

# Superpave5

## Superpave Design at Five Percent Air Voids



**THE CENTER**

The Heritage Group

March 11, 2019

Is there a way?

To improve asphalt  
pavement performance

**WITHOUT**

Increasing COST?

# Marshall Mix Design

- Design Air Voids 3-5%

Construction (8%)

Decreases to

- Field Compaction
  - 8% after rolling
  - 4% after traffic

Service Life (4%)



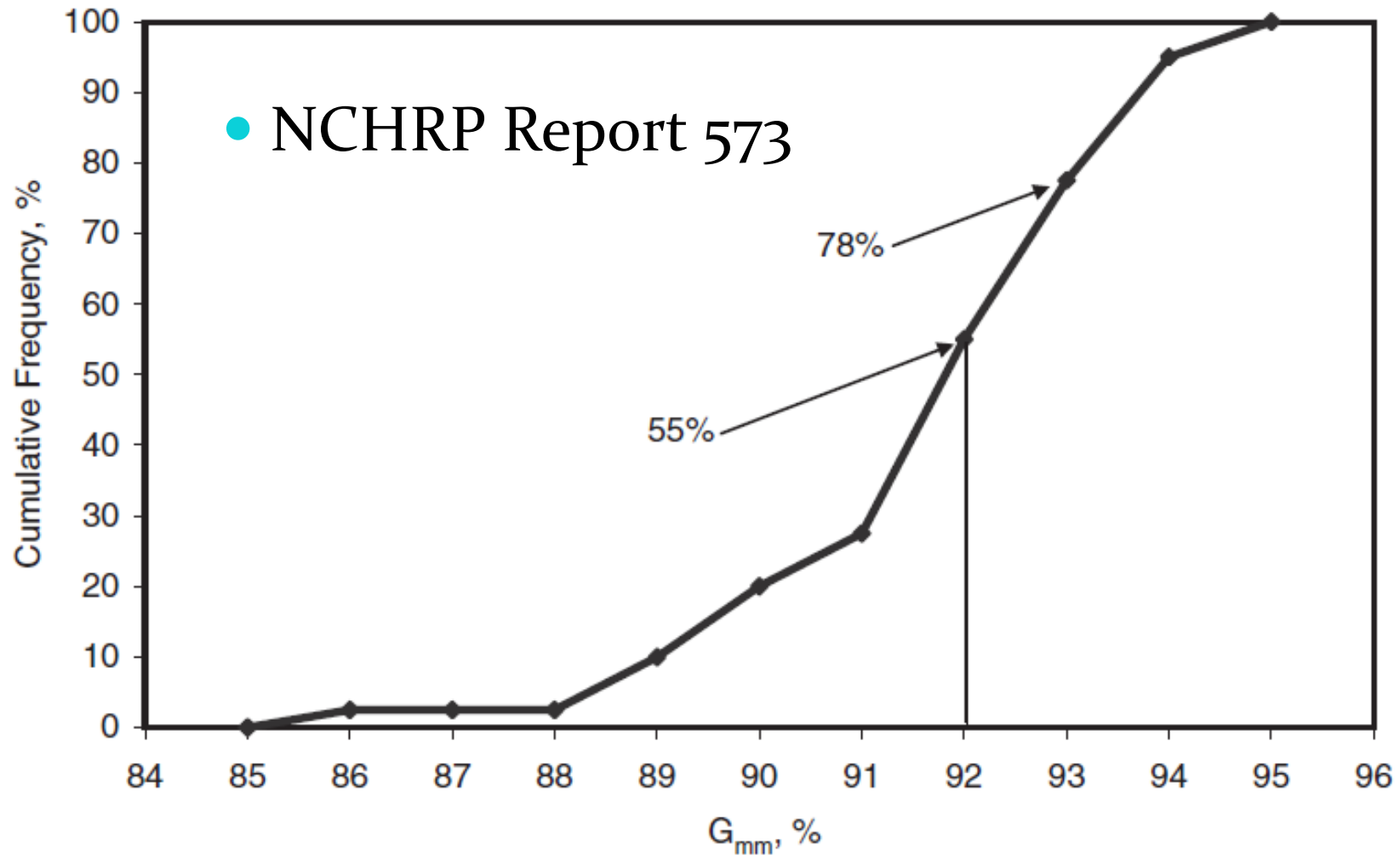
# Strategic Highway Research Program



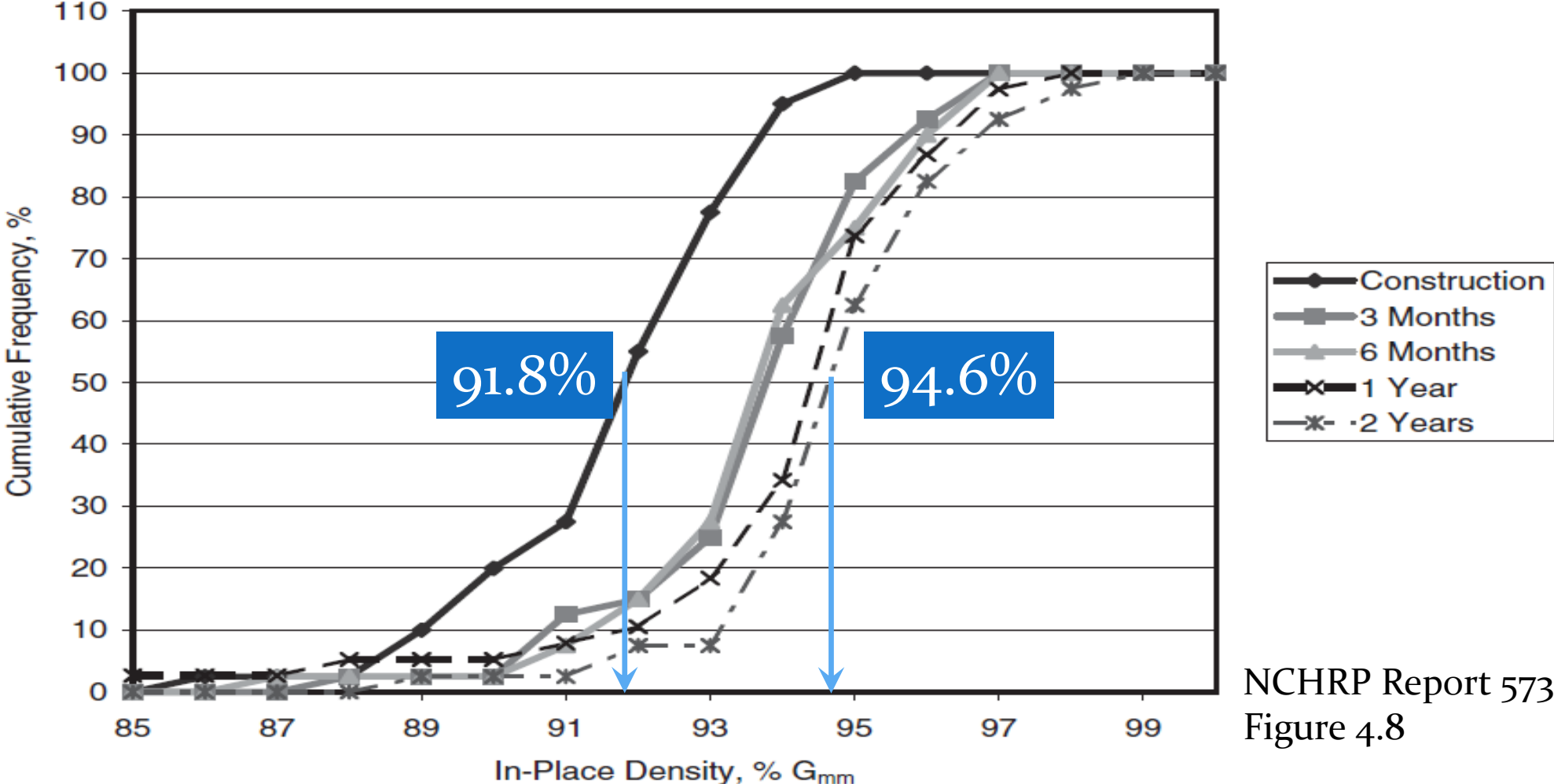
- “Marshall” carried forward
- Design air voids fixed at 4%
- Recommended compaction set at 92% Gmm



