2019 Imperial – OAPC Asphalt Technical Symposium

Superpave5

Superpave Design at Five Percent Air Voids

THE CENTER
The Heritage Group

June 18, 2019

Question?

Is there a way?

To improve asphalt pavement performance

WITHOUT

Increasing COST?

Marshall Mix Design

- Design Air Voids 3-5%

Construction (8%)

Decreases to

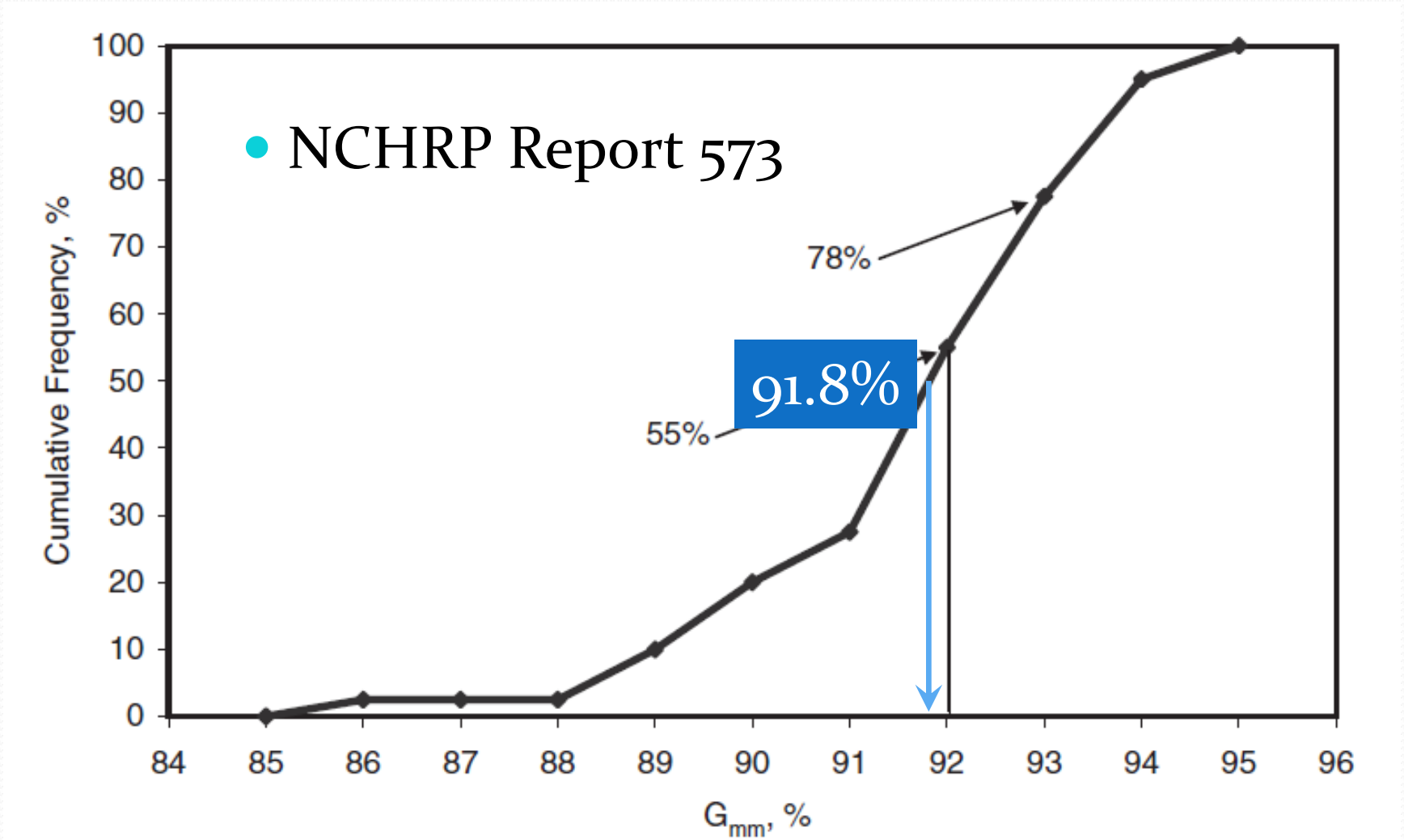
Service Life (4%)

