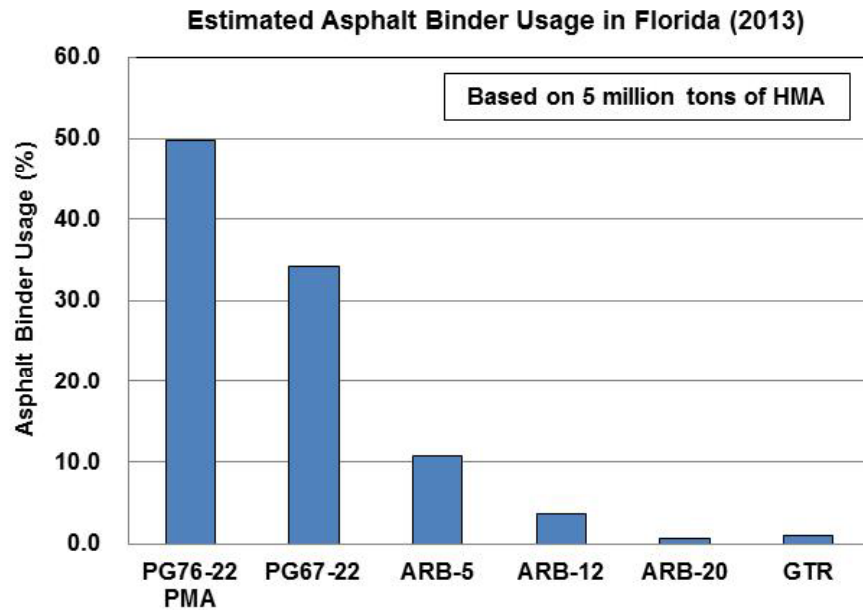
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- 2001 APT evaluation of rutting resistance of a polymer modified PG76-22 asphalt binder
  - Traffic level D (10 to < 30 million ESALs) requires PG76-22 binder for final structural course
  - Traffic level E ( $\geq$  30 million ESALs) requires PG76-22 binder for top two structural courses
  - Recommended for use at intersections or other facilities with slow moving and concentrated truck loads
- Deficient pavements due to rutting and cracking have steadily decreased over the last 10 years





# Background



- Supply shortage and price increase of SBS polymer for asphalt industry
- Asphalt Rubber (AR) Binder may provide an alternative modifier to SBS polymer and create competition to lower cost



# Background

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- 1988 Florida Legislature
  - Florida Statute 336.044
  - Directed FDOT to research and if feasible, expand use of waste materials particularly GTR in construction
  
- 1994 Asphalt rubber binder (ARB) specifications developed as a standard practice
  - ARB-5, ARB-12 and ARB-20
  - FDOT usage since 1994: Over 7 million tires
  - Good cracking performance: Issues with settlement



# Alternatives to SBS PMA Binder

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- PG76-22 AR Binders
  - 2014 FDOT Standard Specification
  - GTR and Hybrid (GTR + SBS polymer)
- Potential way to address supply shortage and cost of SBS polymer and increase the use of recycled tire rubber



# Objectives and Scope

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- Evaluate asphalt rubber binder as an alternative to polymer modified asphalt binder for use in structural courses that requires a PG76-22 grade
- Performance evaluation was conducted for both rutting and cracking using APT and different laboratory tests



# Materials Evaluated

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<b>Mixture Type</b>	<b>Binder Producer</b>	<b>Binder Type</b>	<b>Mixture ID</b>
12.5 mm Fine	A	PG76-22 SBS PMA	Control
12.5 mm Fine	A	ARB-5	ARB-5
12.5 mm Fine	B	PG76-22 Hybrid	Hybrid B
12.5 mm Fine	A	PG76-22 Hybrid	Hybrid A
12.5 mm Fine	C	PG76-22 GTR	GTR C
12.5 mm Fine	A	PG76-22 GTR	GTR A



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# Accelerated Pavement Testing



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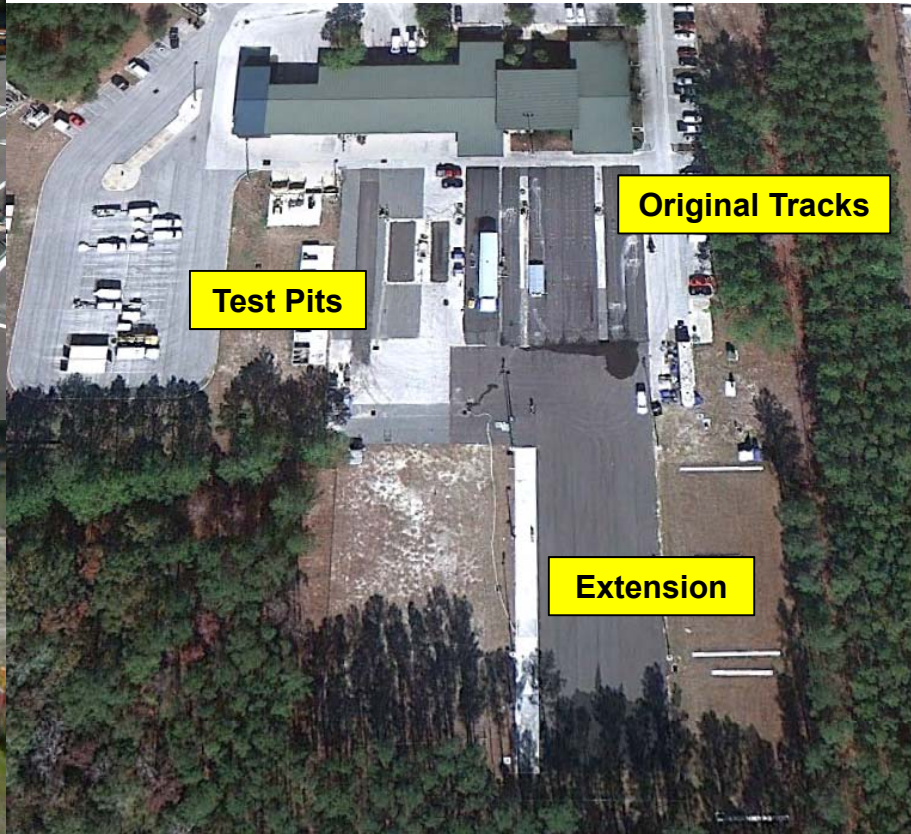
# Florida's APT Program

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- Initiated in 2000
- Housed at the State Materials Office in Gainesville, FL
- Test site consists of eight 12 feet linear tracks
  - Originally 150 feet long
  - Seven tracks extended additional 300 feet in 2001
- Two additional tracks include water table control
- Loading performed using a Heavy Vehicle Simulator (HVS)