# As-Constructed Air Voids?



# Typical Final Density



NCHRP Report 573  
Figure 4.8

France Developed  
Mix Design Method





Design to 5%





Construct to 5%



Performance Good

1994 1 1



**Superpave5**

*Inspired by LCPC*

# Superpave5 Concept

*Mix Design  
5% air voids*



*Field Compaction  
95% Gmm*



*No change in  
asphalt content*

# Does it Change Asphalt Content?

	Superpave4	
NMAS	VMA	Effective Asphalt (volume)
9.5	15.0	11.0
12.5	14.0	10.0
19.0	13.0	9.0
25.0	12.0	8.0

# Does it Change Asphalt Content?

**Asphalt Content Stays Same**

	Superpave4	Superpave5
NMAS	Effective Asphalt (volume)	Effective Asphalt (volume)
9.0	11.0	11.0
12.5	10.0	10.0
19.0	9.0	9.0
25.0	8.0	8.0

# Asphalt Content

Design  
Gradation  
Changes

	Superpave4	Superpave5
NMAS	Effective VMA Asphalt (Volume)	Effective VMA Asphalt (Volume)
9.5	11.0	11.0
12.5	14.0	10.0
19.0	13.0	9.0
25.0	12.0	8.0

# Asphalt Content

	Superpave4		Superpave5	
NMAS	VMA	Effective Asphalt (Volume)	VMA	Effective Asphalt (Volume)
9.5	15.0	11.0	14.0	11.0
12.5	14.0	10.0	13.0	10.0
19.0	13.0	9.0	14.0	9.0
25.0	12.0	8.0	13.0	8.0

Design  
Gyrations  
Change



# Design Gyration??

		Mixture Type	
ESAL	Gyrations	9.5-mm	19.0-mm
	70	X	
	50	X	
	30	X	
	70	X	X
	50	X	X
million	30	X	X

Purdue University  
 Evaluated  
 Engineering  
 Properties

# Conclusions

- Designs at 4% Air Voids  
And 93% Gmm Compaction

**100 gyrations**

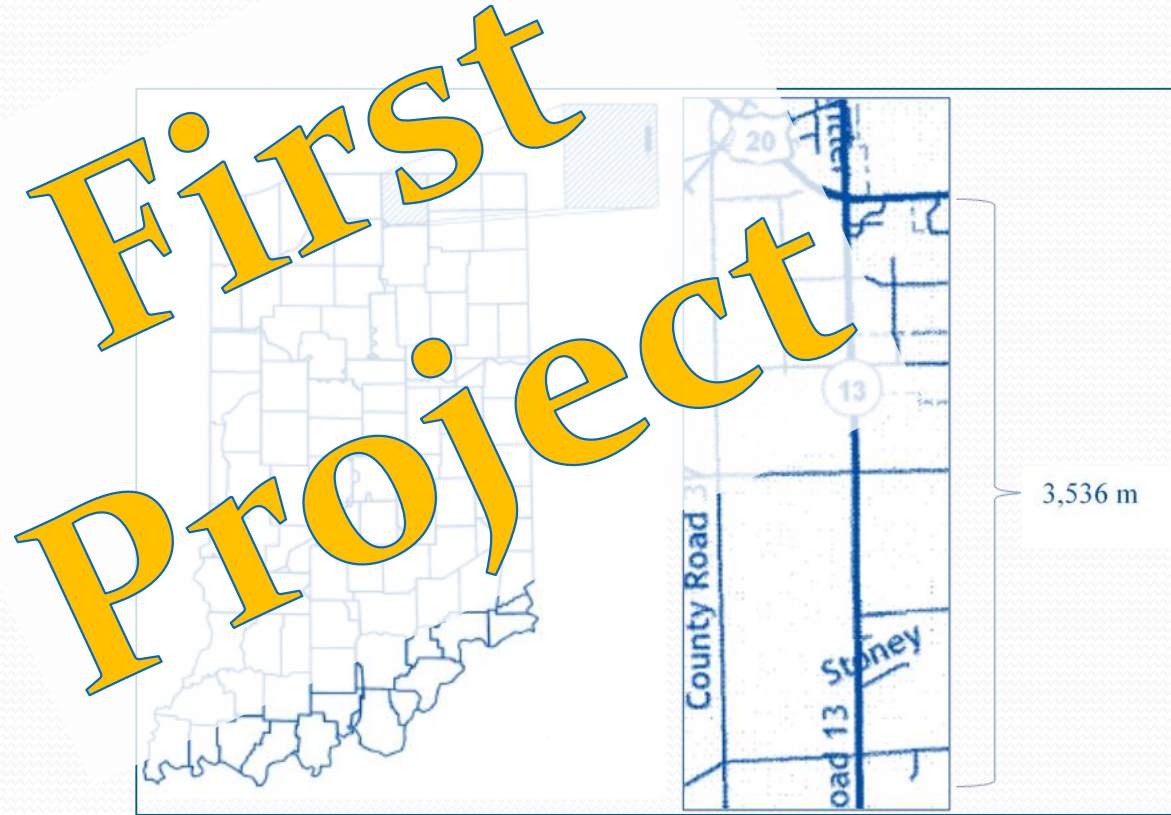
**Stiffness, Rutting  $\approx$**

- Designs at 5% Air Voids  
And 95% Gmm Compaction

**30 gyrations**

# SR 13, Middlebury, Indiana

- 2013 Trial Project
  - 13,400 AADT
  - 19% heavy trucks

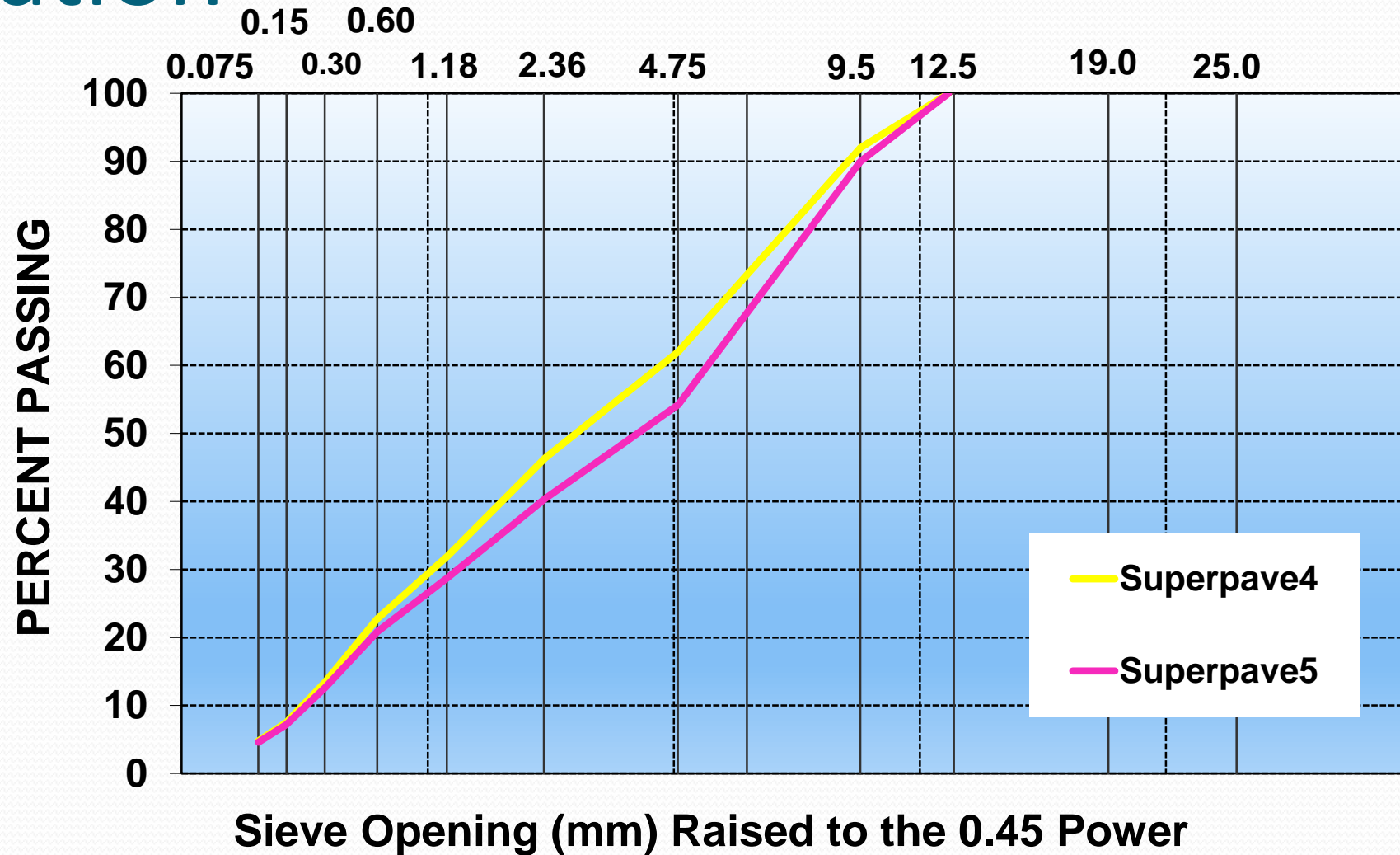


	Superpave4	Superpave5
#11 Steel Slag	40	43
#12 Limestone	20	17
Stone Sand	15	18
Natural Sand	18	15
RAS (Shingles)	7	7

