

# OGFC Durability

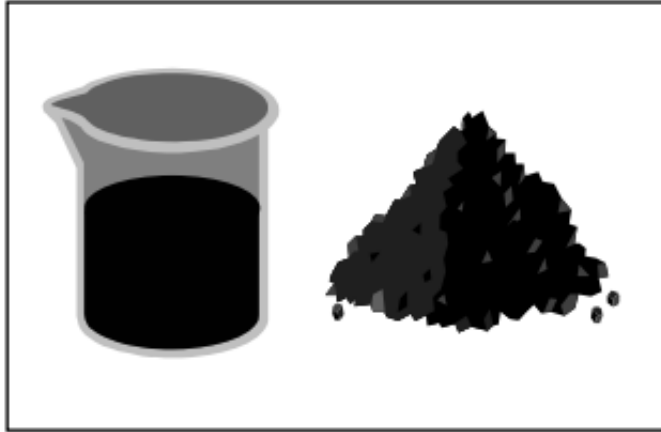
ACAF 2024 Florida Asphalt Expo and Conference

Orlando, FL

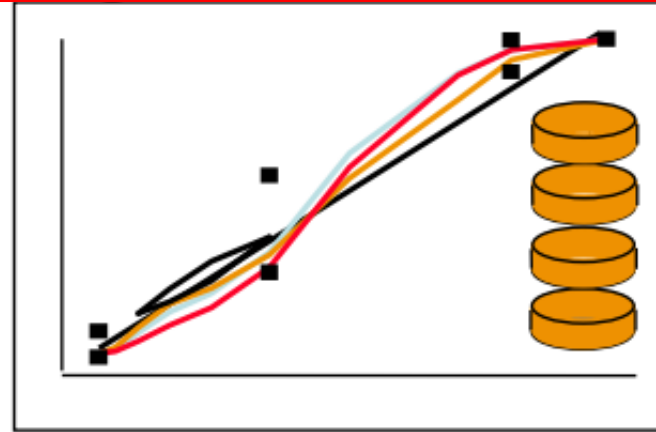
December 18<sup>th</sup>, 2024

Grover Allen, Ph.D., P.E.

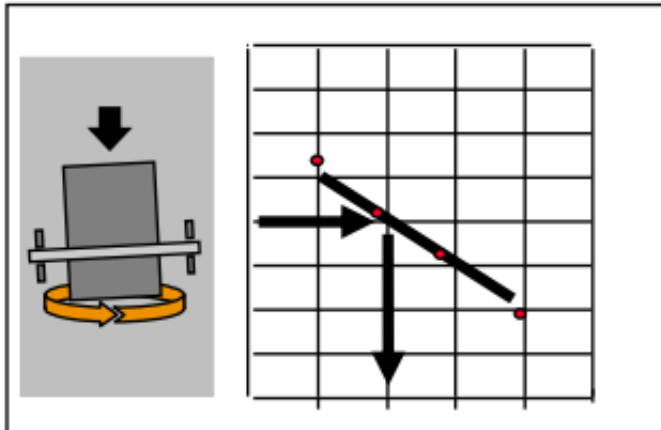
# Basic Steps of Asphalt Mix Design



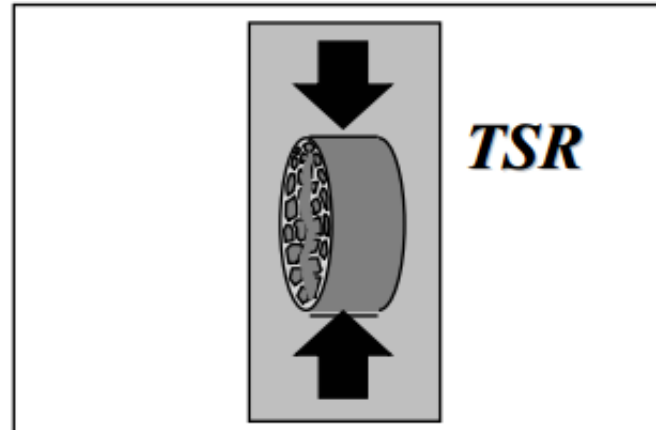
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content

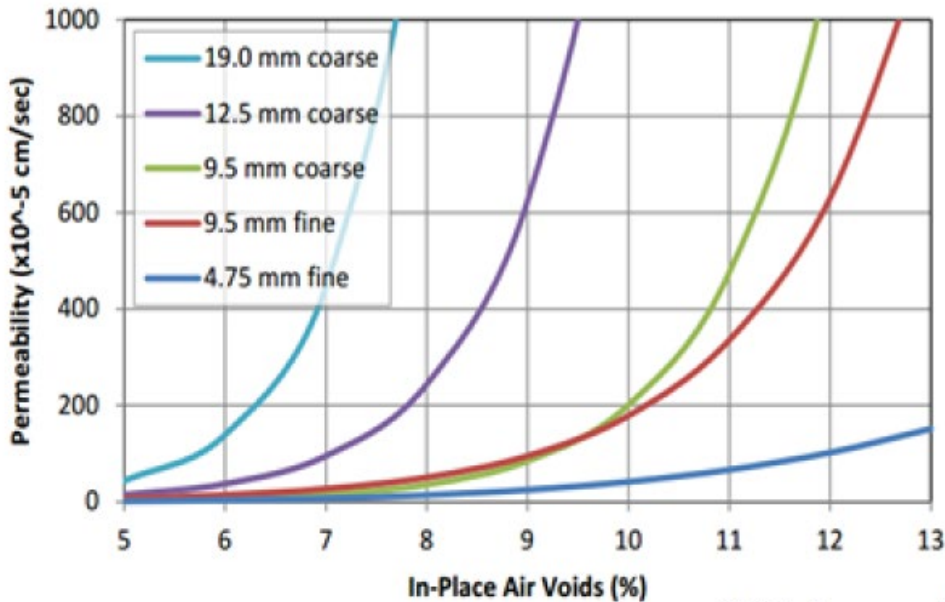
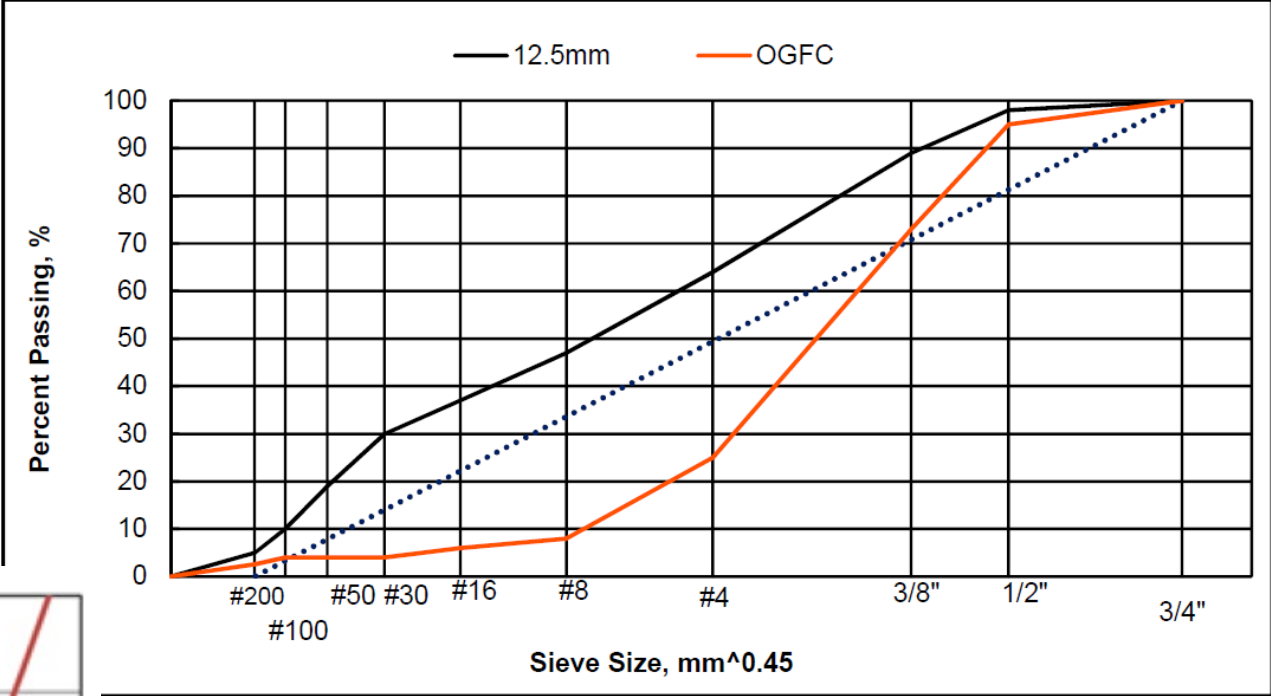