# Florida's APT Program



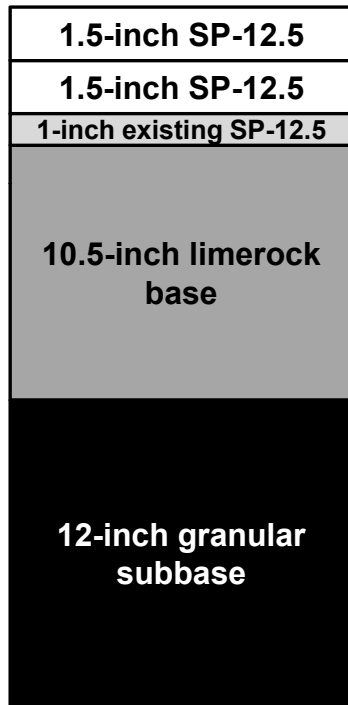
Florida Department of Transportation



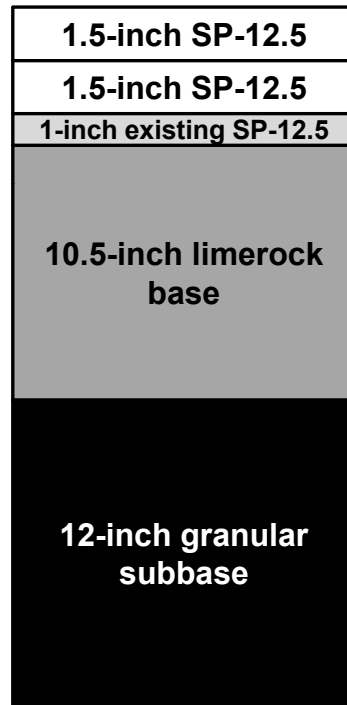
# Experimental Design

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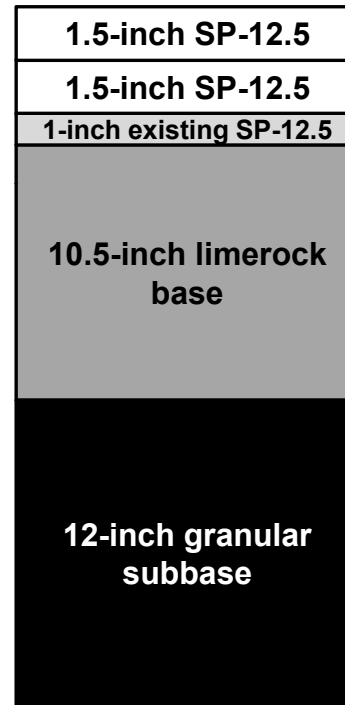
## PG76-22 PMA (SBS)



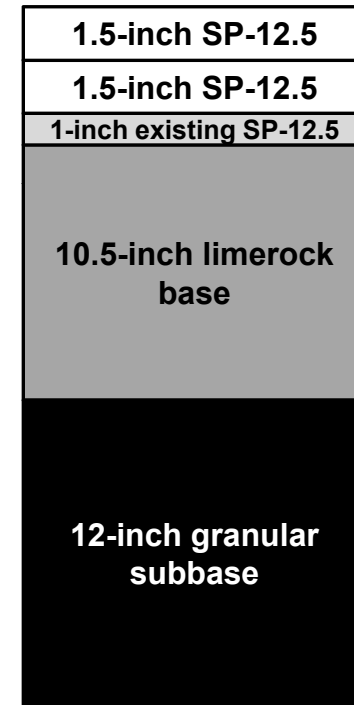
## ARB-5



## Blend of GTR and Polymer PG76-22 ARB (Hybrid)



## PG76-22 ARB (GTR)



(two binder suppliers) (two binder suppliers)