## Mix Designs

	Superpave4	Superpave5
Gyrations	100	30
Asphalt Content	5.1%	5.4%
Recycled Binder Ratio	0.206	0.193
Air Voids	4.0	5.0
VMA	15.5	17.0

# Gradation





Counter-Flow Drum Mix Plant



Superpave4



# Same Rolling Train

Superpave5 Compaction



# Mix Construction Properties

	Superpave4			Superpave5		
	Design	QC	QA	Design	QC	QA
Asphalt, %	5.1	5.1	5.0	5.4	5.5	5.2
Air Voids, %	4.0	3.5	4.1	5.0	4.5	4.0
Density, %Gmm	-	-	91.6	-	94.7	96.9

# 2018 Core Locations

Location	Superpave4	Superpave5
1	206+66	155+95
2	147+37	180+25
3	124+74	214+74



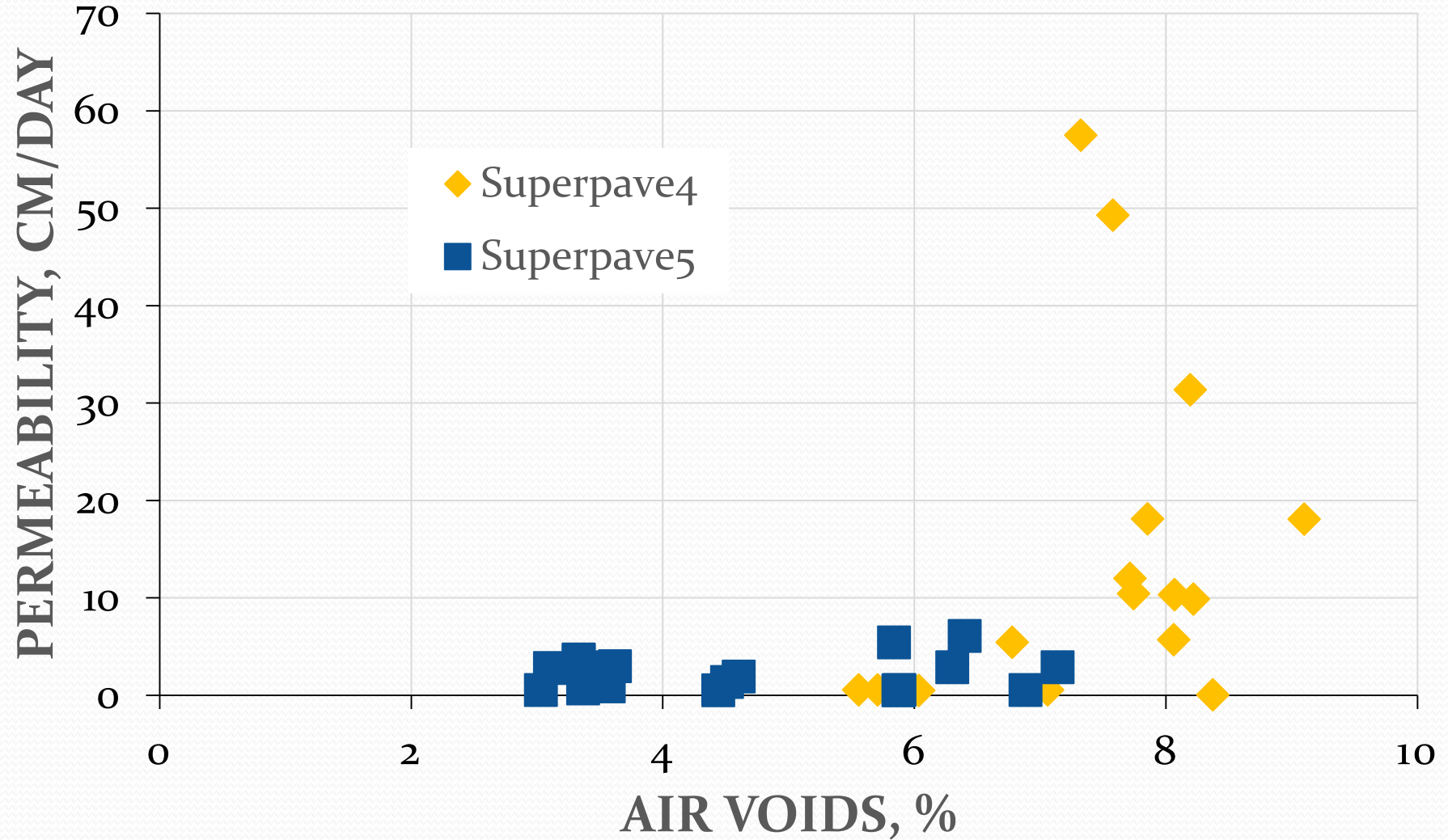
Six Cores At Each Location

# Core Properties

	Superpave <sub>4</sub>			Superpave <sub>5</sub>		
	Loc 1	Loc 2	Loc 3	Loc 1	Loc 2	Loc 3
Thickness, mm	37.3	37.7	34.5	35.2	36.2	42.8
Asphalt, %	5.34	5.35	5.56	5.67	5.36	5.82
Density, %Gmm	91.8	94.0	92.3	95.7	93.6	96.6