4. Moisture Sensitivity

# How to make an OGFC mixture – Aggregate Structure



asphalt institute



NCAT - Brown and Heitzman 2013

Aggregate Sieve Size	SP-12.5 (Dense)	FC-5 (OGFC)
12.5-mm (1/2-in)	90-100	85-100
9.5-mm (3/8-in)	90	60-75
4.75-mm (No. 4)	---	15-25
2.36-mm (No. 8)	28-58	5-10
75-µm (No. 200)	2-10	2-5

← Break Point sieve

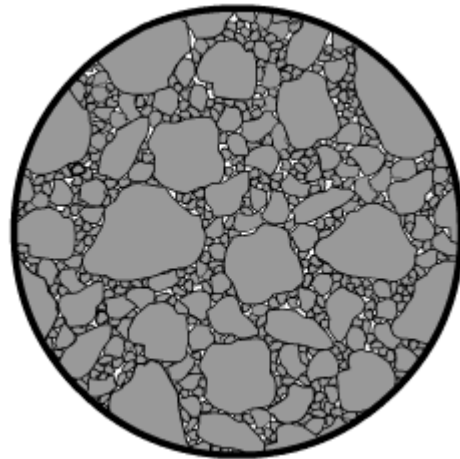
# How to make an OGFC mixture





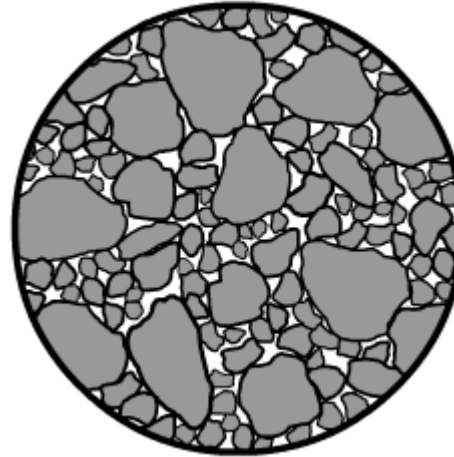
# Dense Graded vs OGFC Mix

**Dense Graded Mix**



- **4% Air Voids**
- **4.5-6% Asphalt**

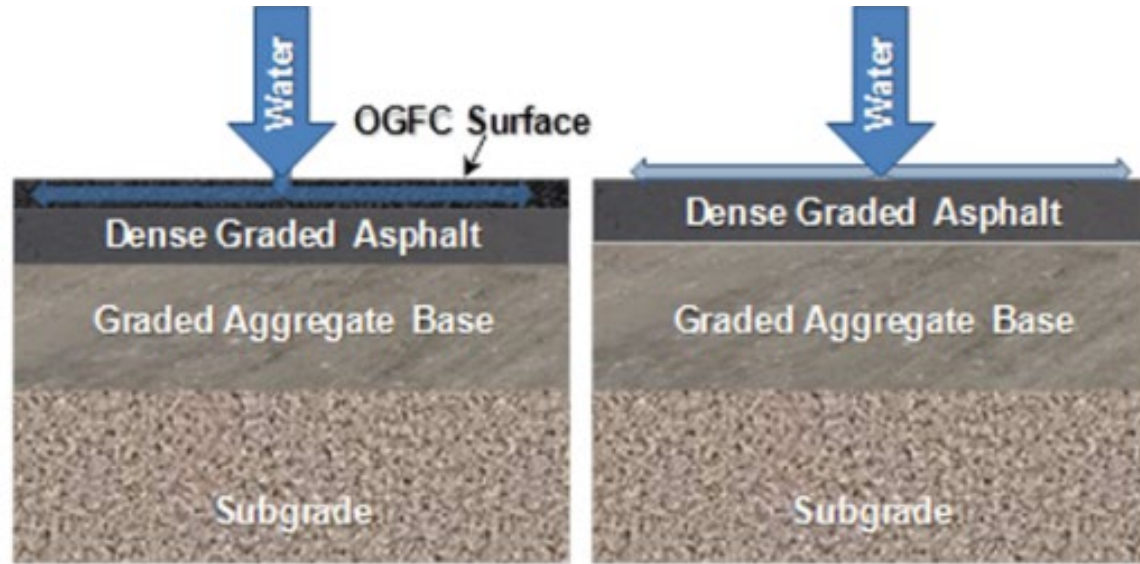
**Open Graded Mix  
(OGFC)**



- **15-20% Air Voids**
- **5.5-8% Asphalt**



# Why are OGFCs Important?

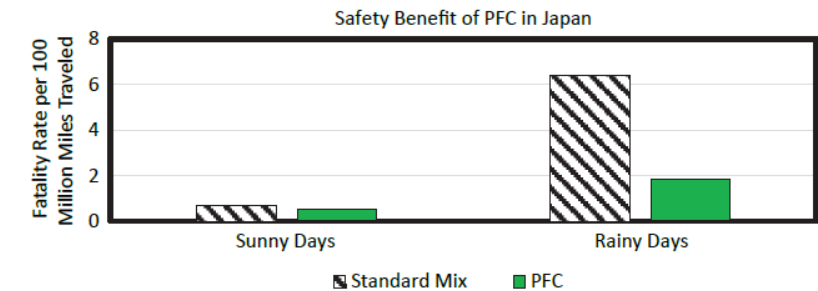


Putman and Kline (2012). Comparison of Mix Design Methods for Porous Asphalt Mixtures. Journal of Materials in Civil Engineering. Vol 24; 11.

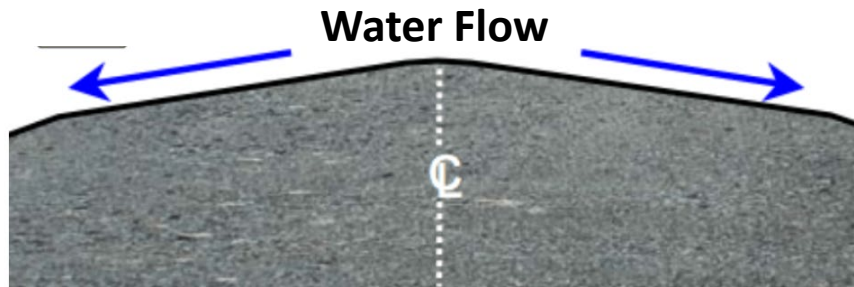
## OGFC Pavements:

Save lives and provide better driving experience

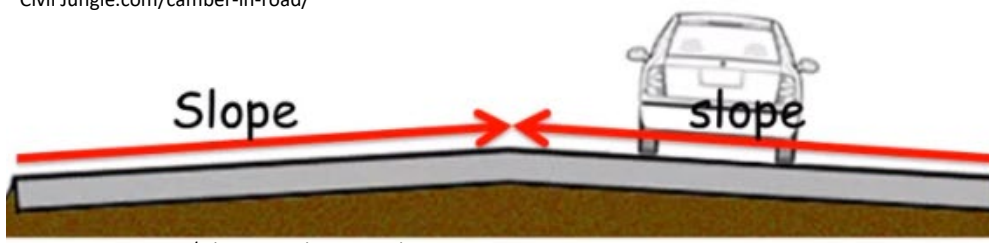
- Reduce splash, spray, hydroplaning in wet conditions (5-10%)
- Much quieter, Reduce headlight glare, Resist rutting
- In use since 1944
- **FDOT** requires OGFC on all interstates; OGFC represents approximately 50% of FDOT-maintained lane miles in FL



Fatality reduction on rainy days (Shimeno & Tanaka, 2010).