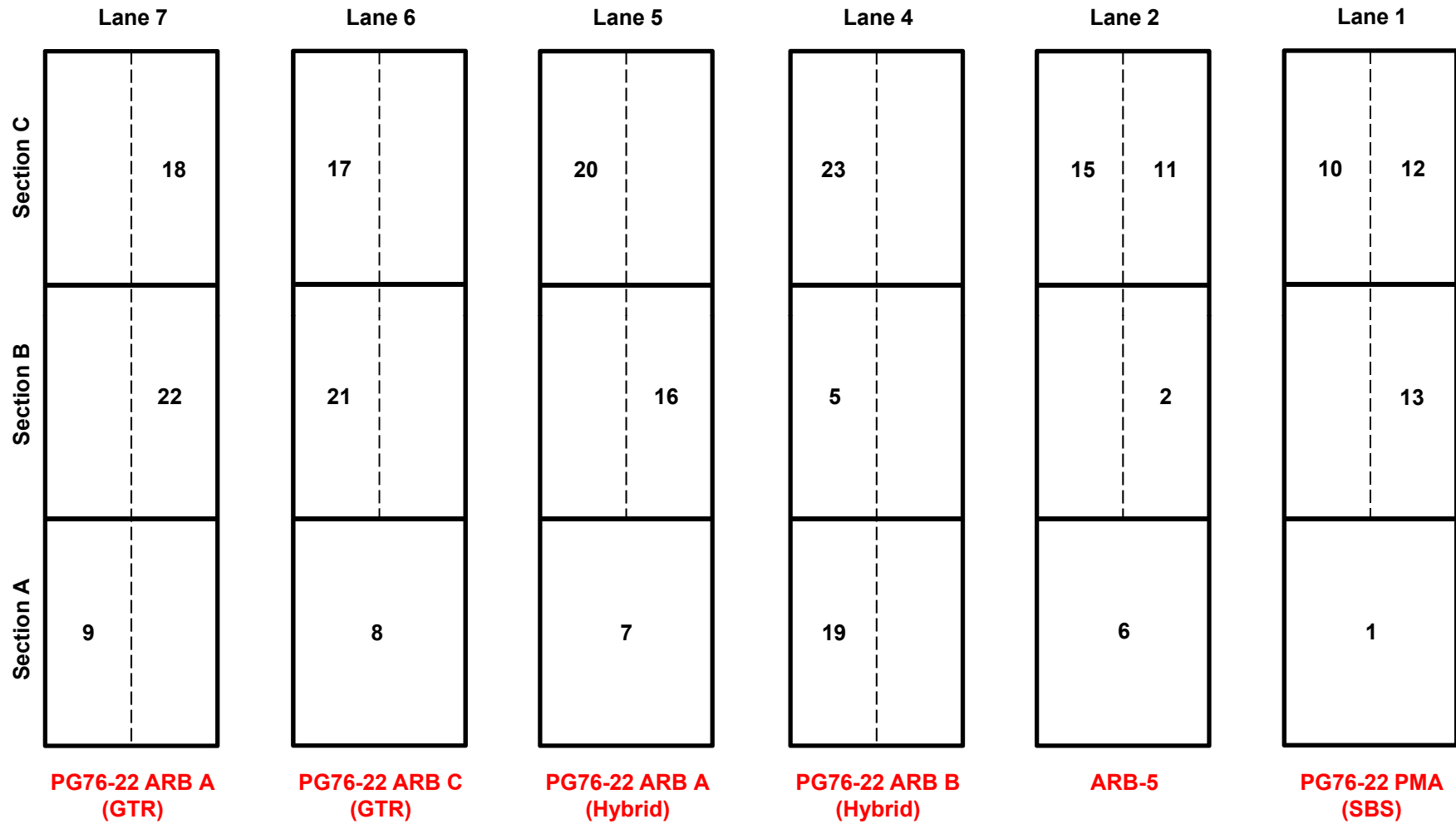
# Rut Evaluation

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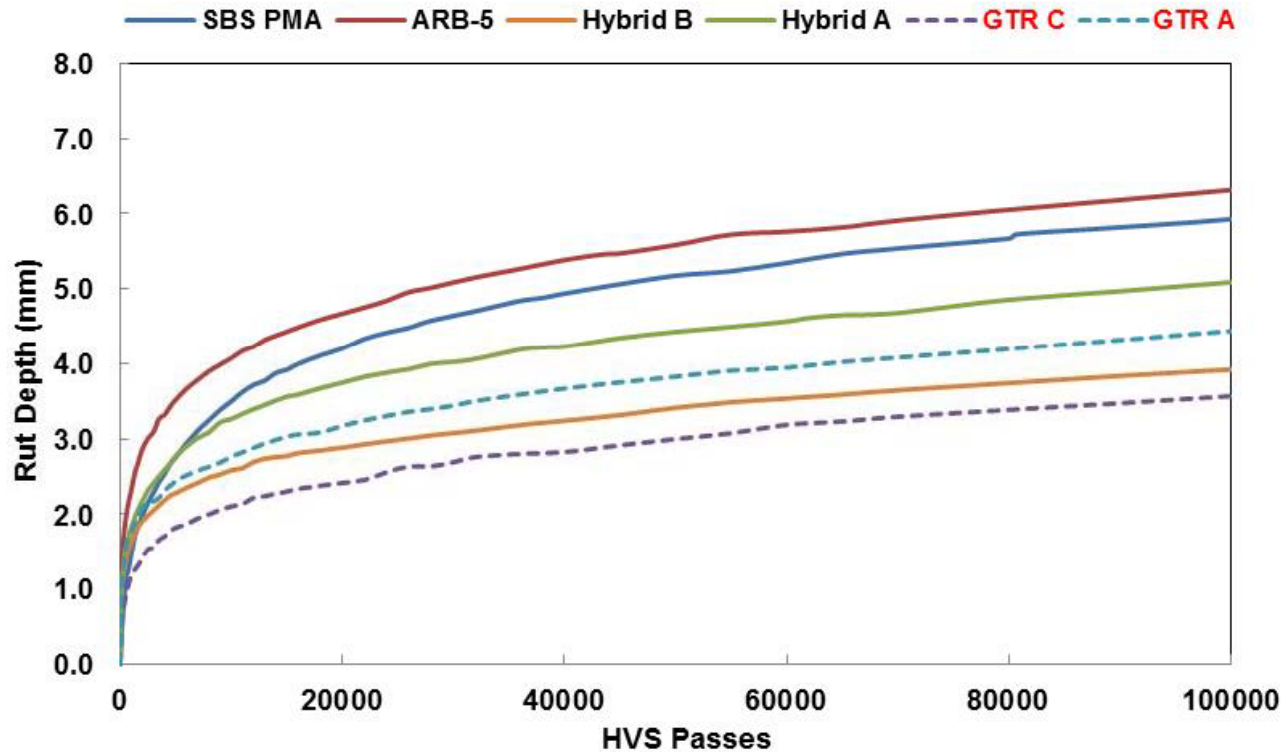
- Heavy Vehicle Simulator (HVS)
- 9-kip wheel load (Super Single)
- 4 inches of wander
- Test temperature of 50 °C



# HVS Test Sequence



# APT Rut Profiles



Mixture	APT Rut After 100,000 Passes (mm)
PG76-22 SBS PMA	5.9
ARB-5	6.6
PG76-22 Hybrid B	3.9
PG76-22 Hybrid A	5.1
<b>PG76-22 GTR C</b>	<b>3.6</b>
<b>PG76-22 GTR A</b>	<b>4.4</b>

- Average rut depth of 3.6 – 6.6 mm (0.14 – 0.26 in) after 100,000 HVS passes



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# Laboratory Materials Testing



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# Binder Tests

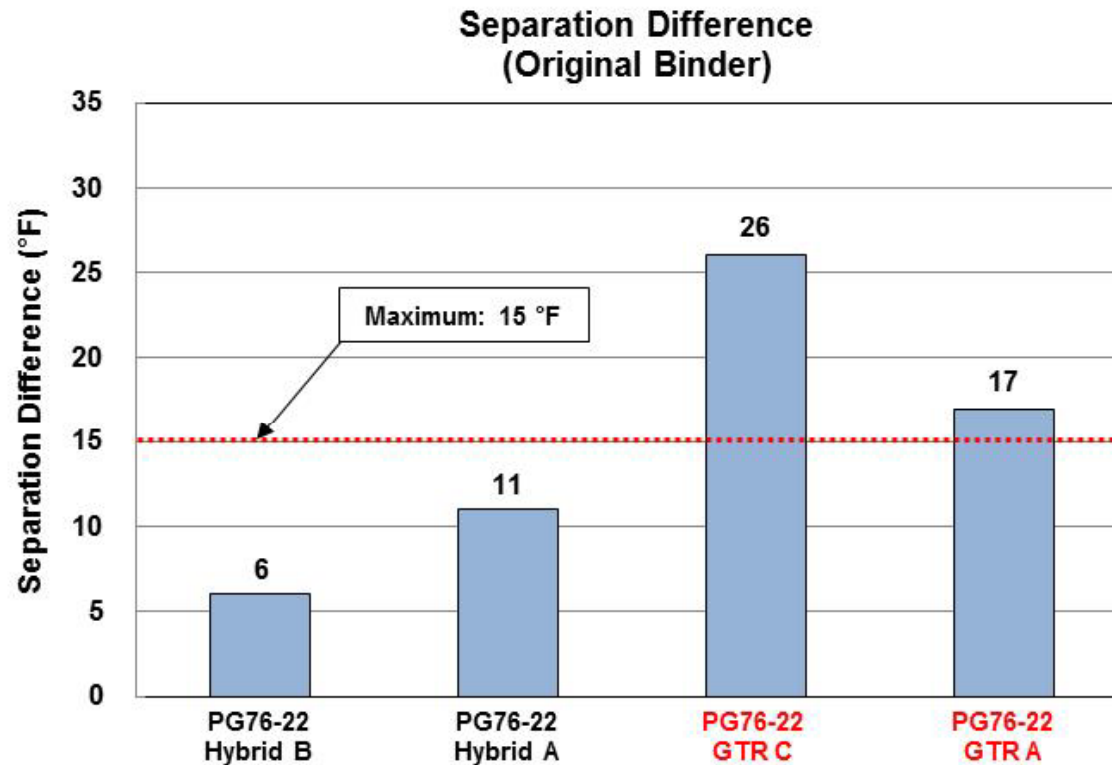
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- 2014 FDOT Standard Specification
- Separation
- Viscosity
- Dynamic Shear Rheometer (DSR)
- Multiple Stress Creep Recovery (MSCR)
- Bending Beam Rheometer (BBR)