Average Values

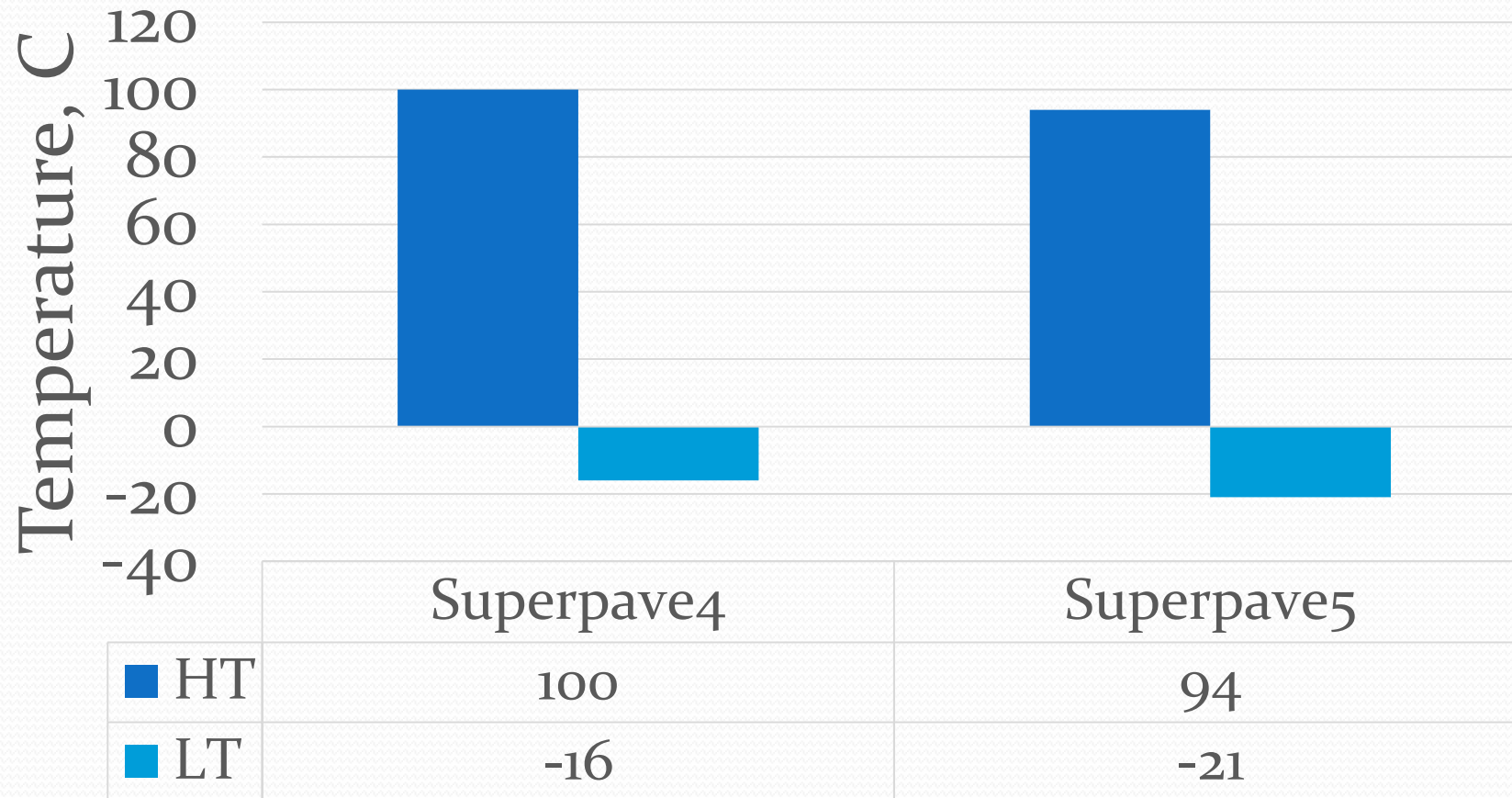
# Permeability



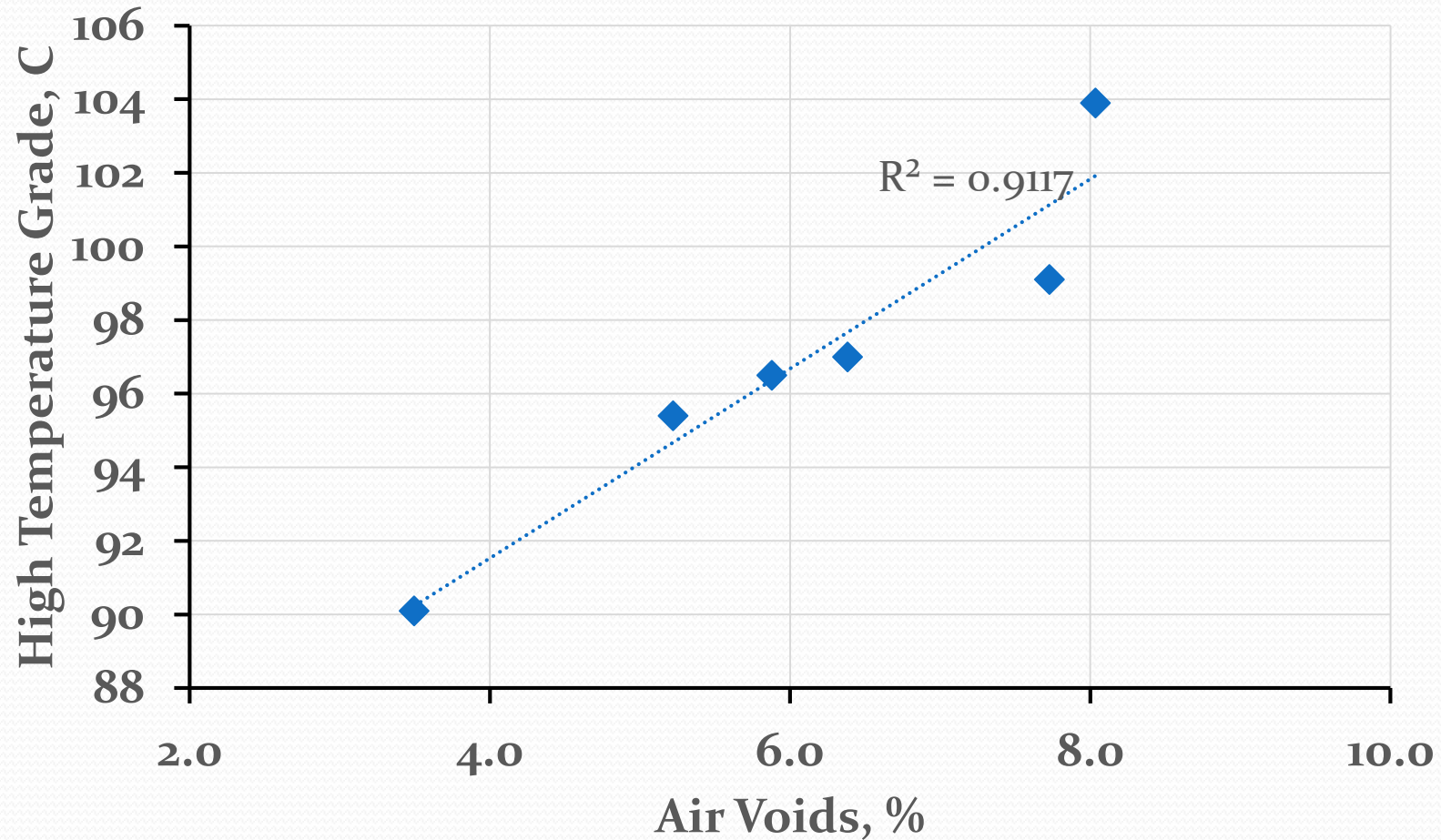
# Recovered Asphalt Binder Grade

	Superpave4				Superpave5			
Location	High Fail Temp., °C	Low Fail Temp m, °C	Low Fail Temp, S, °C	$\Delta T_c$ , °C	High Fail Temp, °C	Low Fail Temp, m, °C	Low Fail Temp, S, °C	$\Delta T_c$ , °C
1	99.1	-15.6	-24.8	-9.2	95.4	-20.5	-24.9	-4.4
2	97.0	-20.4	-25.8	-5.4	96.5	-18.5	-23.4	-4.9
3	103.9	-12.7	-23.1	-10.4	90.1	-24.1	-25.7	-1.5
Average	100.0	-16.2	-24.6	-8.3	94.0	-21.0	-24.7	-3.6