Civil Jungle.com/camber-in-road/



constructioncost.co/what-is-camber-in-road



# FDOT OGFC (FC-5) Specification Requirements and “Typical” Properties (2025 Standard Spec Book – Section 337)



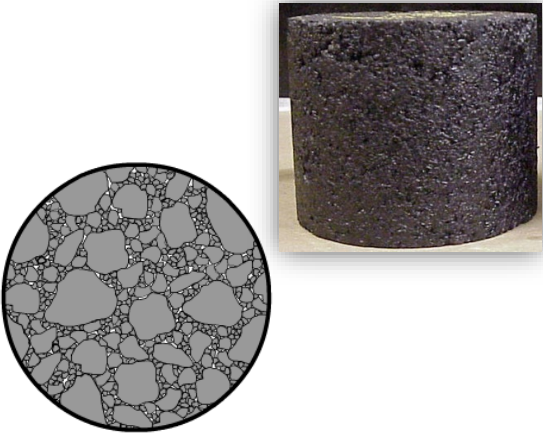
Mix Requirements	SP-12.5 (Dense)	FC-5 (OGFC)
Draindown (AASHTO T 305)	--	Visual (0.3% Typical)
Permeability	--	>1000 mL/h (Typical)
Aged Cantabro (AASHTO T 401)	--	20% max (Internal)
Air Voids (AASHTO T 331)	4%	15%-20% (Typical)
Lift Thickness (Typical), in.	2.0-3.0	0.75

Materials/Additives	SP-12.5 (Dense)	FC-5 (OGFC)
Hydrated Lime (Granite)	1%	1%
LASA (FM 1-T 283)	As required	As required
Polymers (916-2.1)	--	Required (PG 76-22)
Fibers (337-2.7.1)	--	0.3 - 0.4%
RAP allowance	YES	NO

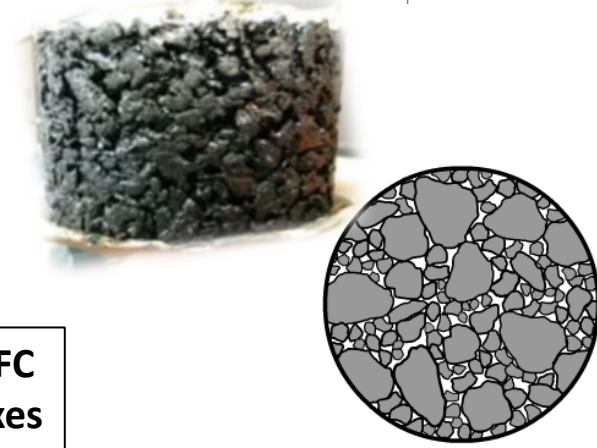




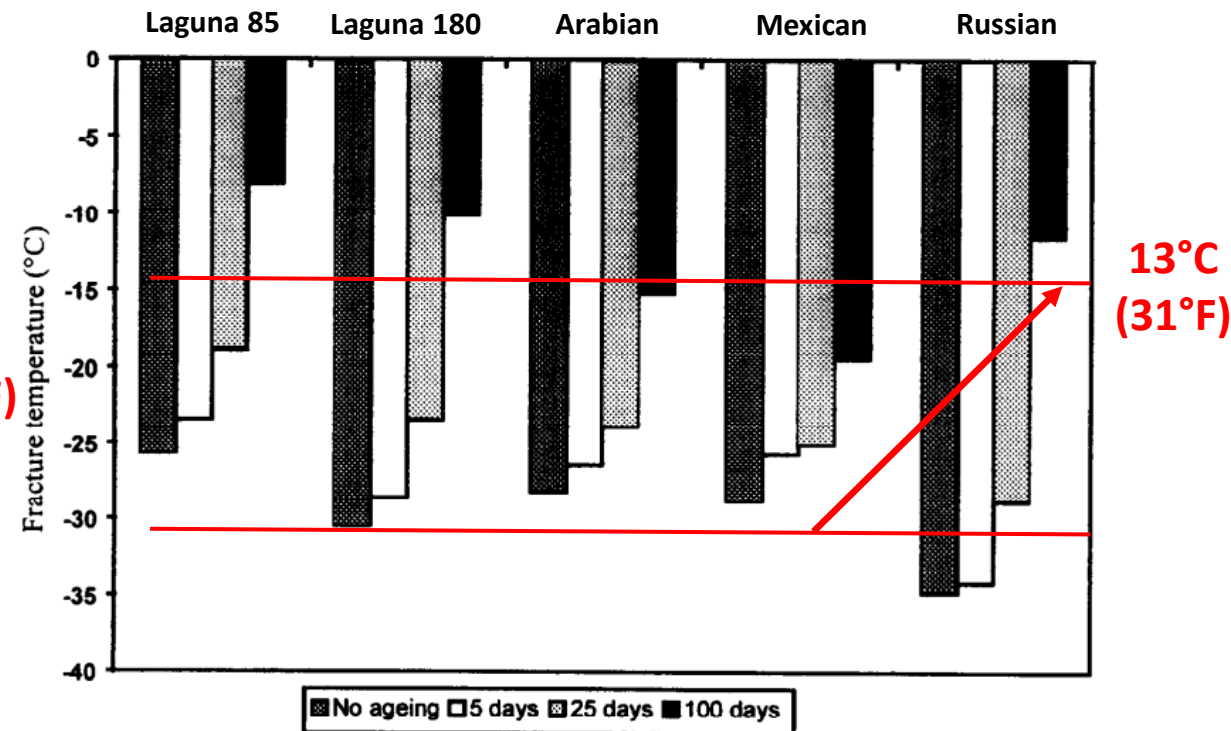
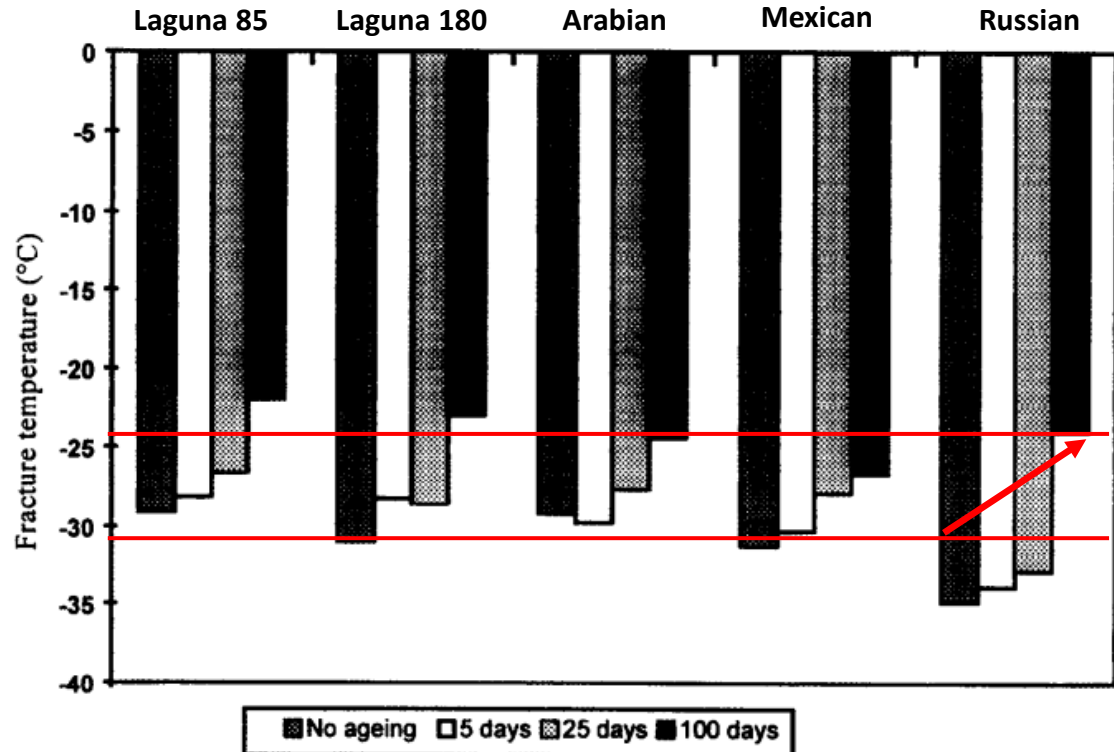
# Problems Associated with OGFC – Rapid Aging/Raveling