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

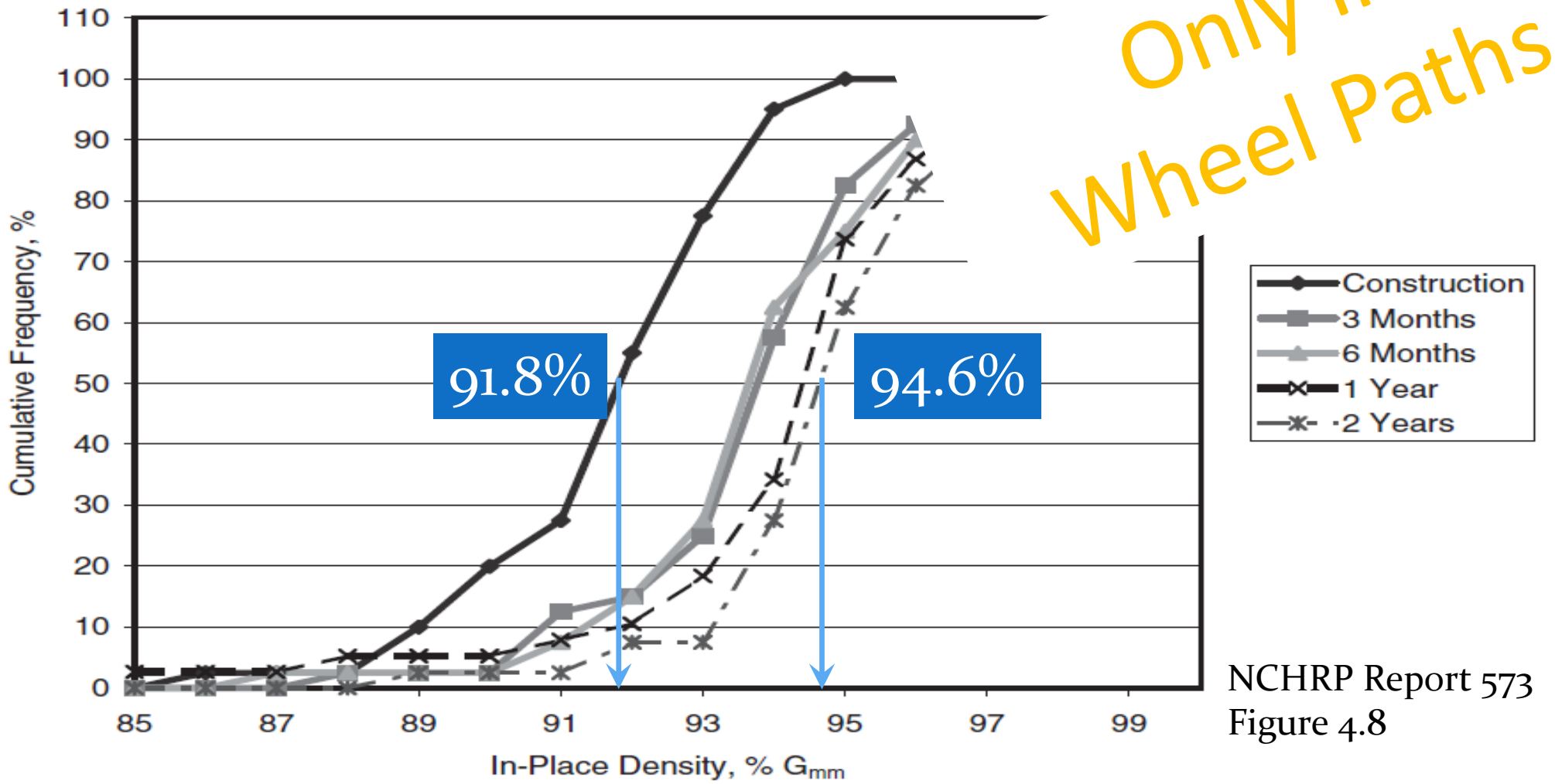
Strategic Highway Research Program

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

As-Constructed Air Voids?



Typical Final Density



Only in Wheel Paths

NCHRP Report 573
Figure 4.8

LCPC Developed Mix Design Method


Design to 5%


Construct to 5%


Performance Good
'94 : :

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?

	Superpave4		Superpave5	
NMAS	VMA	Effective Asphalt (volume)	VMA	Effective Asphalt (volume)
9.5		11.0		11.0
12.5		10.0		10.0
19.0		9.0		9.0
25.0		8.0		8.0

Asphalt Content Stays Same

Asphalt Content

Gradation Changes

NMAS	Superpave4		Superpave5	
	VMA	Effective Asphalt (volume)	VMA	Effective Asphalt (volume)
9.5	15.0	10.0	16.0	11.0
12.5	14.0	10.0	15.0	10.0
19.0	13.0	9.0	14.0	9.0
25.0	12.0	8.0	13.0	8.0

Asphalt Content

Gyrations Change

NMAS	Superpave4 VMA	Superpave4 Effective Asphalt (volume)	Superpave5 VMA	Superpave5 Effective Asphalt (volume)
9.5	15.0	11.0	16.0	11.0
12.5	14.0	10.0	15.0	10.0
19.0	13.0	9.0	14.0	9.0
25.0	12.0	8.0	13.0	8.0

Design Gyrations??

		Mixture Type	
ESAL	Gyrations	9.5-mm	19.0-mm
	70	x	
	50	x	
	30	x	
	70	x	x
	50	x	x
	30	x	x