# Asphalt Binder Grade

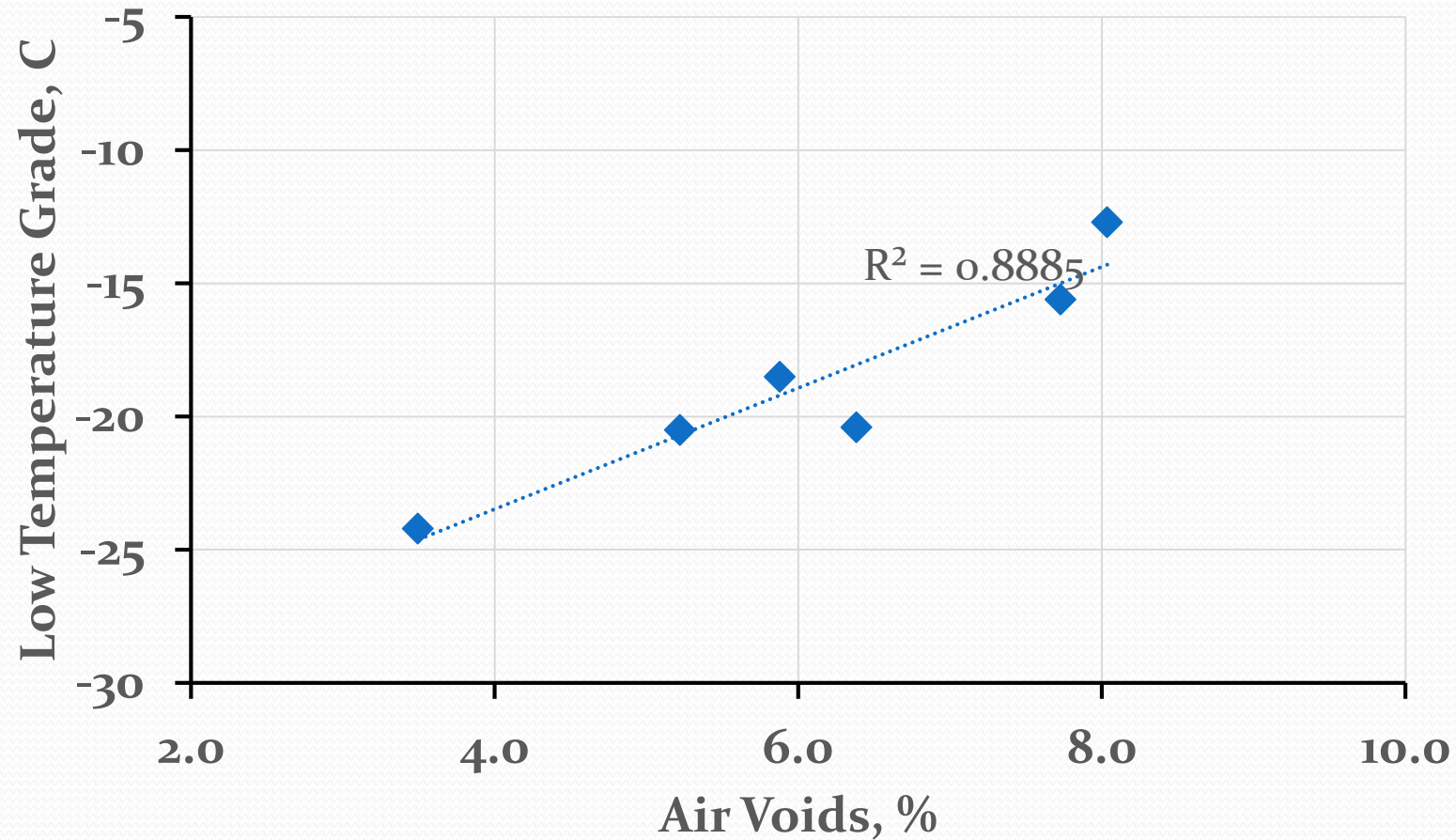


# Correlation PG High Temp to In-Place Air Voids

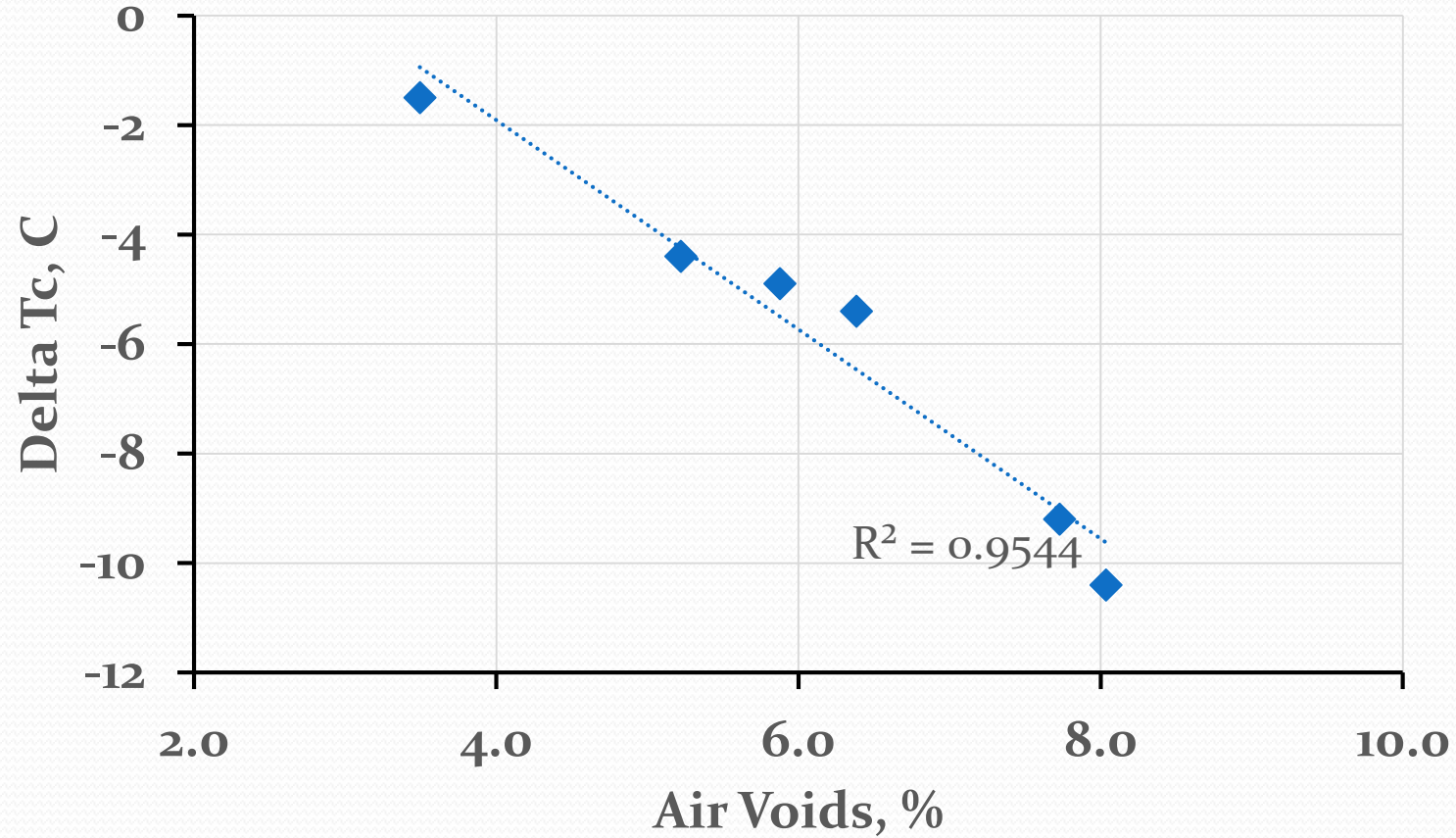




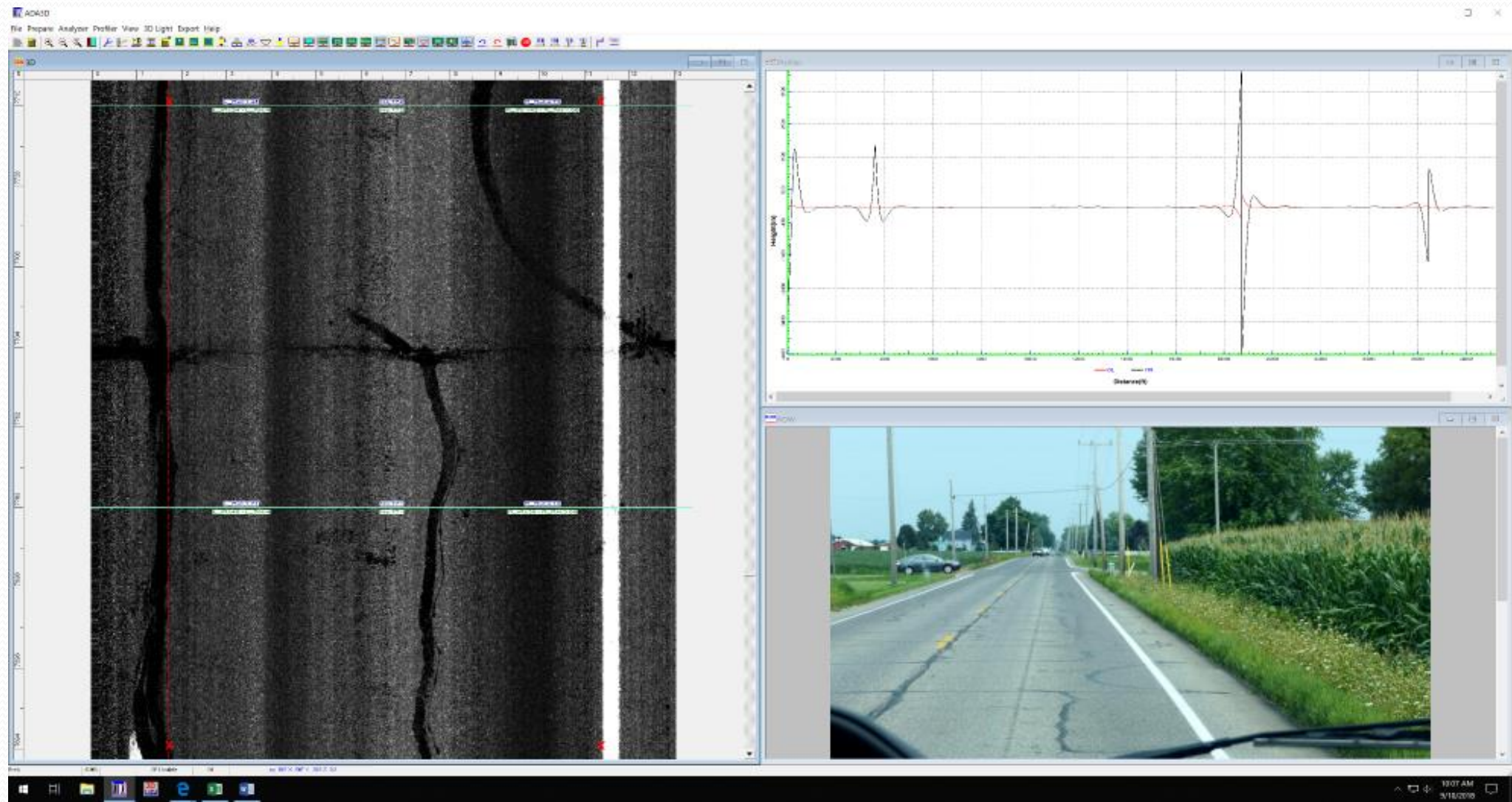
# Correlation PG Low Temp to In-Place Air Voids