**Dense Mixes**



**OGFC Mixes**





# Examples of Poor OGFC Durability in the Southeast (MS)



asphalt institute



Age: 1.2 yrs

I-20 EB Rankin County



Age: 3.3 yrs

I-55 SB Lincoln County



Age: 5.4 yrs

I-20 EB Rankin County



Age: 4.4 yrs

I-20 EB Hinds County

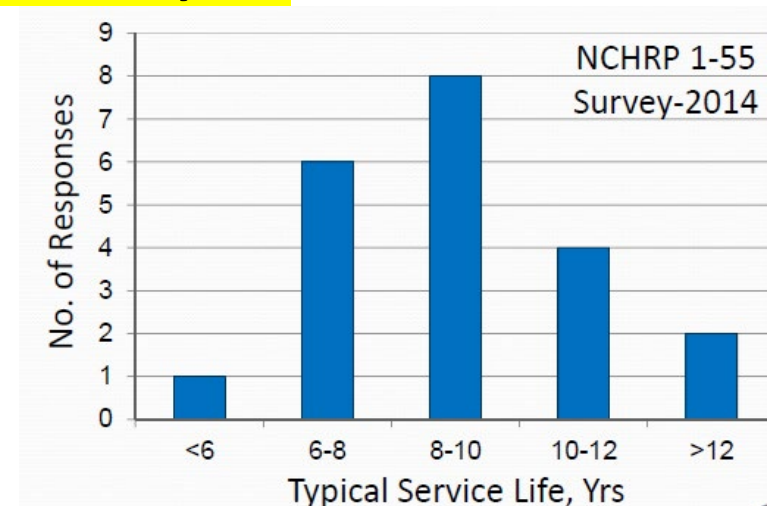


## Expected life (Durability):

DG Surface: ~15-20 years

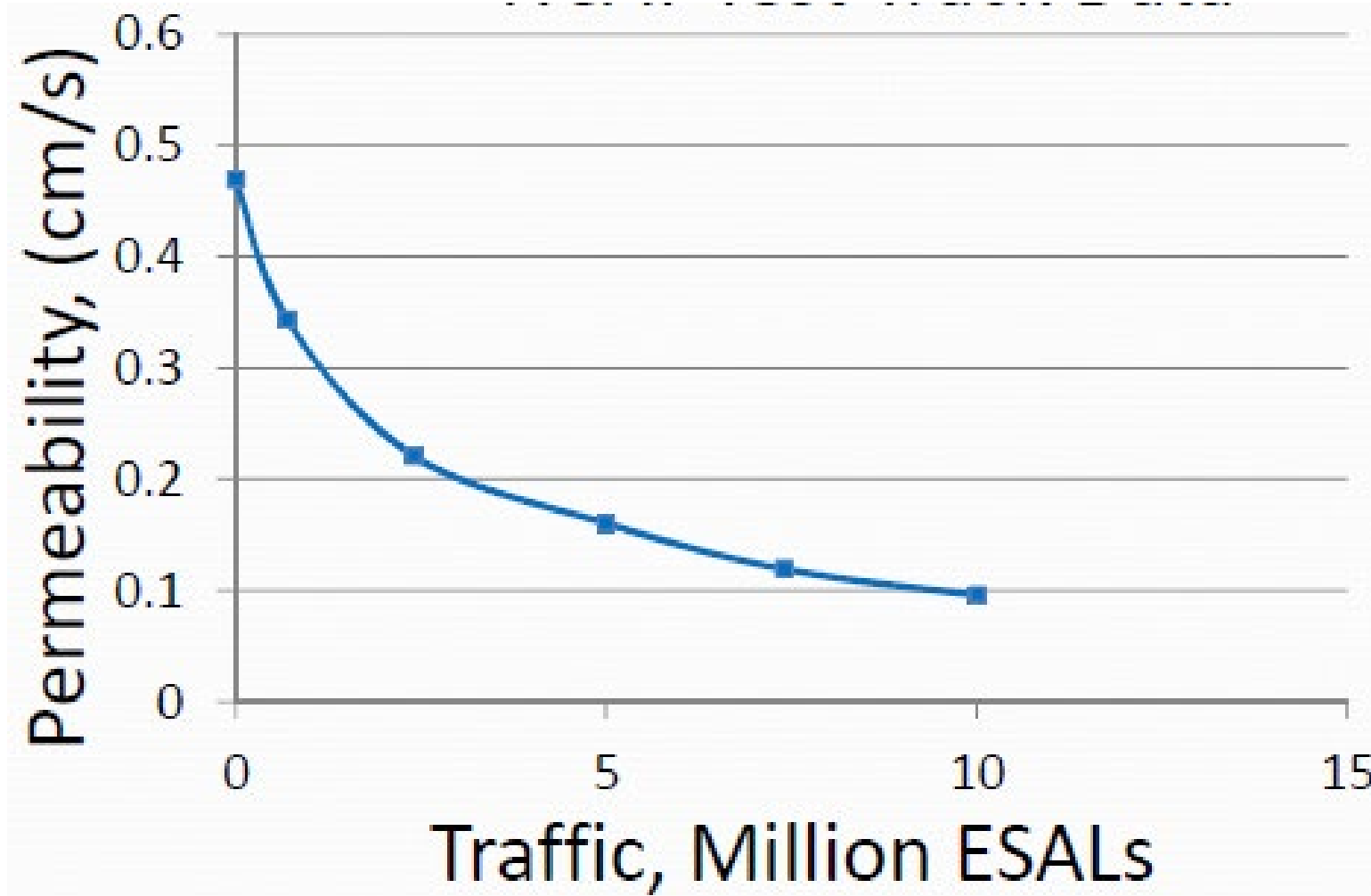
OGFC: ~6-12 years

Florida FC-5: >12 years



# Problems Associated with OGFC – Functionality

Reduced Permeability over time

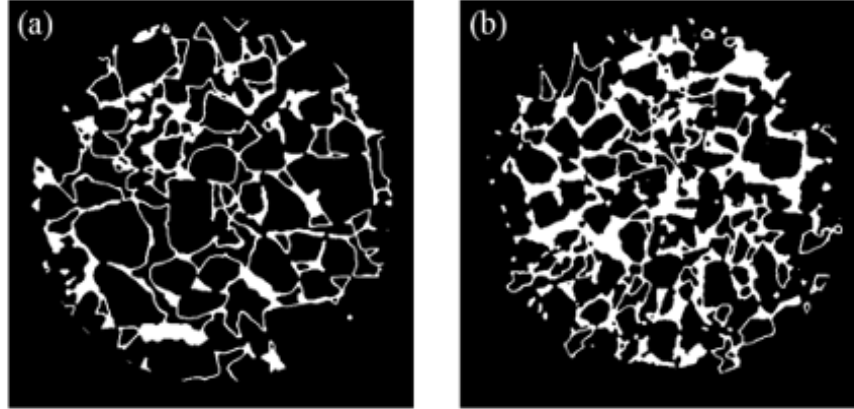


NCAT Test Track Data

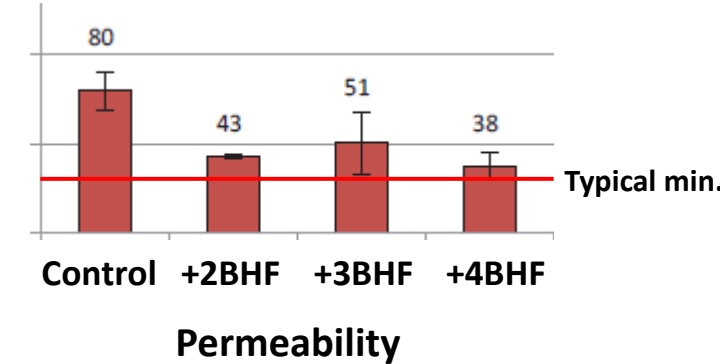
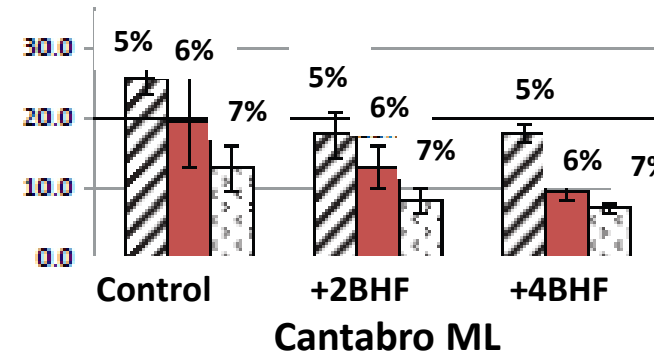
“At the end of an OGFC’s functional life, it behaves more like a dense-graded surface.” – Arumbula et. Al, 2013

# How to Improve OGFC – Design

## 1. Increase Binder Content/Increase Baghouse Fines (BHF):

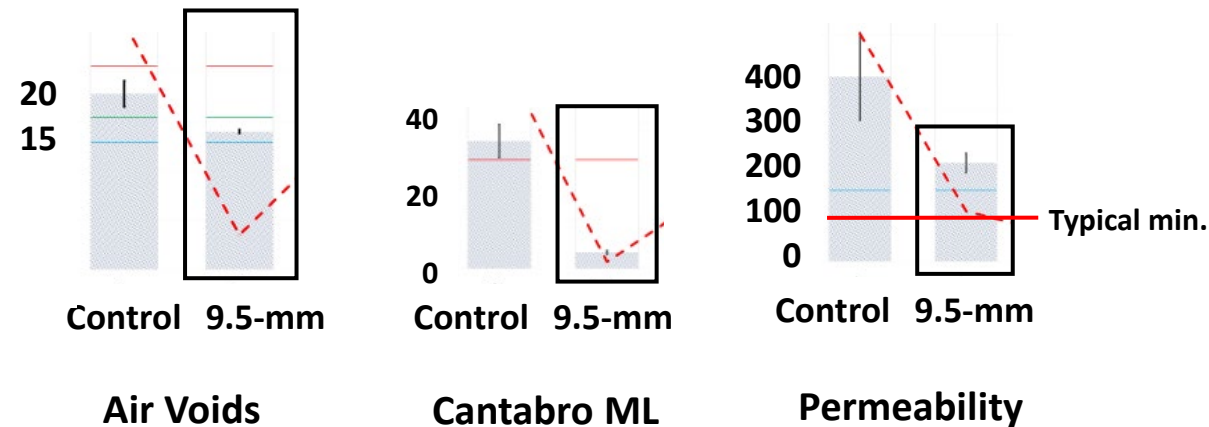


Mortar distribution – (a) OGFC (b) dense mix



Jing et al. (2019). Lab and Field Aging Effect on Bitumen Chemistry and Rheology in Porous Asphalt Mixture. NCHRP 1-55 Report 877. Performance-based mix design for porous friction course

## 2. Decrease Air Voids:



Abohamer et al. (2023). Effects of AV Content, Crumb Rubber, and pozzolonic fillers on OGFC lab performance.