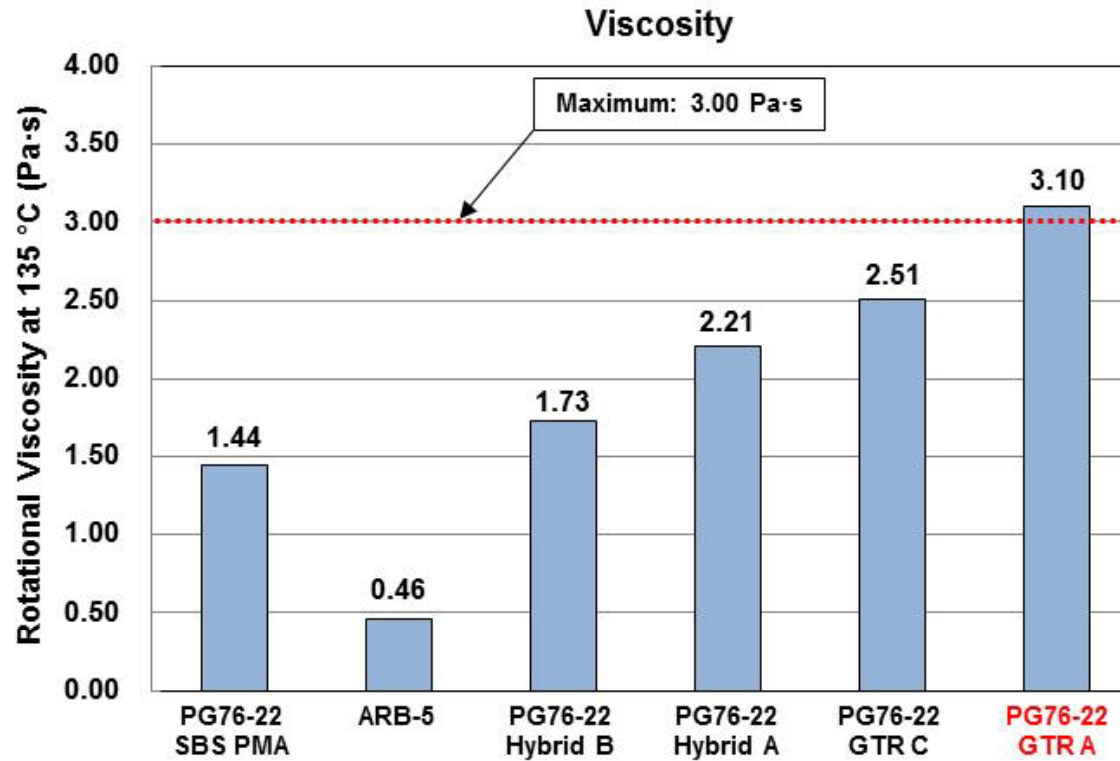
# Separation

- Separation Difference



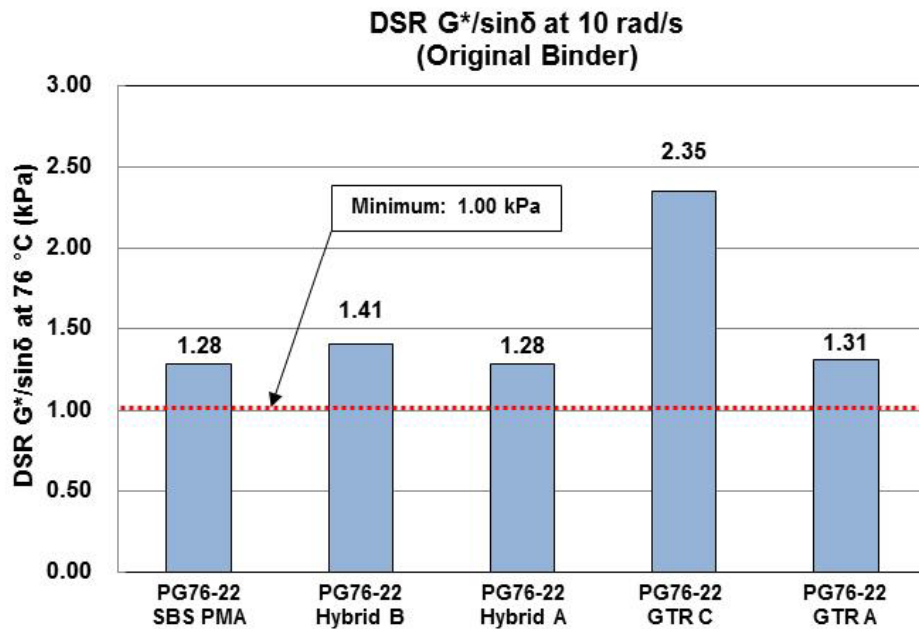
# Viscosity

- Rotational Viscosity

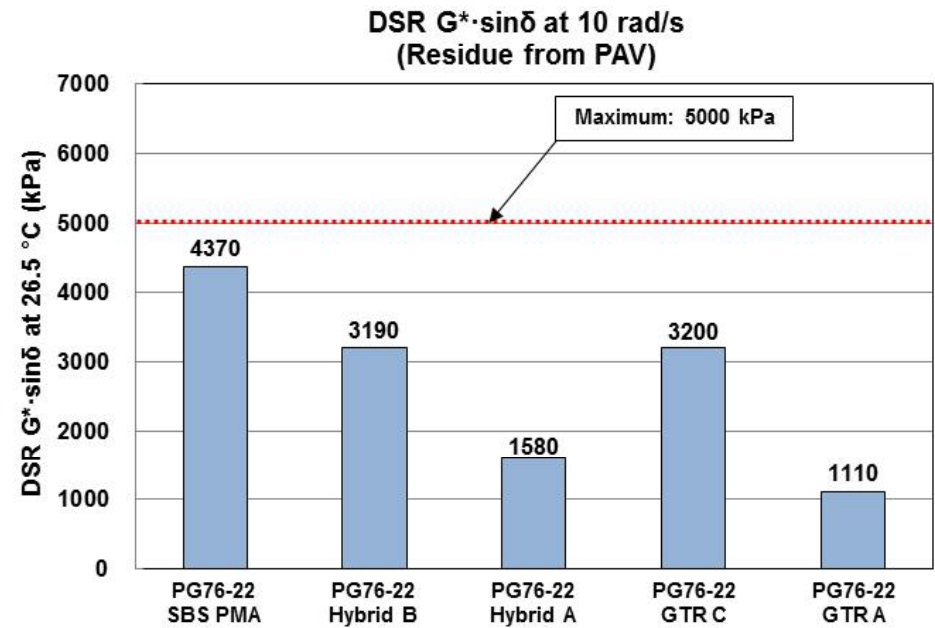




# Dynamic Shear Rheometer (DSR)



DSR  $G^*/\sin\delta$

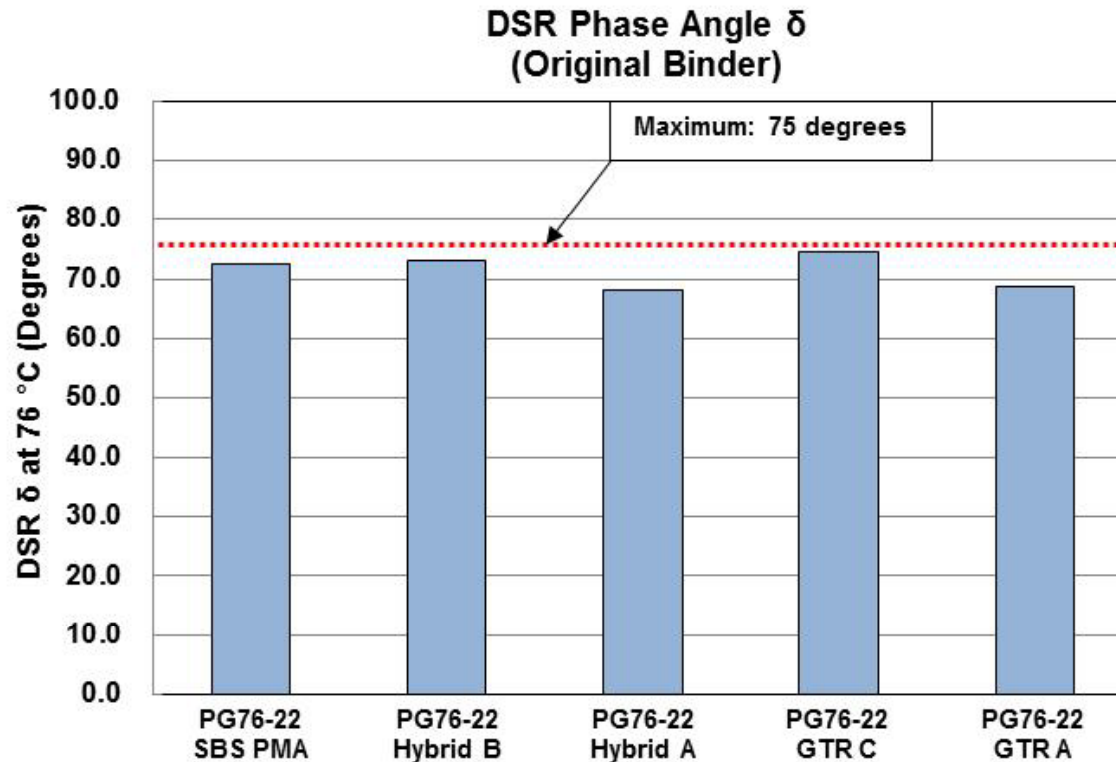