# Correlation Delta Tc to In-Place Air Voids



# Pavement Condition Collection



# Smoothness and Rut Depth from Van

	Superpave4				Superpave5			
	IRI (in/mi)		Rut Depth (in)		IRI (in/mi)		Rut Depth (in)	
	LWP	RWP	LWP	RWP	LWP	RWP	LWP	RWP
Average Three Locations	43	91	0.22	0.31	28	120	0.14	0.22
Entire Project	47	119	0.13	0.26	53	206	0.14	0.26

# Crack Data from Automated Collection

	Superpave4		Superpave5	
Location	Length (ft/100 ft)	Crack Density (% area)	Length (ft/100 ft)	Crack Density (% area)
Average Three Locations	142	1.39	171	2.04
Entire Project	141	1.80	299	1.97



Superpave4

Superpave5

A close-up photograph of asphalt pavement. The surface is dark grey and shows signs of wear, including several small, irregular cracks. A bright yellow line, likely a lane marking, runs vertically along the right side of the frame. The text "Superpave4" is overlaid in the bottom left corner in a yellow, sans-serif font.

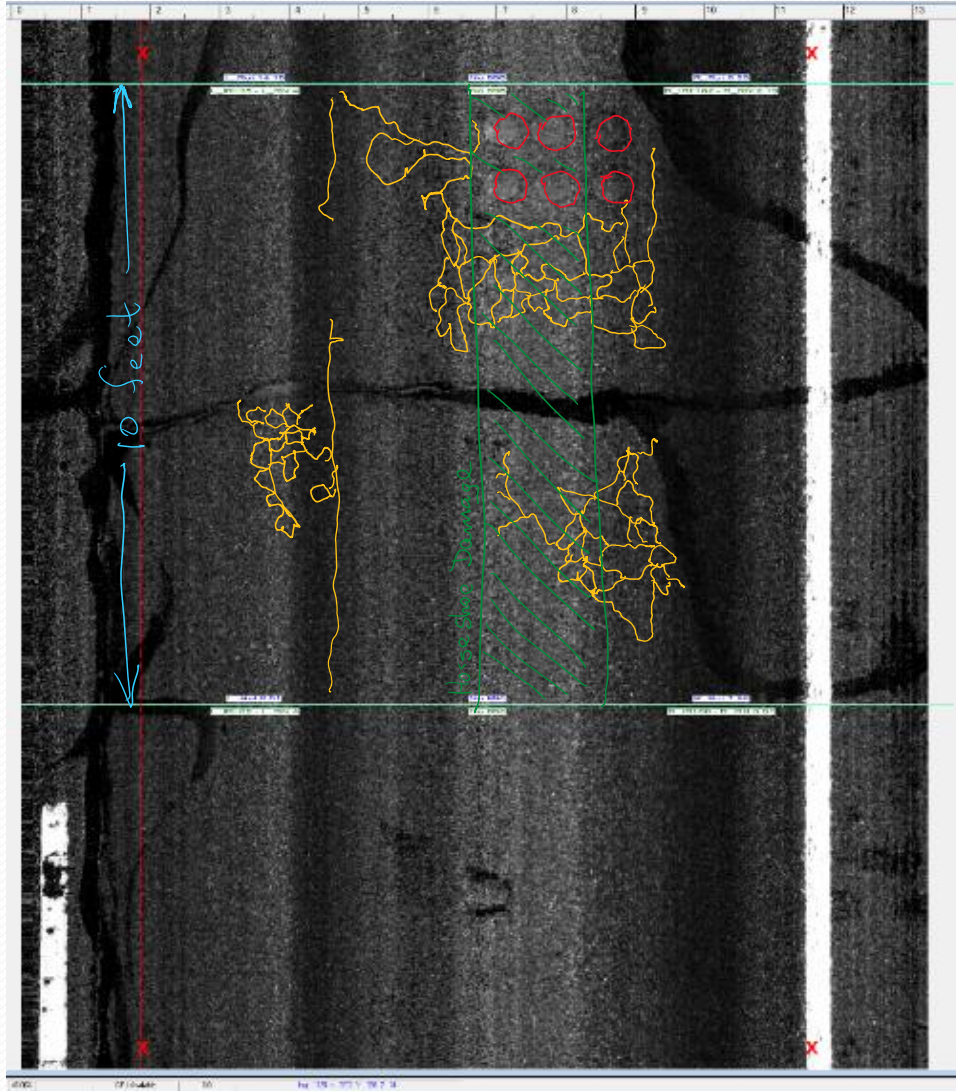
Superpave4



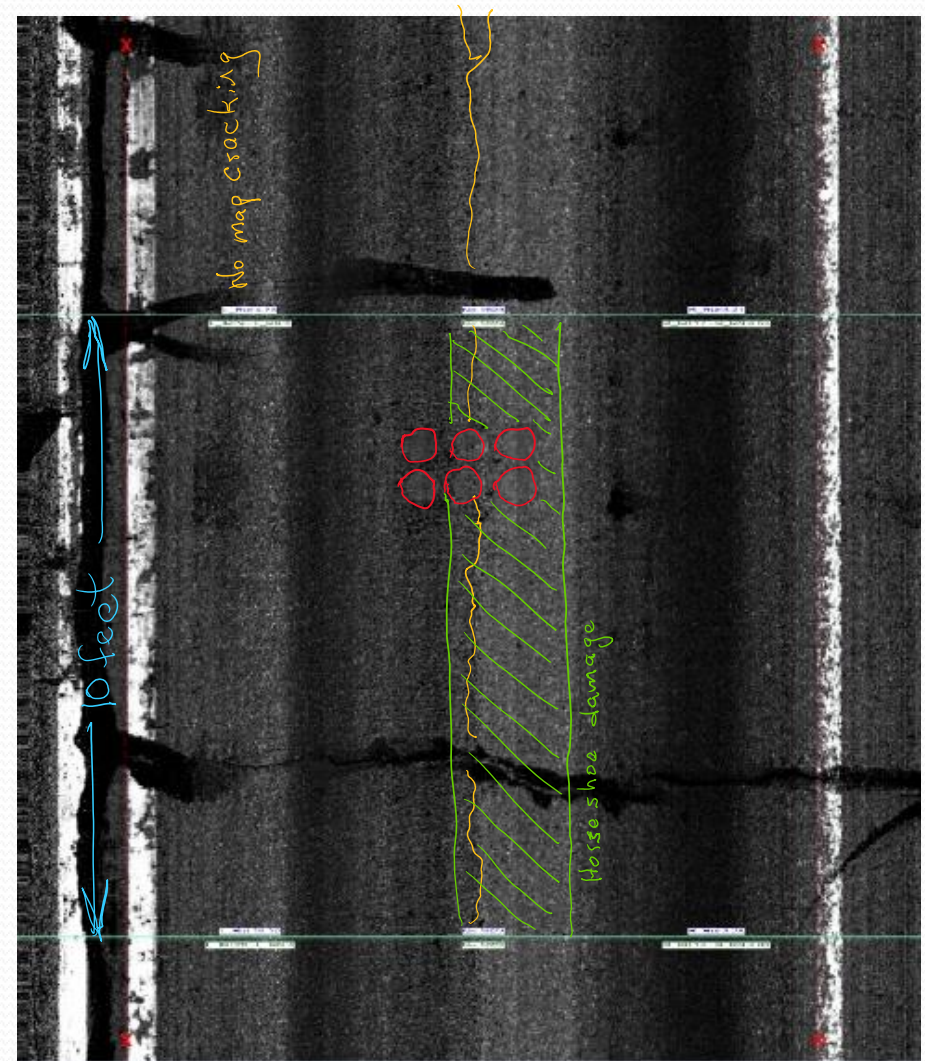
Superpave5



# Superpave4



# Superpave5



What Did We Learn?