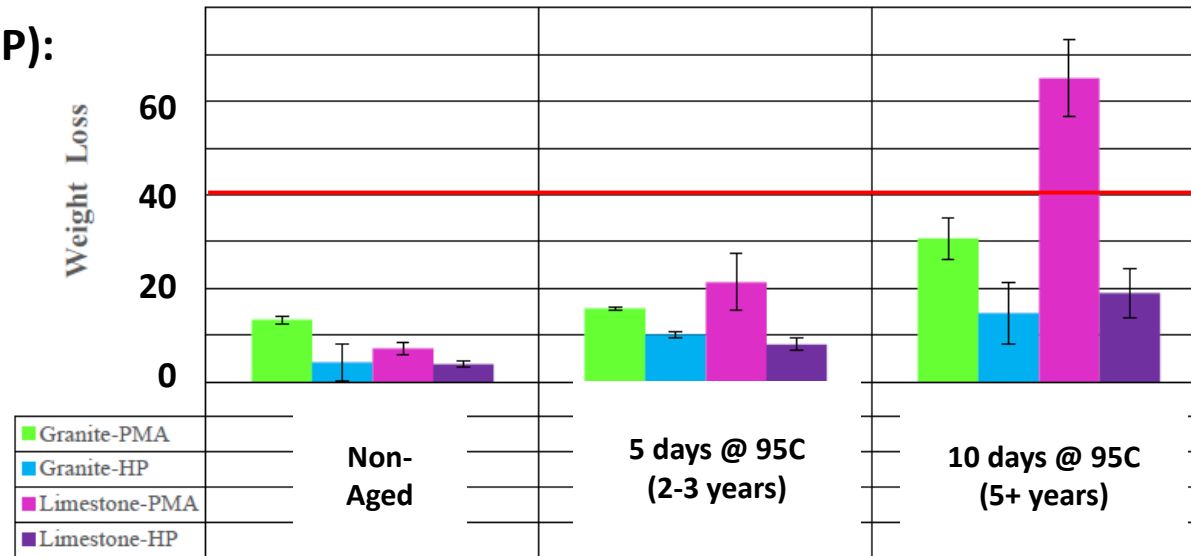


# How to Improve OGFC – Materials

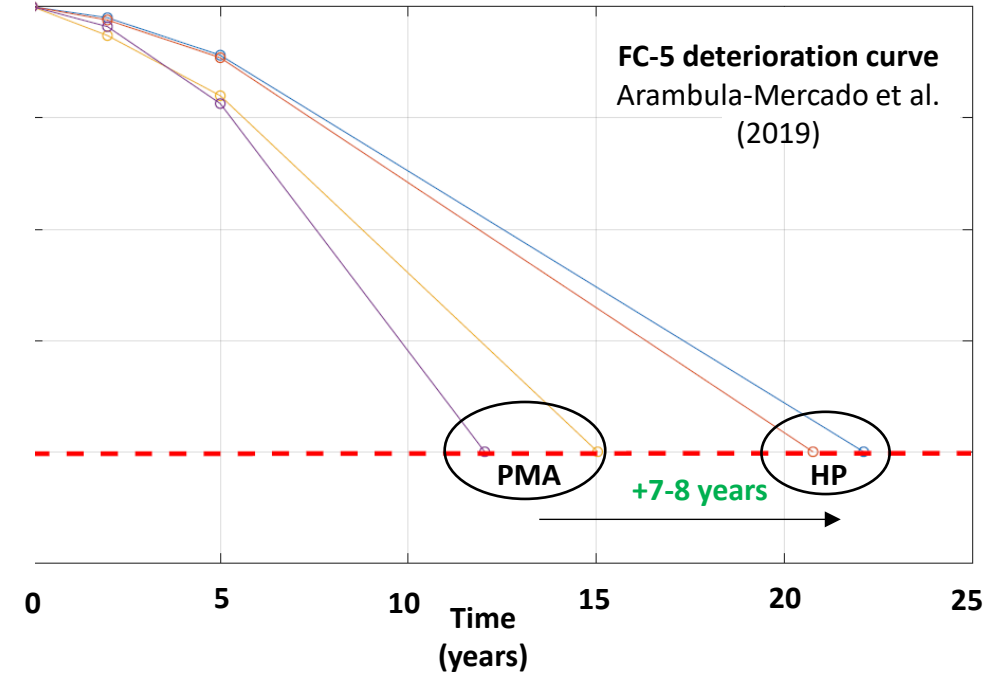


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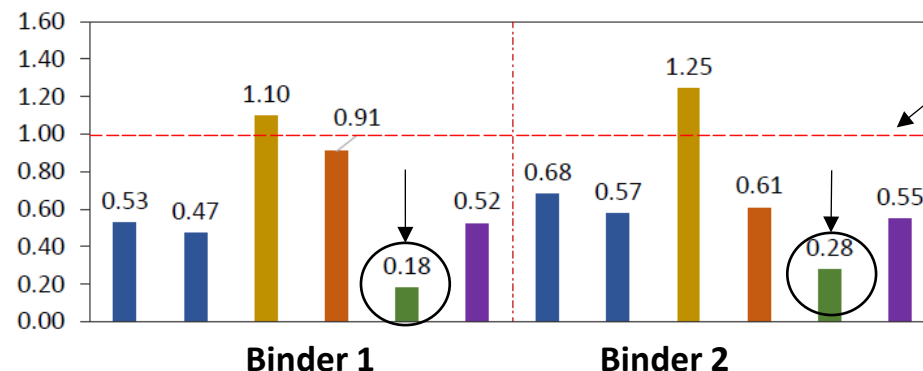
## 1. HiMA (HP):



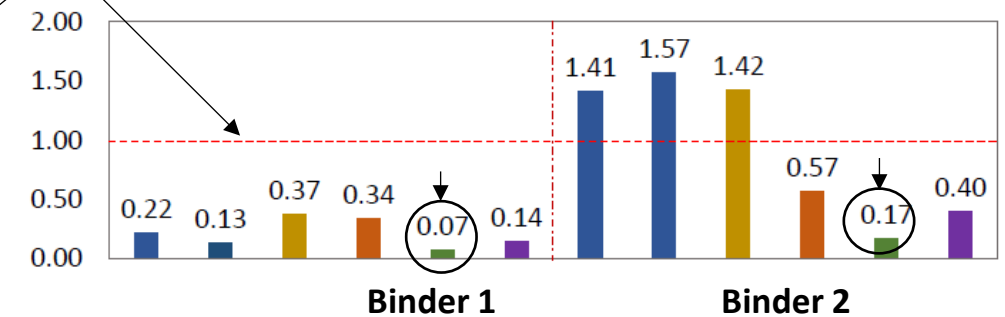
Arambula-Mercado et al. (2019) Evaluation of FC-5 with PG 76-22 HP to Reduce Raveling.



## 2. Age-resistant asphalts:



Control

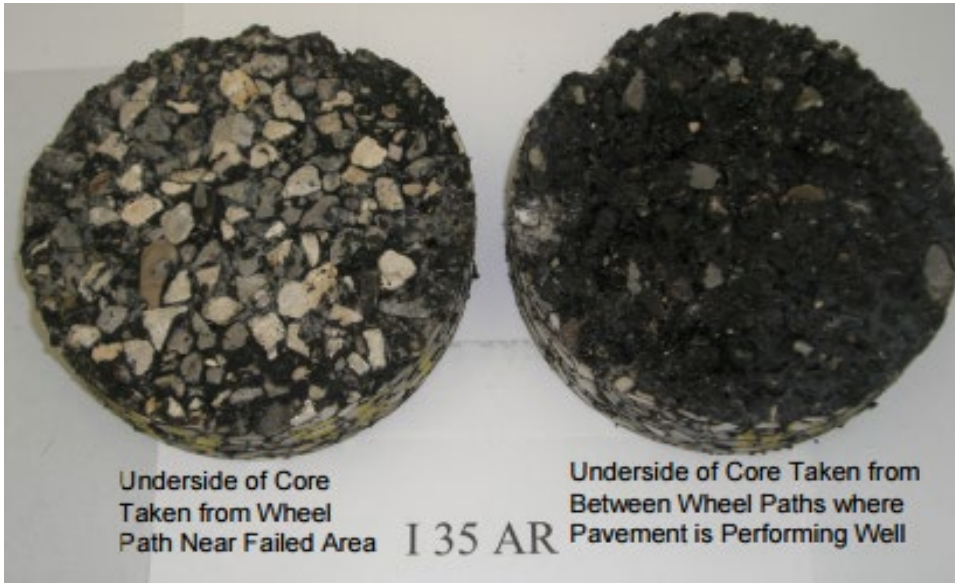
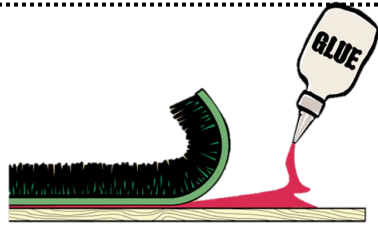


Reduced aging rate by **70-90%**!

Rodriguez et al. (2019). Rheological and chemical evaluation of aging resistant binder technologies.

# How to Improve OGFC – Construction

## 1. Good Bond:



Performance and Cost Effectiveness of Permeable Friction Course Pavements – FHWA/TX-12/0-5836-2, TTI, 2013