Purdue University Evaluated Engineering Properties

Conclusions

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

100 gyrations

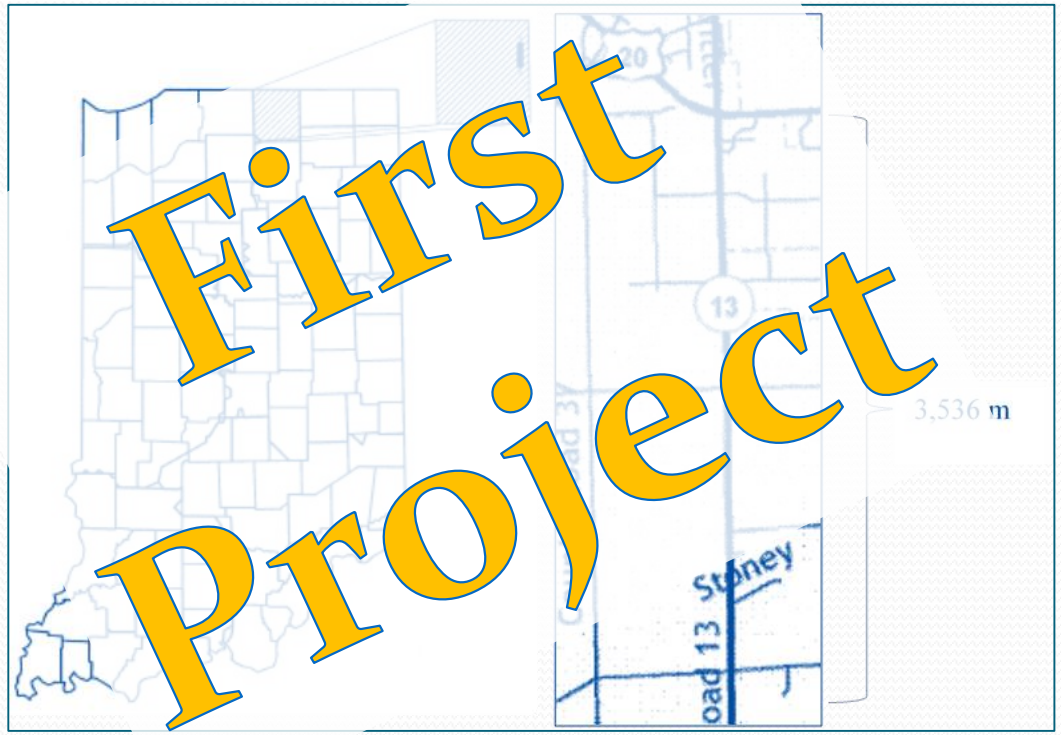
Stiffness, Rutting ≈

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

30 gyrations

SR 13, Middlebury, Indiana

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

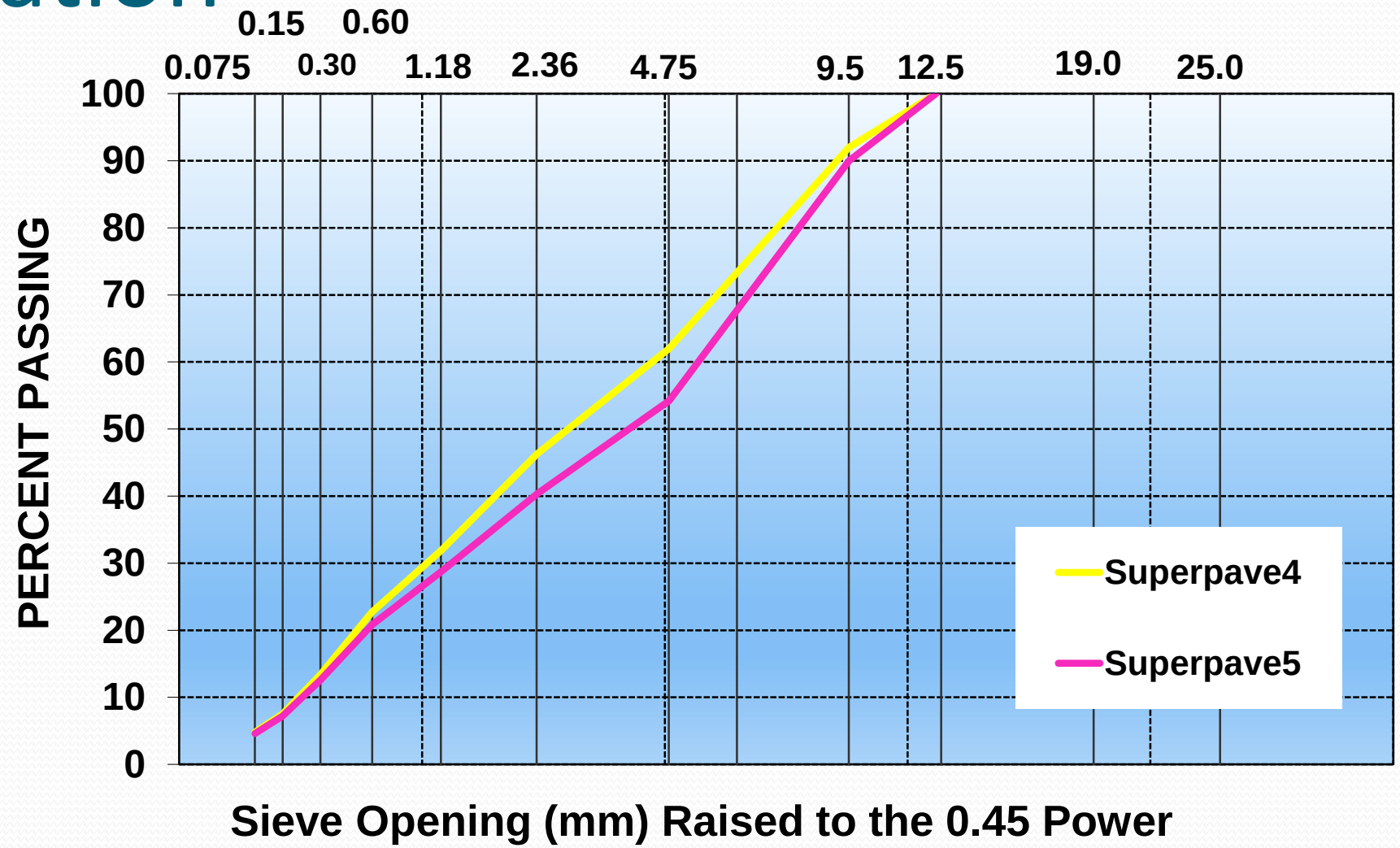


Mix Designs

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

	Superpave4	Superpave5
Gyration	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


0.15
0.60
0.075
0.30
1.18
2.36
4.75
9.5
12.5
19.0
25.0
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
Superpave4
Superpave5
Sieve Opening (mm) Raised to the 0.45 Power