DSR  $G^*\cdot\sin\delta$



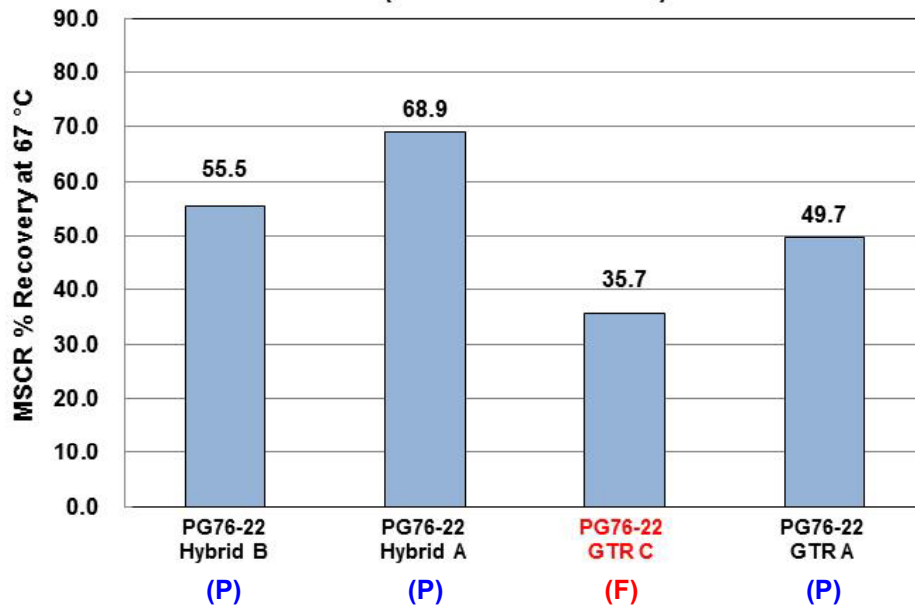
# Dynamic Shear Rheometer (DSR)

- DSR Phase Angle  $\delta$



# Multiple Stress Creep Recovery (MSCR)

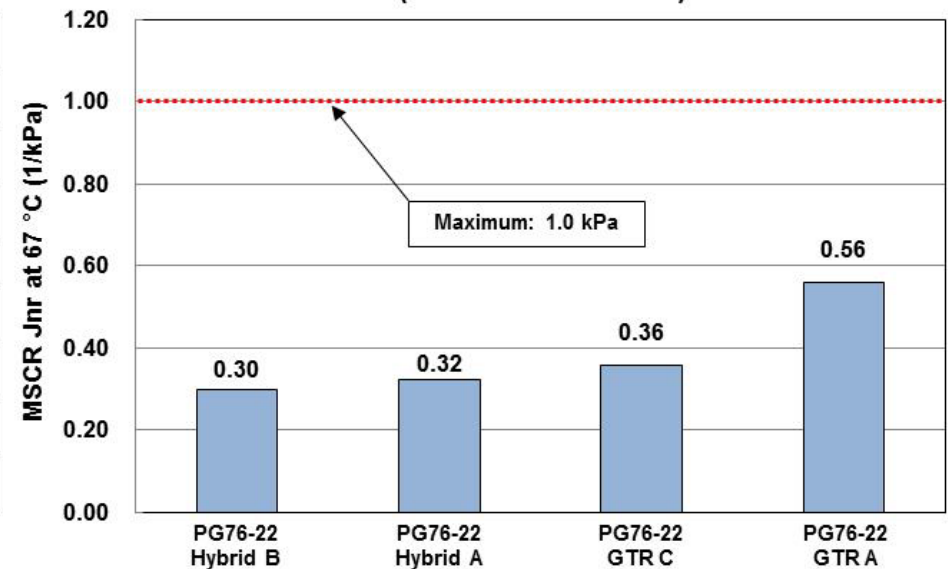
MSCR % Recovery at 3.2 kPa  
(Residue from RTFO)