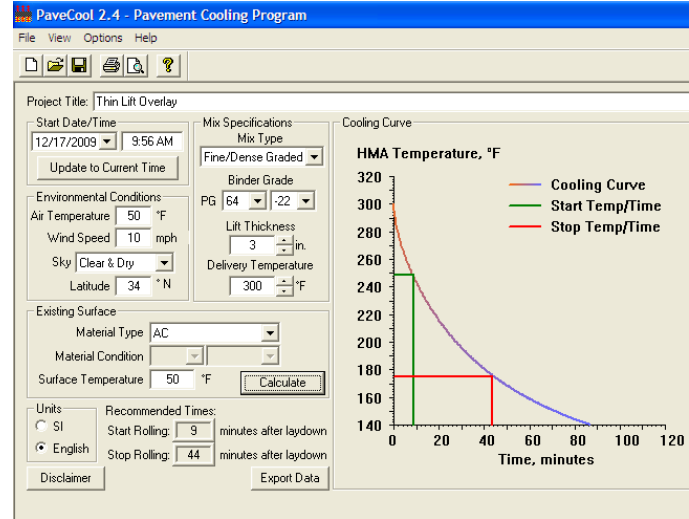
“By decreasing the overlay thickness, the importance of tack coat cohesive characteristics increases.”

– FHWA/TX-18/0-6857-1

“It is recommended that a **heavier tack coat** be used to improve the performance of OGFC.” – NCAT Report 12-10.

**Less important than preventing removal!**

## 2. Proper laydown temp:

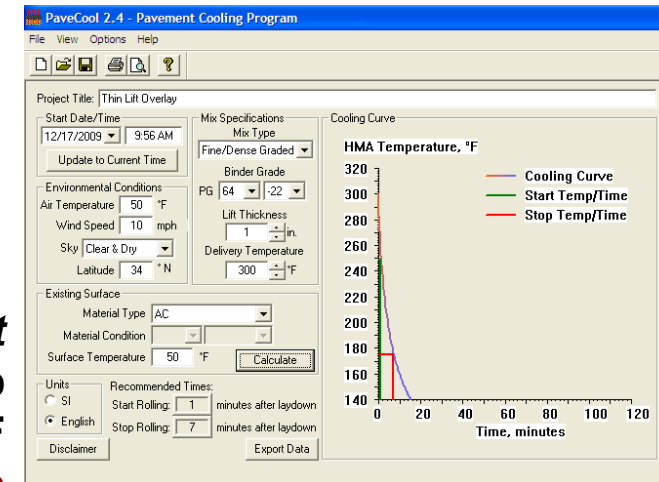


## 3 Inch Lift

50°F Air, Surface Temp

Mix Delivery temp - 300°F

**44 minutes to complete compaction operations**



## 1 Inch Lift

50°F Air, Surface Temp

Mix Delivery temp - 300°F

**7 minutes to complete compaction operations**

Gierhart. Climate Considerations for Thin-lift Overlays.