Counter-Flow Drum Mix Plant


Superpave4


Same Rolling Train
Superpave5 Compaction
3064
CATERPILLAR
VERSA-VIBE
MACHINE CONTROL
Paving Contractors
www.walshkelly.com

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

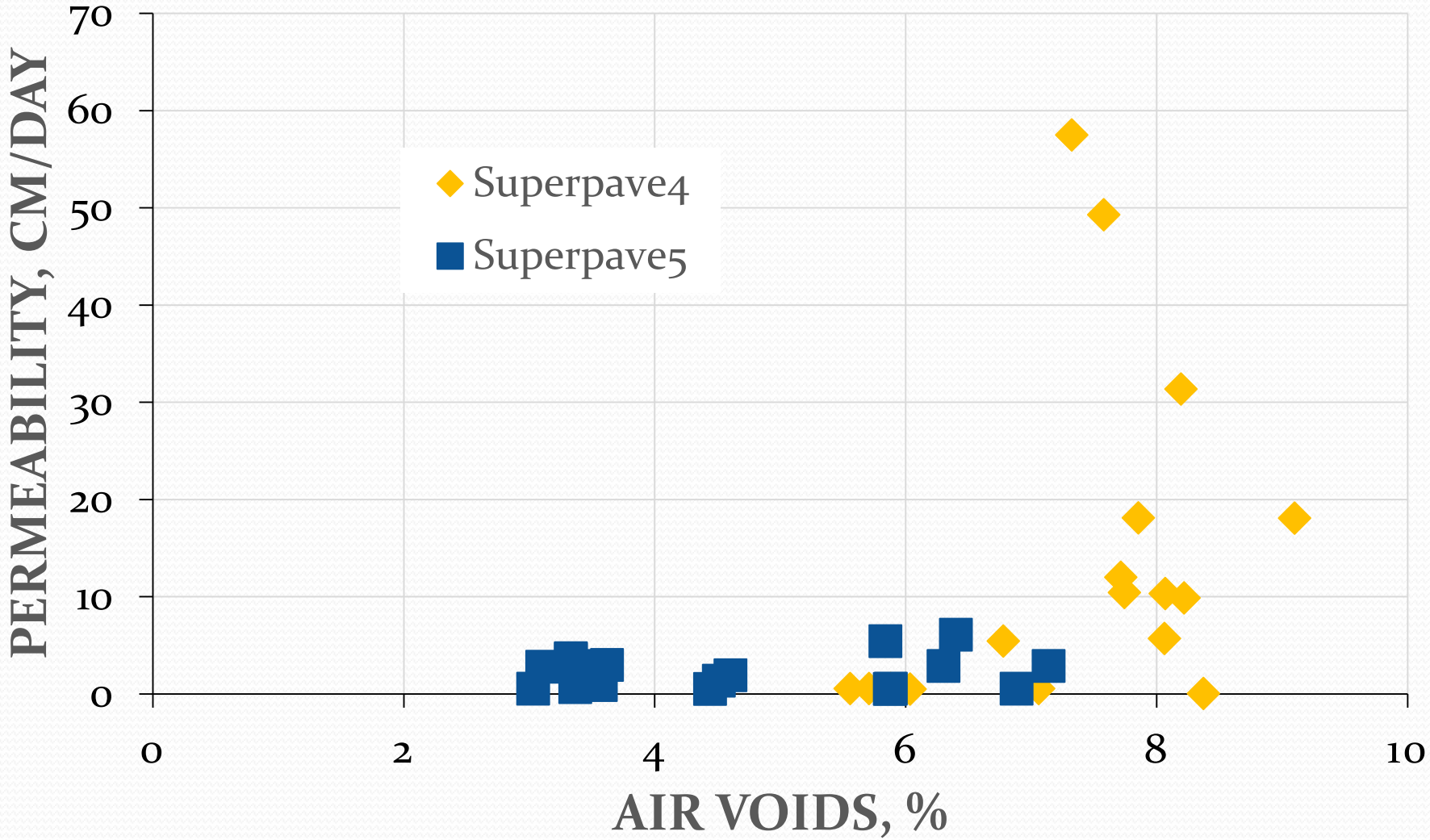

Six Cores At Each Location

Core Properties

	Superpave4			Superpave5		
	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

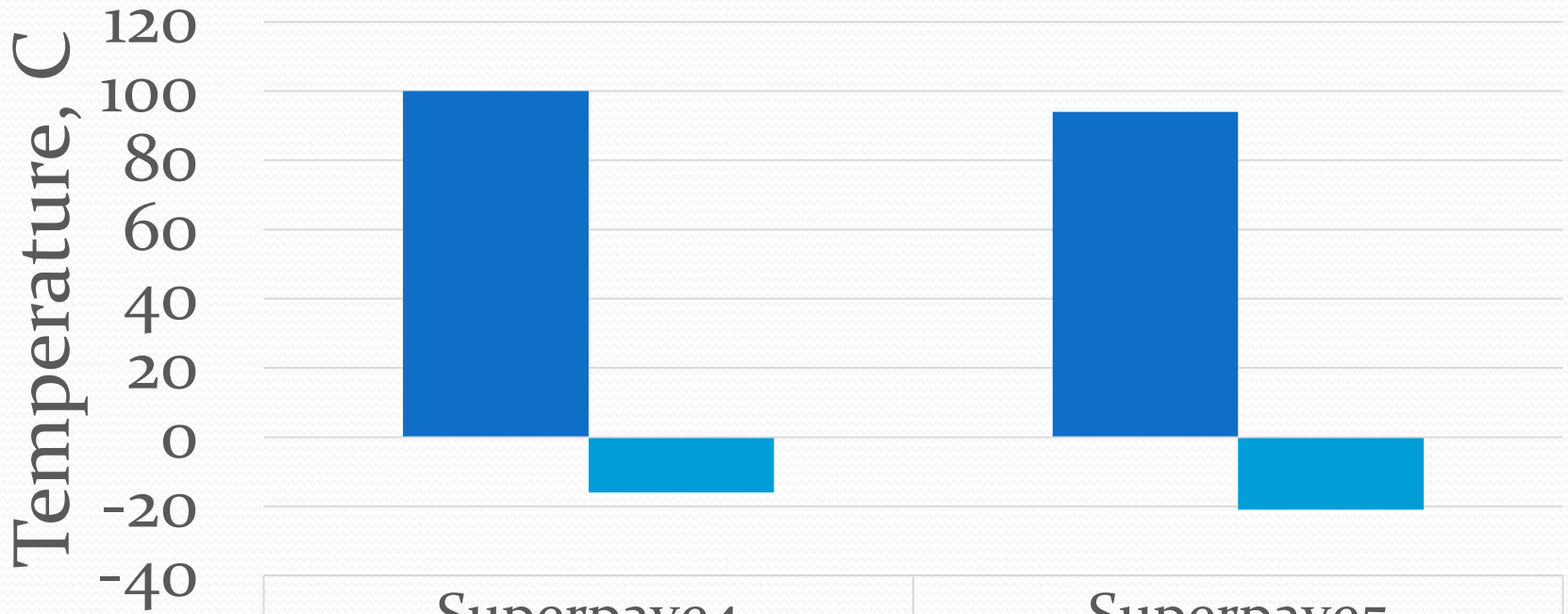