$$P : \% R_{3.2} > 29.37 (J_{nr3.2})^{-0.2633}$$

MSCR % Recovery

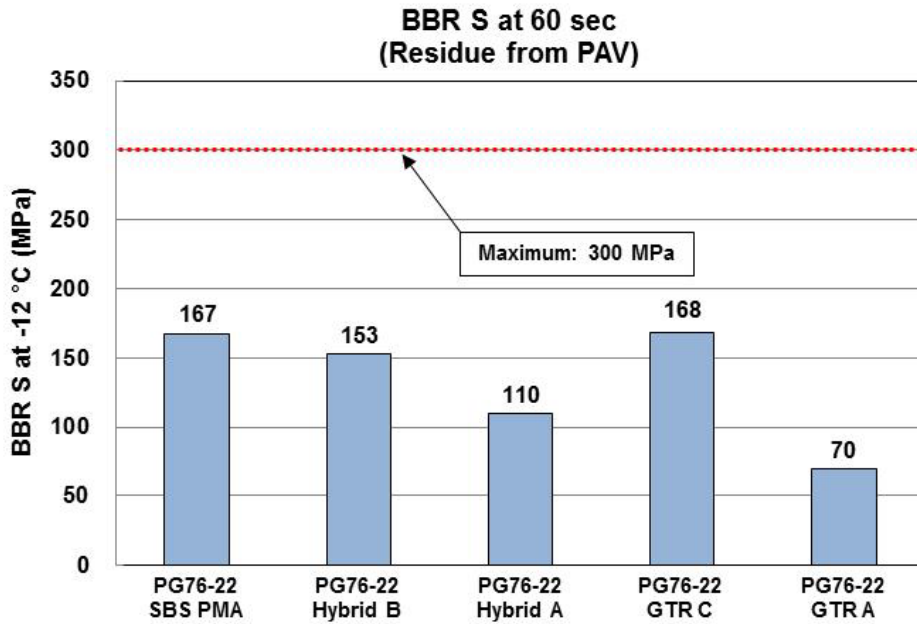
MSCR Jnr at 3.2 kPa  
(Residue from RTFO)



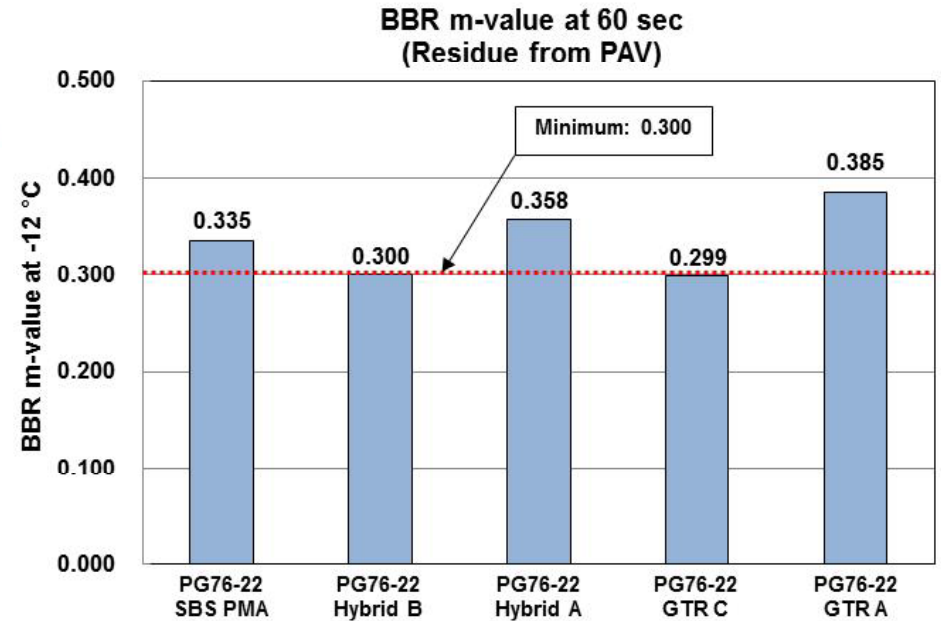
MSCR Non-Recoverable Compliance Jnr



# Bending Beam Rheometer (BBR)



**BBR Creep Stiffness S**



**BBR m-value**



# Mixture Tests

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- Volumetric Properties
- Asphalt Mixture Performance Tester (AMPT)
  - Dynamic Modulus
  - Flow Number
- Superpave Indirect Tension Test (IDT)
  - Resilient Modulus
  - Creep
  - Strength



# Volumetric Properties

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Mix Type	$G_{mb}$	$G_{mm}$	Air Voids (%)
12.5 mm PG76-22 SBS PMA	2.416	2.501	3.4
12.5 mm ARB-5	2.409	2.501	3.7
12.5 mm PG76-22 Hybrid B	2.415	2.506	3.7
12.5 mm PG76-22 Hybrid A	2.420	2.510	3.6
12.5 mm PG76-22 GTR C	2.415	2.502	3.5
12.5 mm PG76-22 GTR A	2.410	2.511	4.1



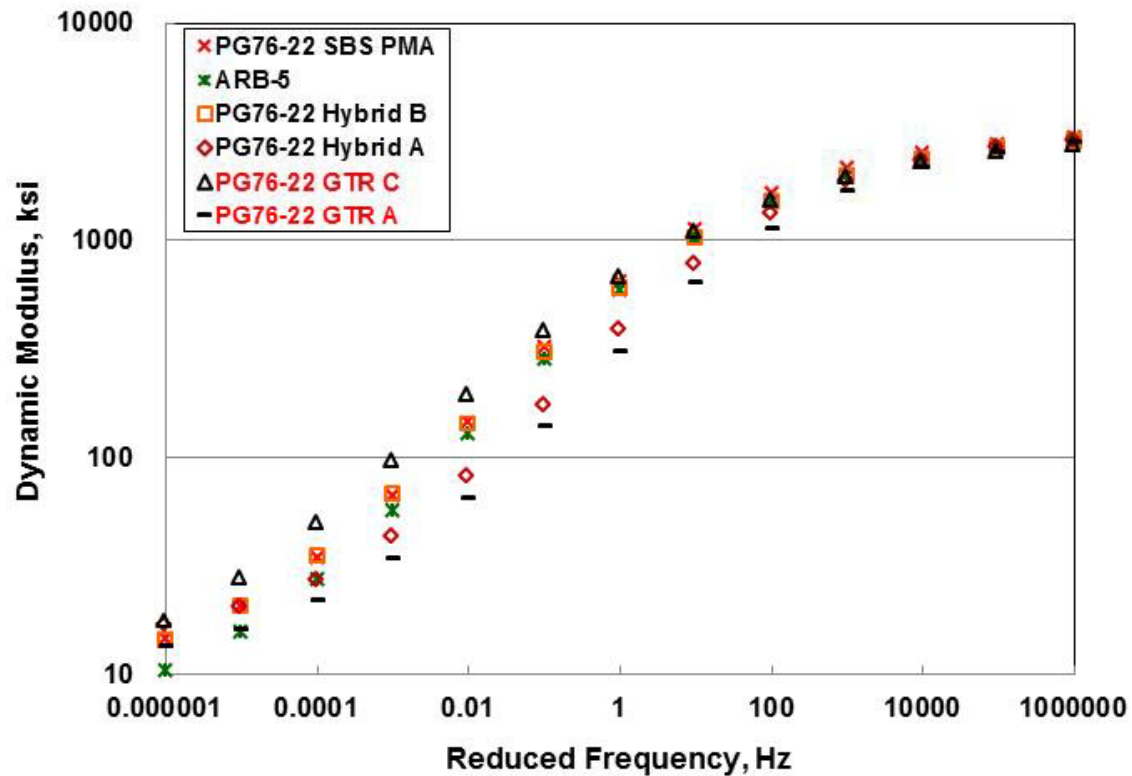
# As-Built Gradations and Binder Content