**Aging of Asphalt Binder  
Directly Related to  
In-Place Air Voids**



What Did We Learn?

**Changes to Mix Design  
Can Reduce Aging**

# Asphalt Binder Properties

- Construction
  - 80% PG 70-22
  - 20% PG 130 -0 (est.)
- Five Years in Service
  - Superpave4      PG 100-16
  - Superpave5      PG 94-21

Effect on  
Life?

# Indiana DOT Implementation

- $<3$  million ESALs                      30 gyrations
- 3 million to  $>30$  million ESALs    50 gyrations

# Superpave5

- 2018

- 12 projects let as Superpave5
- 9 projects built or partially built

- 11 mix designs

- Four 19.0-mm
- Seven 9.5-mm

- 2019

- Standard specifications changed January 2019
- Specification effective September 2019
- For 2019, option to change Superpave4 projects to Superpave5

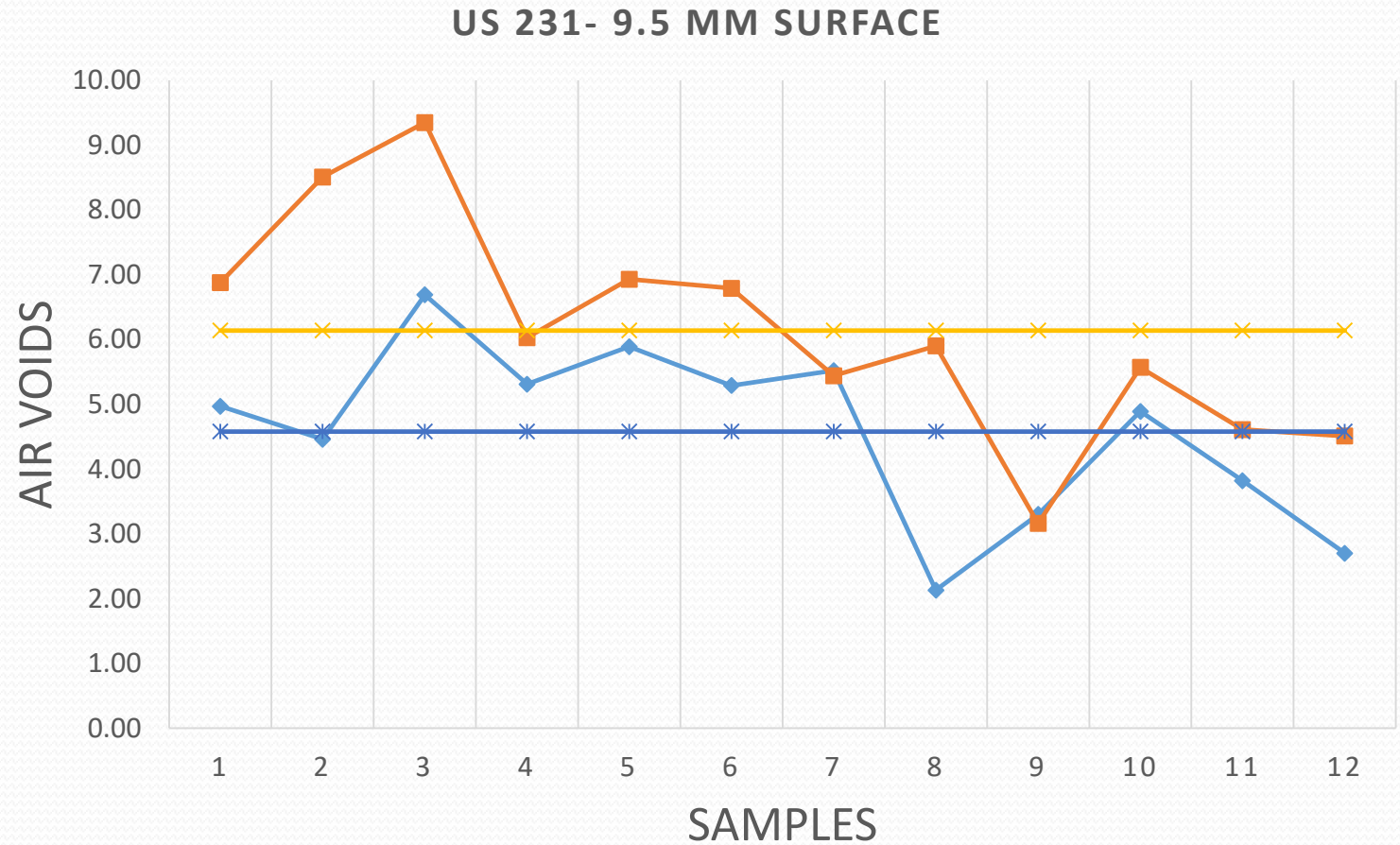
Implementation

Superpave5

How did they  
turn out?

# OK.

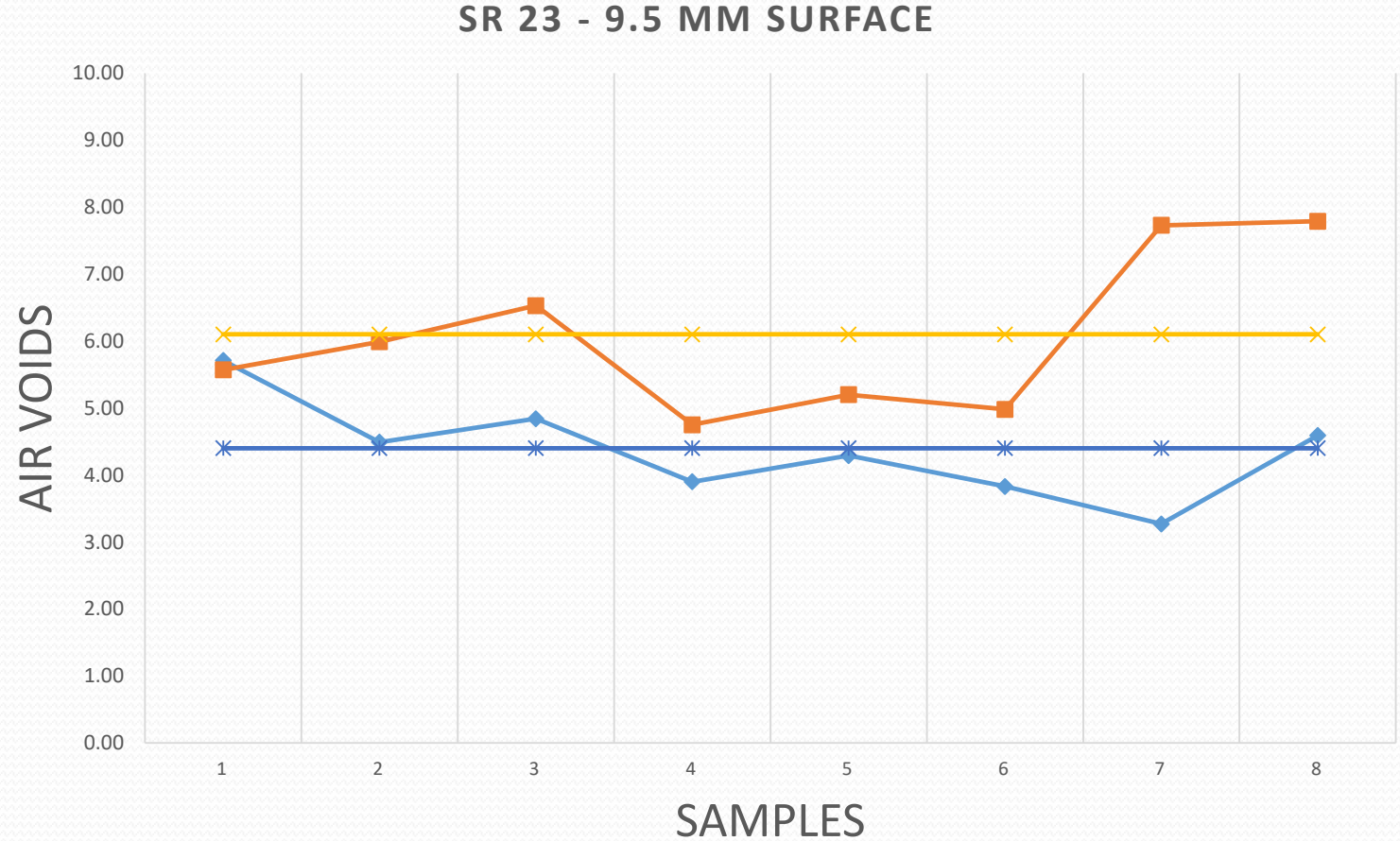
- Gyrotory Voids  
4.58%
- Density  
93.82%  
6.18% voids  
  