Permeability



Recovered Asphalt Binder Grade

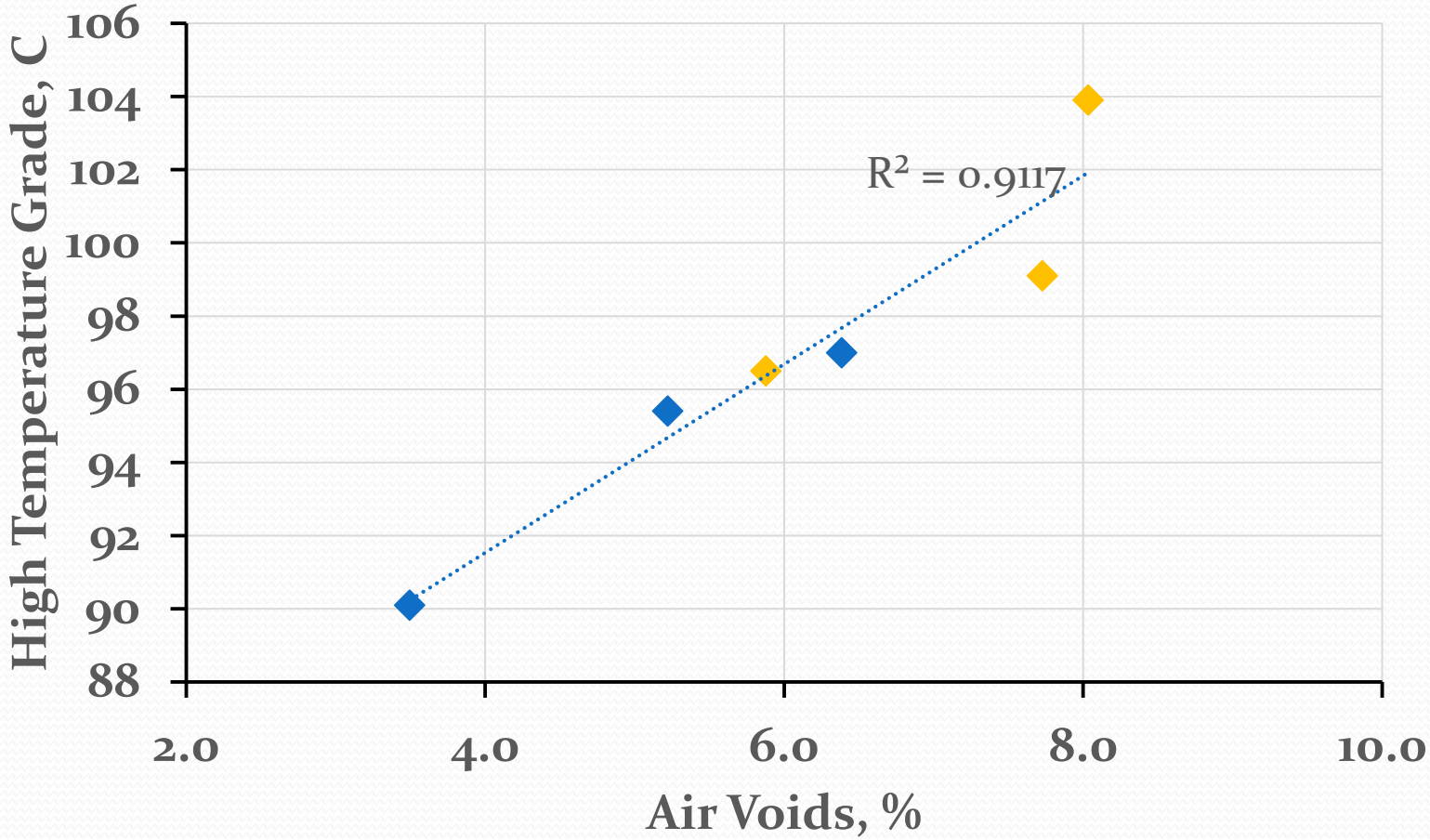
	Superpave4				Superpave5			
Location	High Fail Temp., °C	Low Fail Temp m, °C	Low Fail Temp, S, °C	ΔTc, °C	High Fail Temp, °C	Low Fail Temp, m, °C	Low Fail Temp, S, °C	ΔTc, °C
1	99.1	-15.6	-24.8	-9.2	95.4	-20.5	-24.9	-4.4
2	97.0	-20.4	-25.8	-5.4	96.5	-18.5	-23.4	-4.9
3	103.9	-12.7	-23.1	-10.4	90.1	-24.1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