Sieve Size	JMF	As-Built					
		12.5 mm PG76-22 SBS PMA	12.5 mm ARB-5	12.5 mm PG76-22 Hybrid B	12.5 mm PG76-22 Hybrid A	12.5 mm PG76-22 GTR C	12.5 mm PG76-22 GTR A
3/4"	100	100	100	100	100	100	100
1/2"	100	98	99	99	99	99	99
3/8"	87	87	87	91	91	91	89
#4	62	62	61	65	65	64	62
#8	41	42	41	43	44	42	40
#16	29	30	30	31	31	30	29
#30	22	23	23	23	24	23	22
#50	12	13	14	14	14	13	13
#100	4	5	5	5	6	5	5
#200	2	3	3	3	3	3	3
%AC	5.1	5.0	5.0	5.0	4.8	5.0	4.6



# Asphalt Mixture Performance Tester (AMPT)

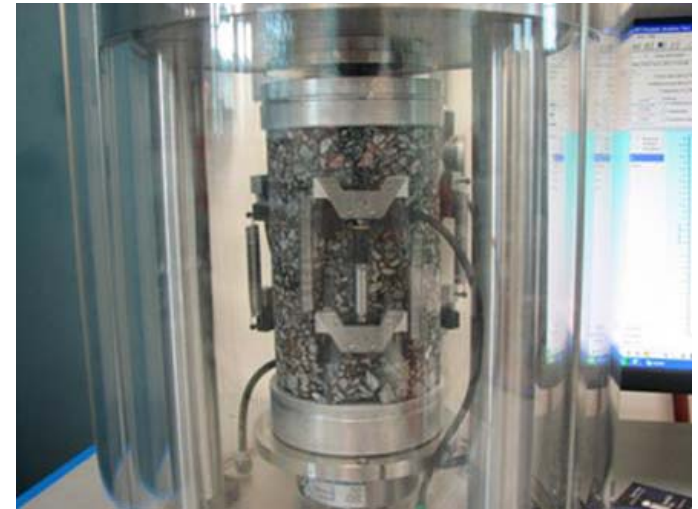
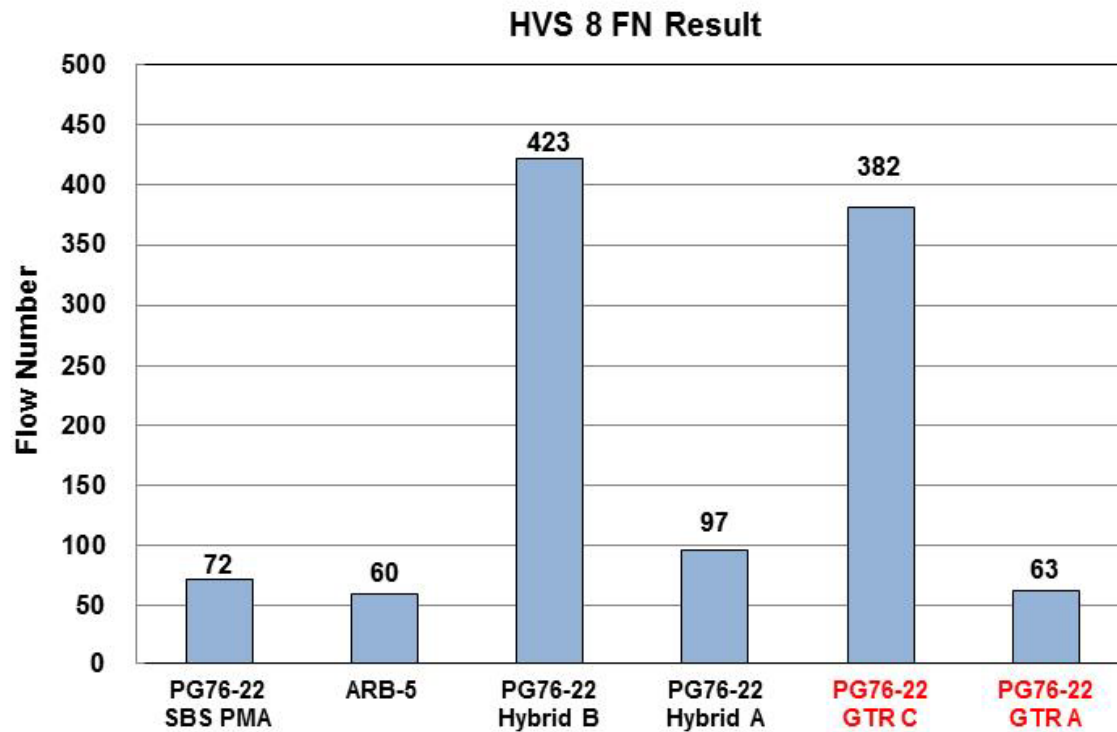
- Dynamic Modulus





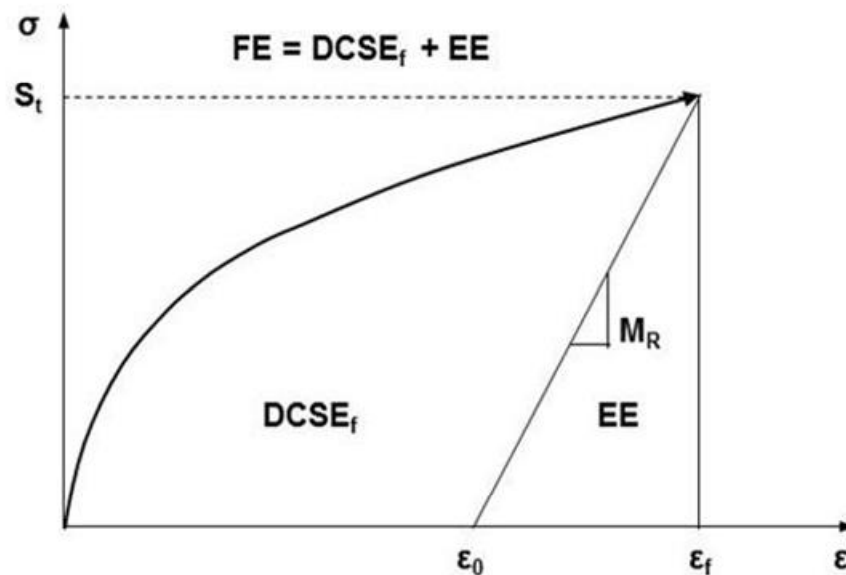
# Asphalt Mixture Performance Tester (AMPT)

- Flow Number



# Superpave IDT

- $M_R$  test: Stiffness
- Creep test: Rate of damage accumulation (Creep compliance rate)
- Strength test: Failure limits