**Stricter air temp requirements during construction?**

Bond Requirements	12.5-mm Dense	12.5-mm OGFC
Tack Coat (402.03.1.2), gal/sy	0.05-0.10	0.10-0.14



# OGFC Maintenance: Rejuvenating Fog Seal

Spring 2019  
Volume 31, Number 1

## Asphalt Technology News

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### Evaluation of Rejuvenating Fog Seals

**Complex Modulus & Complex Viscosity @ 60 °C**  
**After 4 weeks – S3, Mississippi DOT**

**Complex Modulus ( $G^*$ ) @ 60°C (kPa)**

Sample	Value (kPa)	% Change
S3 Control	264.6	-
S3-A	97.2	63.3%
S3-B	115.7	56.3%

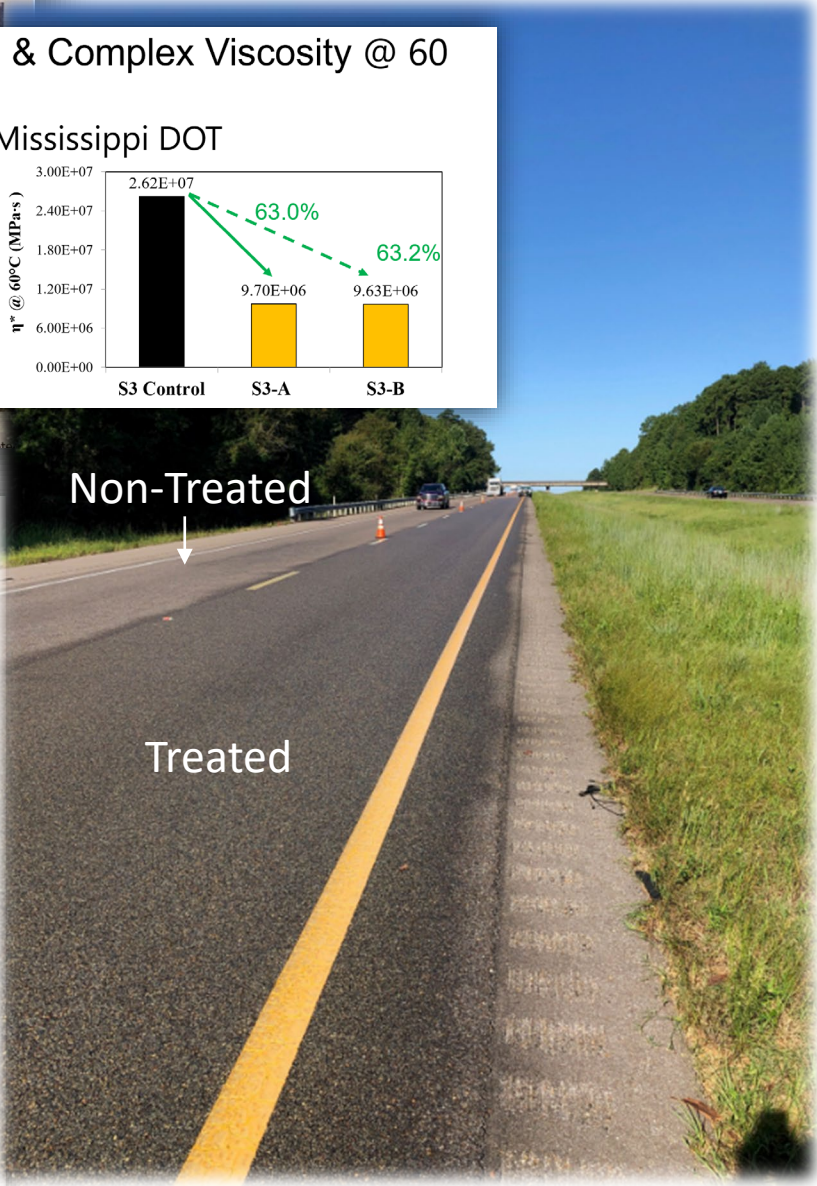
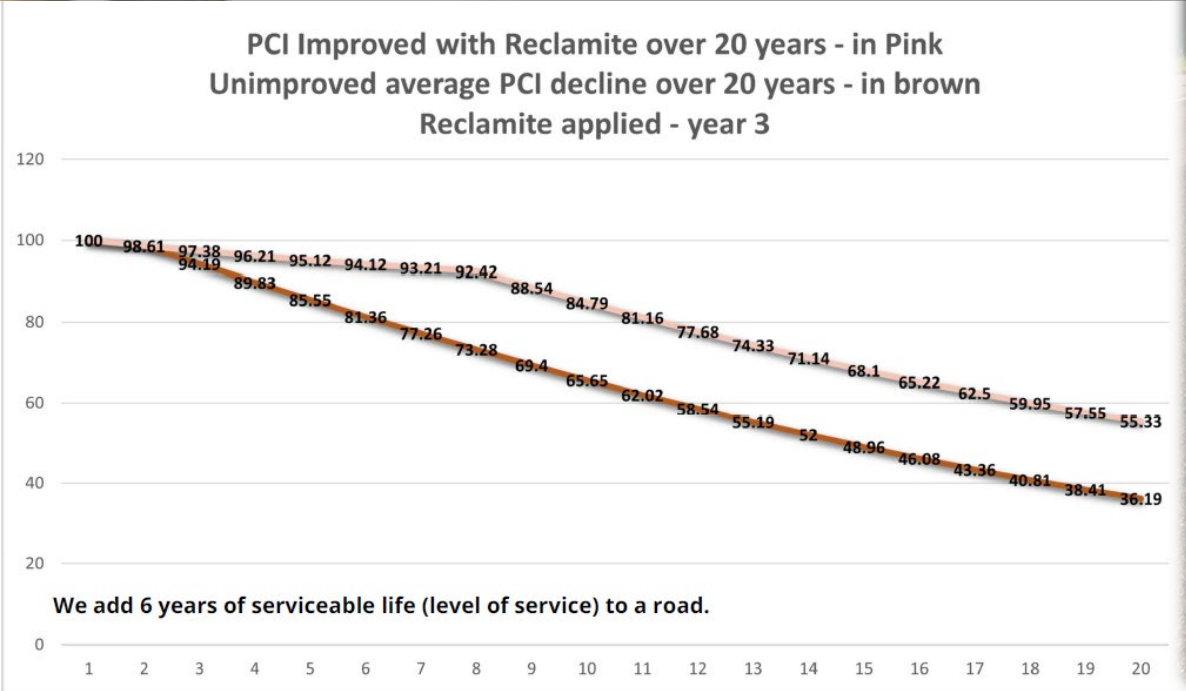
**Complex Viscosity ( $\eta^*$ ) @ 60°C (MPa·s)**

Sample	Value (MPa·s)	% Change
S3 Control	2.62E+07	-
S3-A	9.70E+06	63.0%
S3-B	9.63E+06	63.2%

Delta Mist™ rejuvenator is applied to Section S3 of the NCAT Test Track.