Asphalt Binder Grade

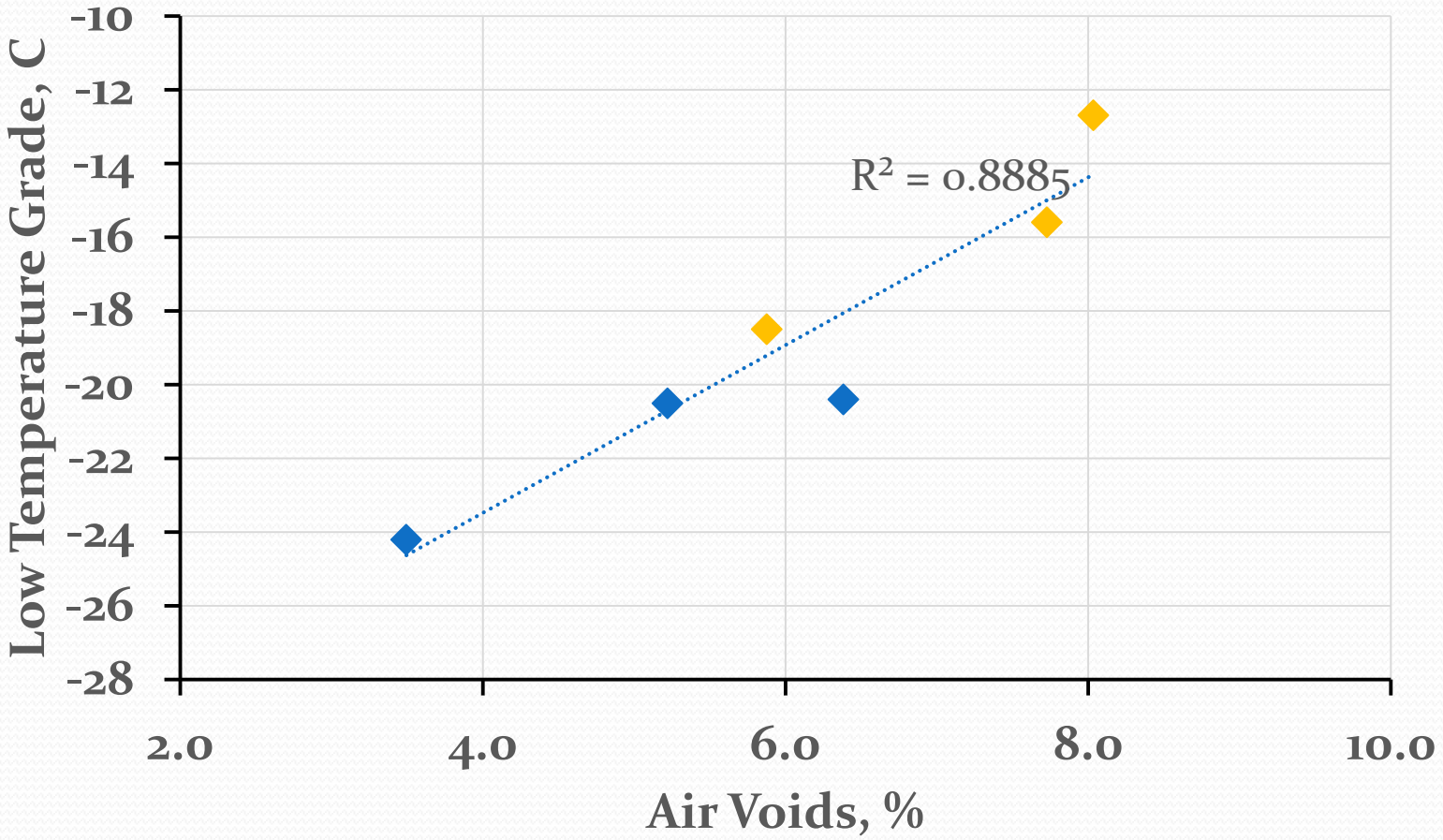


	Superpave4	Superpave5
HT	100	94
LT	-16	-21

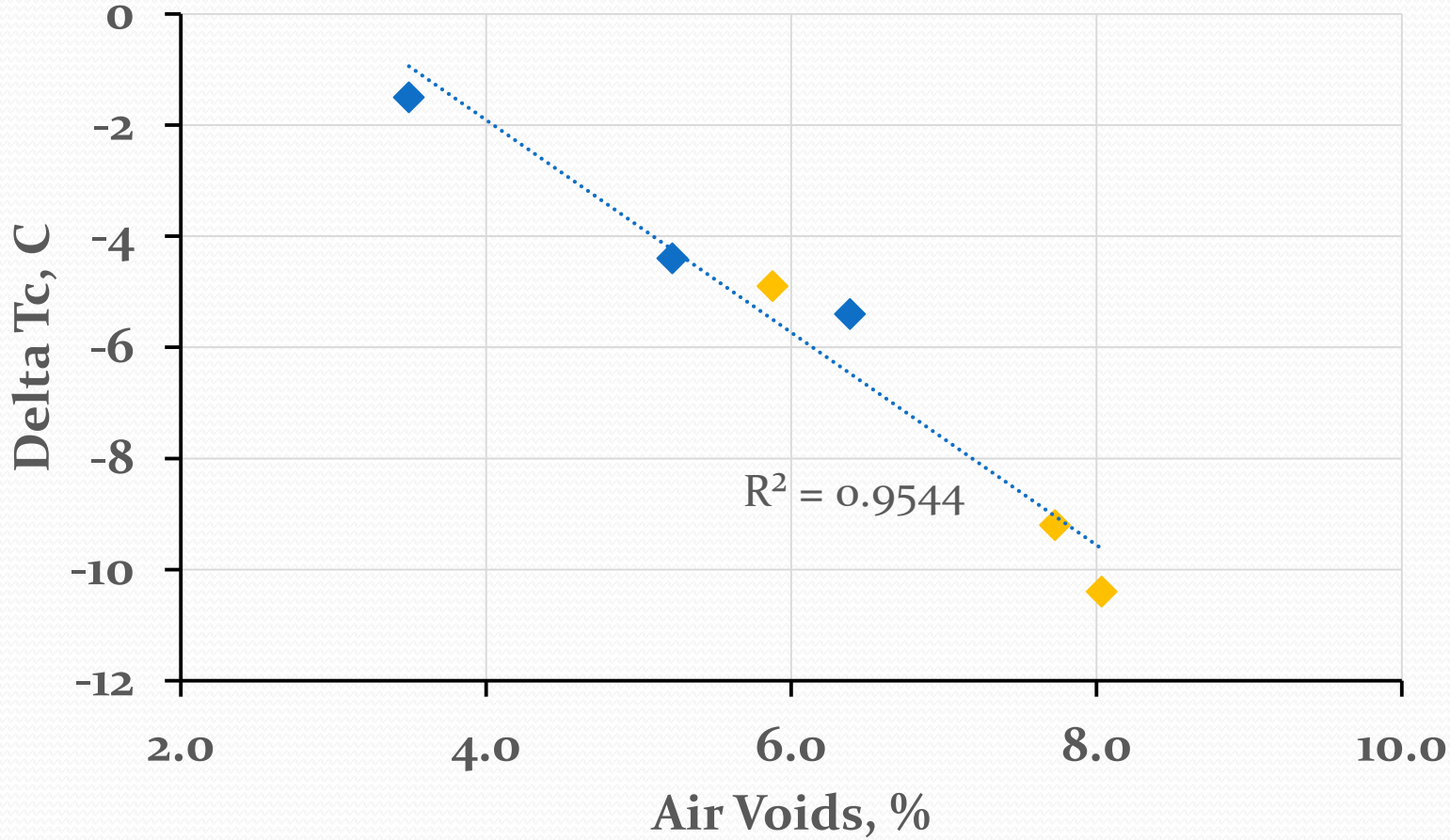