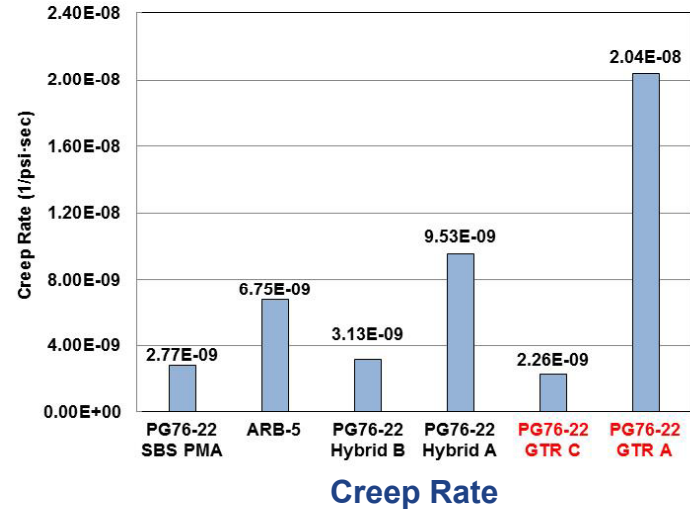
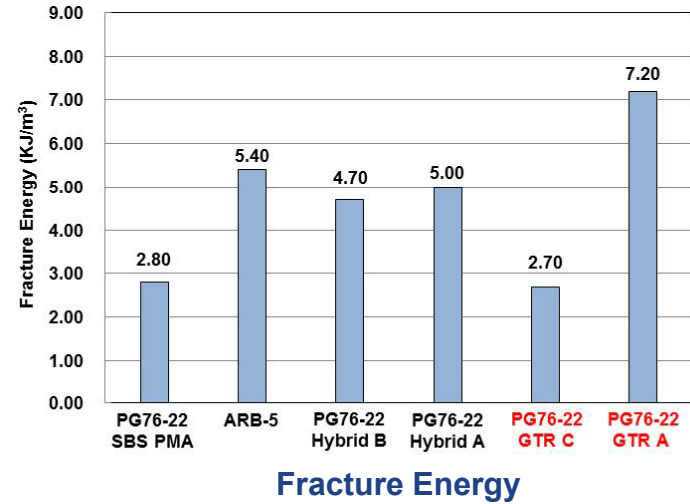
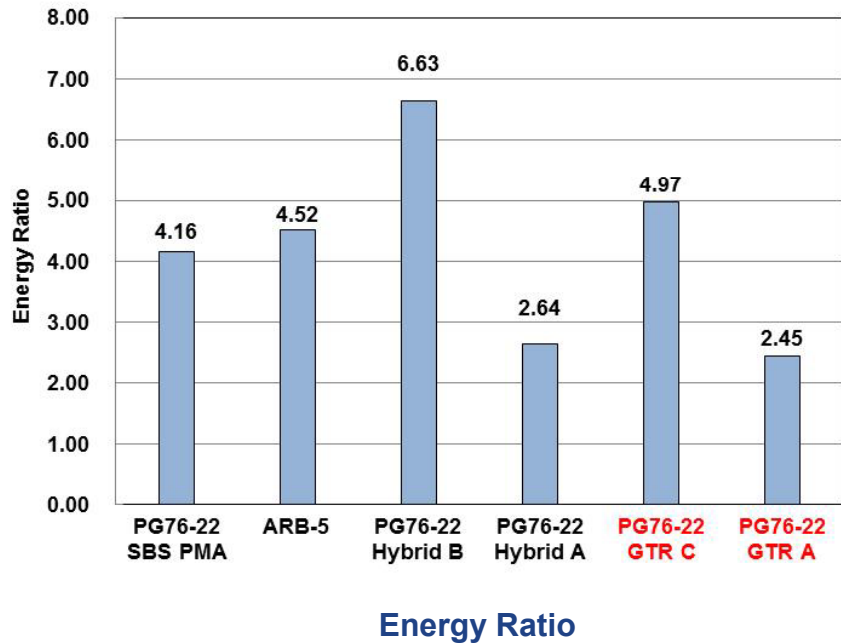


$$ER = \frac{DCSE_f}{DCSE_{min}} = \frac{f(\sigma_t, S_t) \times DCSE_f}{m^{2.98} \times D_1}$$



# Superpave IDT

- Mixture Fracture Properties



# Summary

Mixture	APT Rut After 100,000 Passes (mm)	Flow Number	Fracture Energy (KJ/m <sup>3</sup> )	Creep Rate (1/psi·sec)	Energy Ratio	Overall Rank	
						Rutting	Cracking
PG76-22 SBS PMA	5.9	72	2.8	2.8E-09	4.2	5	3
ARB-5	6.6	60	5.4	6.8E-09	4.5	6	4
PG76-22 Hybrid B	3.9	423	4.7	3.1E-09	6.6	1	1
PG76-22 Hybrid A	5.1	97	5.0	9.5E-09	2.6	3	5
PG76-22 GTR C	3.6	382	2.7	2.3E-09	5.0	2	2
PG76-22 GTR A	4.4	63	7.2	2.0E-08	2.5	4	6



# Summary

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- In general, all mixtures show good rutting performance indicated by average rut depth of 3.60 mm – 6.60 mm (0.14 in – 0.26 in) after 100,000 HVS passes
- Hybrid A and GTR A mixtures exhibit significantly higher creep rate which indicates a greater rate of damage accumulation and relatively worse cracking resistance
- Overall, Hybrid B mixture had the best rutting and cracking performance



# Summary

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- Based on the results in this study, the performance of PG76-22 AR binders (Hybrid and GTR) appear to be comparable to that of PG76-22 PMA binder
- The use of PG76-22 AR Binders
  - One solution for supply shortage of SBS polymer
  - Increase in use of recycled tire rubber
  - Comparable performance with PMA binder



# Steps to Implementation

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- FDOT research on PG76-22 binders with asphalt rubber
  - Contracted university research
  - In-house HVS study
  - NCAT test sections
  
- FDOT Standard Specifications for Road and Bridge Construction Section 916 (2014): PG76-22 (ARB)
  - Separation and MSCR test requirements
  - Minimum 7.0% GTR by weight of asphalt binder
  - Polymer modification is optional



# Steps to Implementation

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- PG76-22 ARB Test Sections

County	Route	Location	Mix Type	Tonnage Placed	Date Constructed
Hernando	US-19	SR-55 (US-19) from County Line Road to Toucan Trail	FC-5	452	06/2012
Jefferson	US-19/27 (SR-20)	SR-20 (US-19/27) from West of SR-57 (US-19) to West of J.C. Lee Road	SP-12.5	508	01/2013
Leon	SR-20	SR-20 Blountstown Highway from Ochlocknee River Bridge to SR-263 Capital Circle	SP-12.5	800	05/2013
Palm Beach	SR-704	SR-704 Okeechobee Boulevard from East of Military to East of Congress	SP-12.5	448	05/2013





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**Thank You**



**Florida Department of Transportation**