1.50% difference





# Not so good.

- Gyrotory Voids  
4.37%
- Density  
93.93%  
6.07% voids
- 1.70% difference



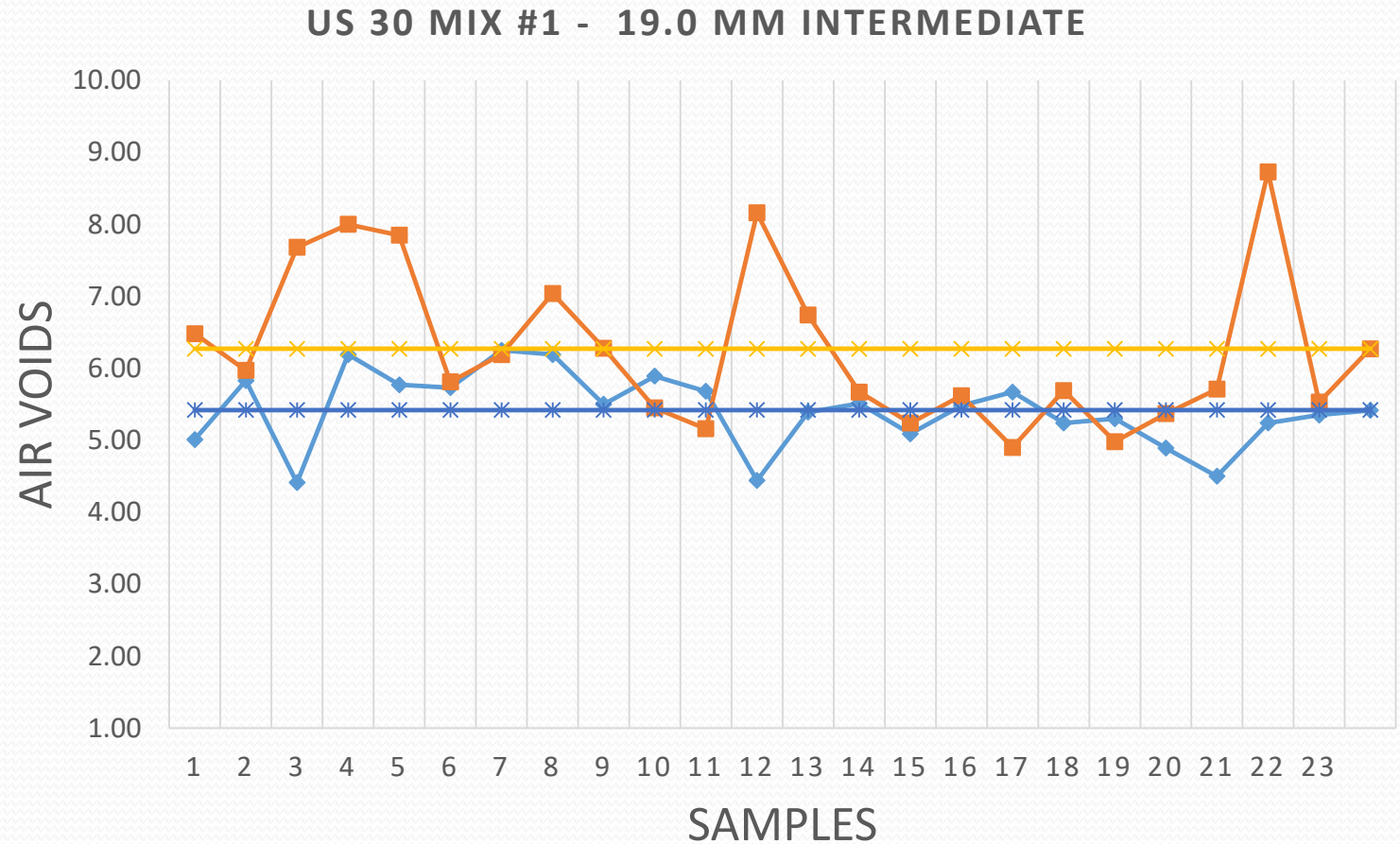
# Good.

- 19.0 mm Intermediate

- Gyrotory Voids  
5.42%

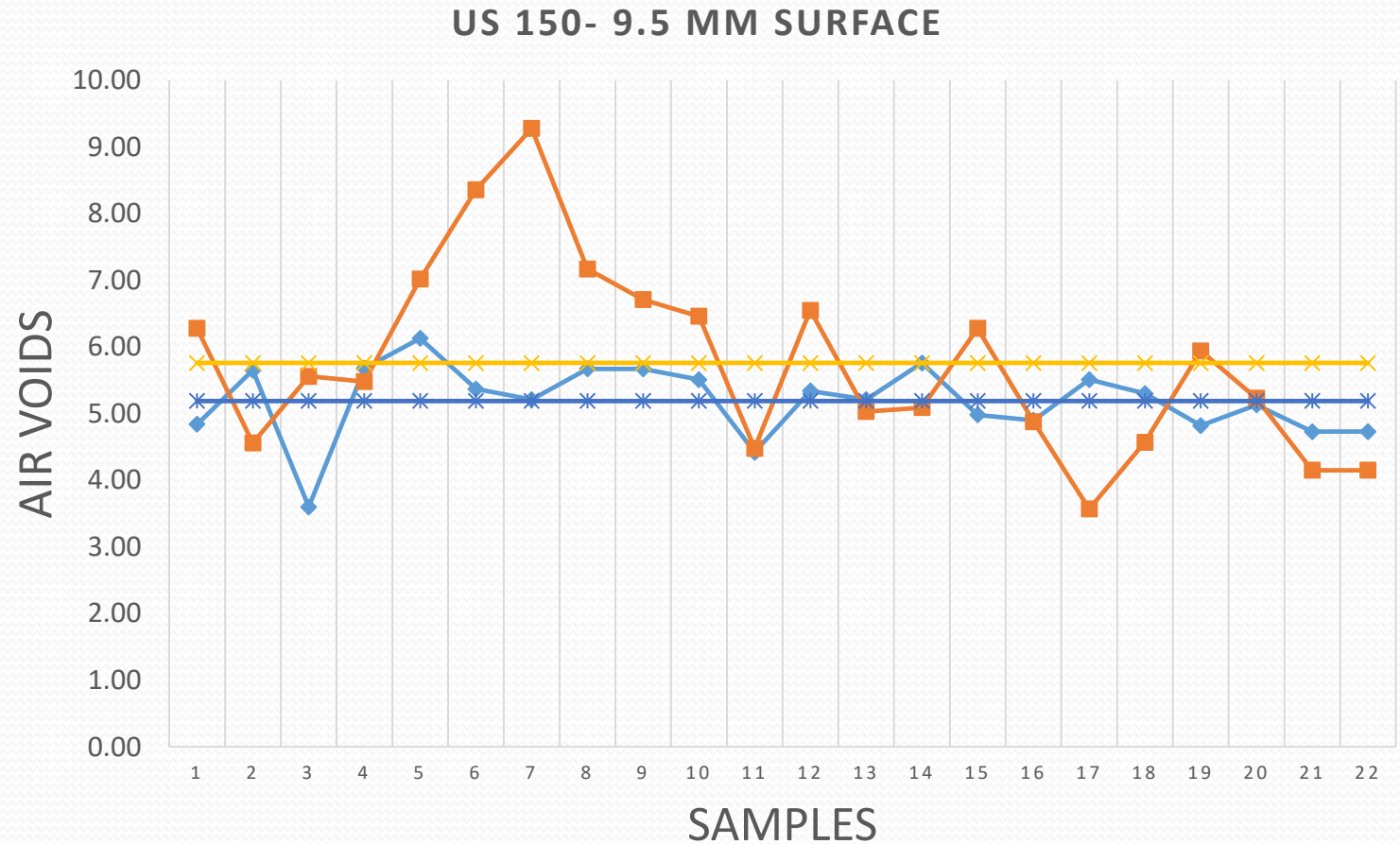
- Density  
93.73% Gmm  
(6.27% voids)

0.85% difference



# Good.

- Gyrotory Voids  
5.19%
- Density  
94.24%  
5.76% voids
- 0.57% difference



# Superpave5

No



B/C ratio?