Correlation PG High Temp to In-Place Air Voids



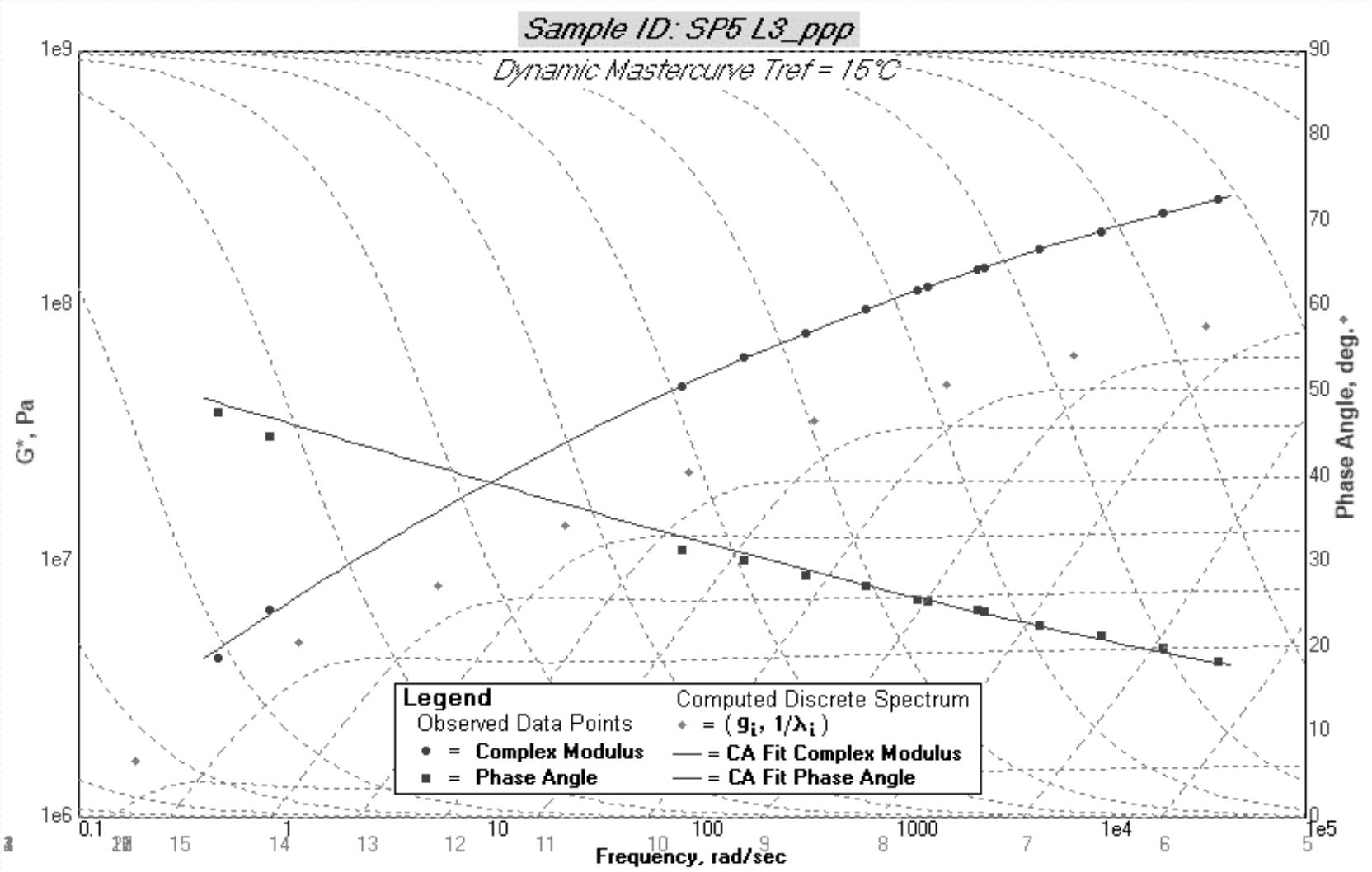
Correlation PG Low Temp to In-Place Air Voids