Corrective Asphalt Materials

Application rate:  
0.05 – 0.12 gal/sy





# How to Improve OGFC – Functionality



## 1. Thicker lift:

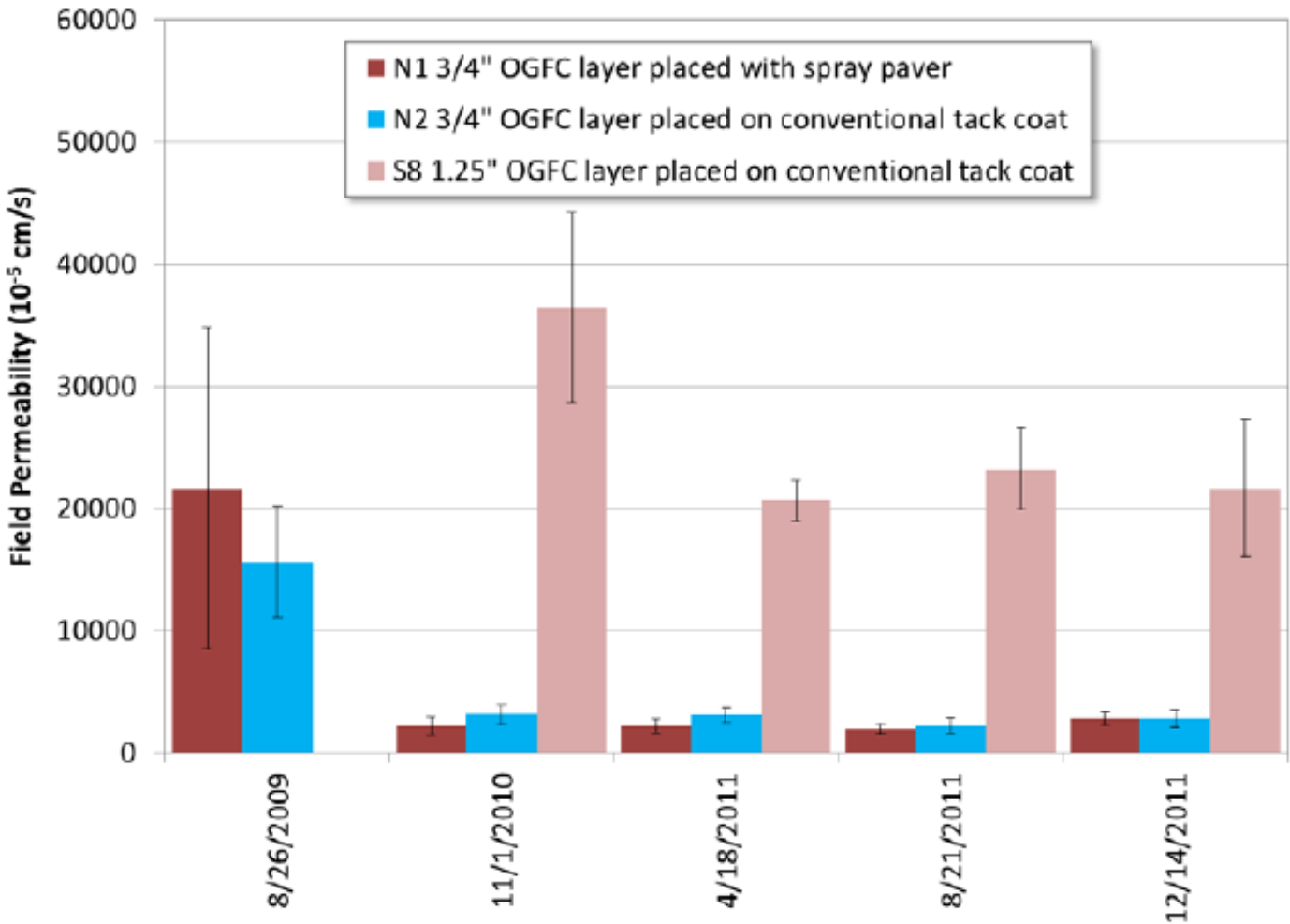


Figure 4.13 2009 Mixture Field Permeability Results  
NCAT Report 12-10

SP-12.5 (Dense)	SP-12.5 (Dense)	FC-5 (OGFC)
Lift Thickness (Typical), in.	2.0-3.0	0.75

# Summary

## Why do we build OGFC Pavements **despite known lower durability?**

- Save lives and provide a better driving experience.
- Can we improve durability and functionality?

**Yes!**

### Pre-construction

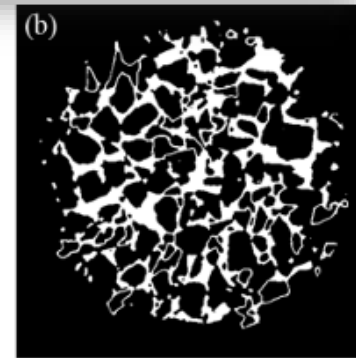
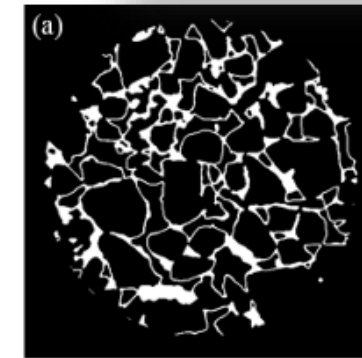
- Design – Higher AC / Higher BHF / Lower Voids / Thicker lifts
- Materials – HP / More age-resistant binders

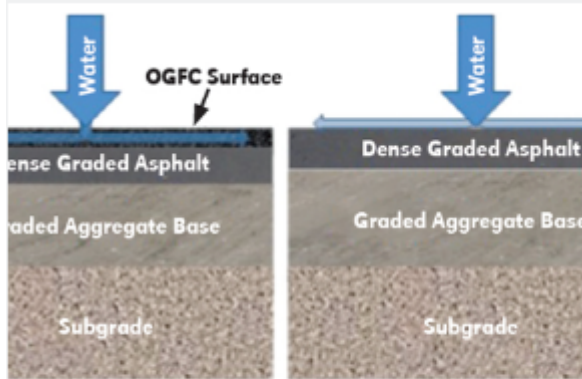
### Construction

- Prioritize good bond / Avoid rapid cooling

### Post-Construction

- Maintenance and Preservation





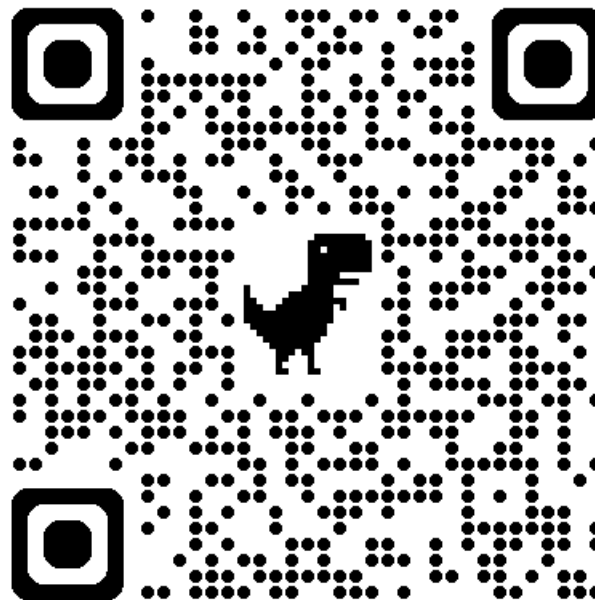
Stoutman and Kline (2012). Comparison of Mix Design Methods for Porous Asphalt Mixtures. *Journal of Materials in Civil Engineering*. Vol 24; 11.

## What is happening with our OGFCs?

### PAVING

JULY 16, 2024 | DR. GROVER ALLEN, PH.D., P.E., DR. BUZZ POWELL, PH.D., P.E.

Four areas of focus for longer-lasting open-grade friction course pavements Basic asphalt mix design teaches us that the following steps are required to ensure a... [READ MORE](#)





# Discussion?



ACAF 2024 FLORIDA ASPHALT EXPO AND CONFERENCE TOGETHER WE SHINE