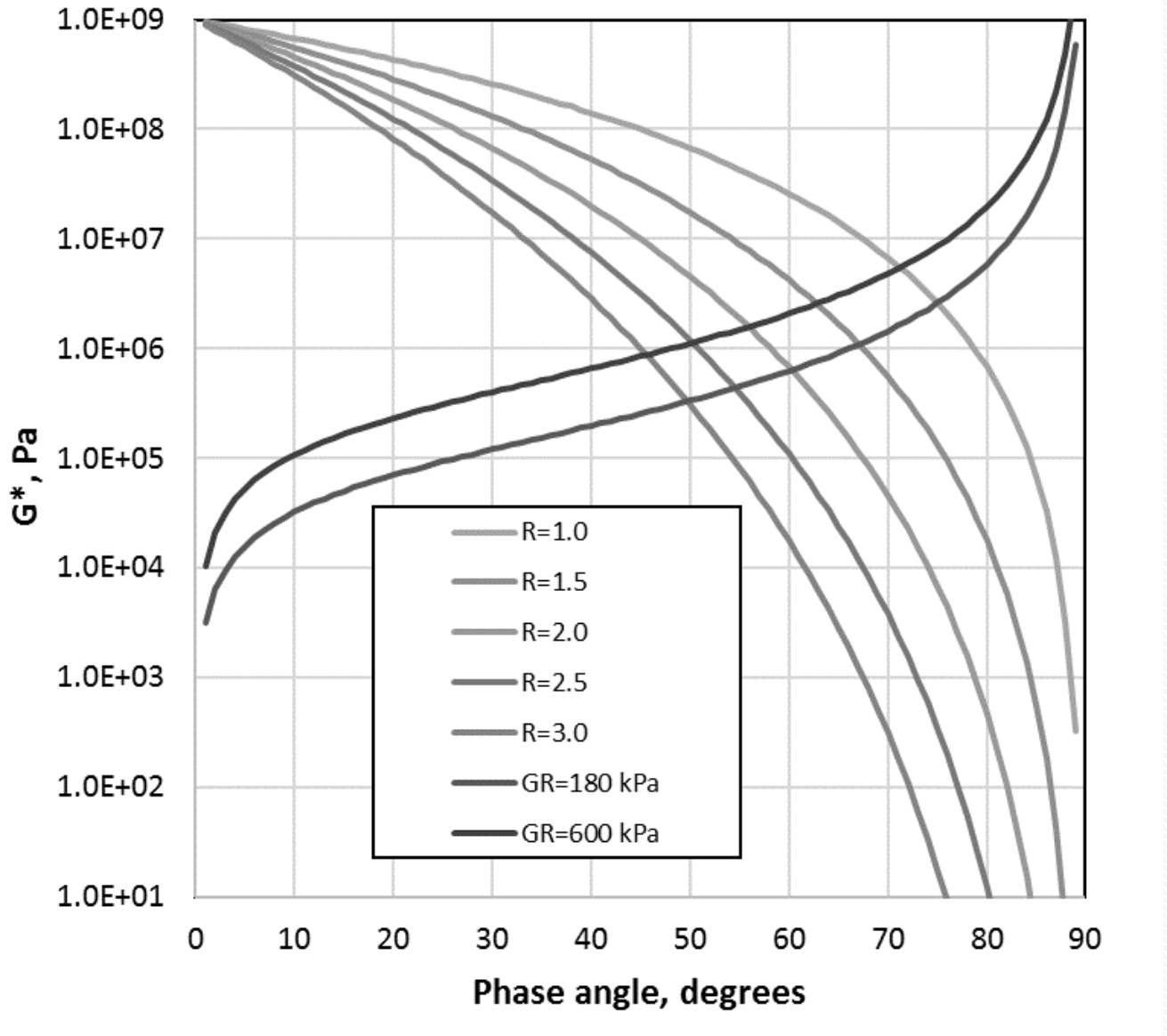
Correlation Delta Tc to In-Place Air Voids



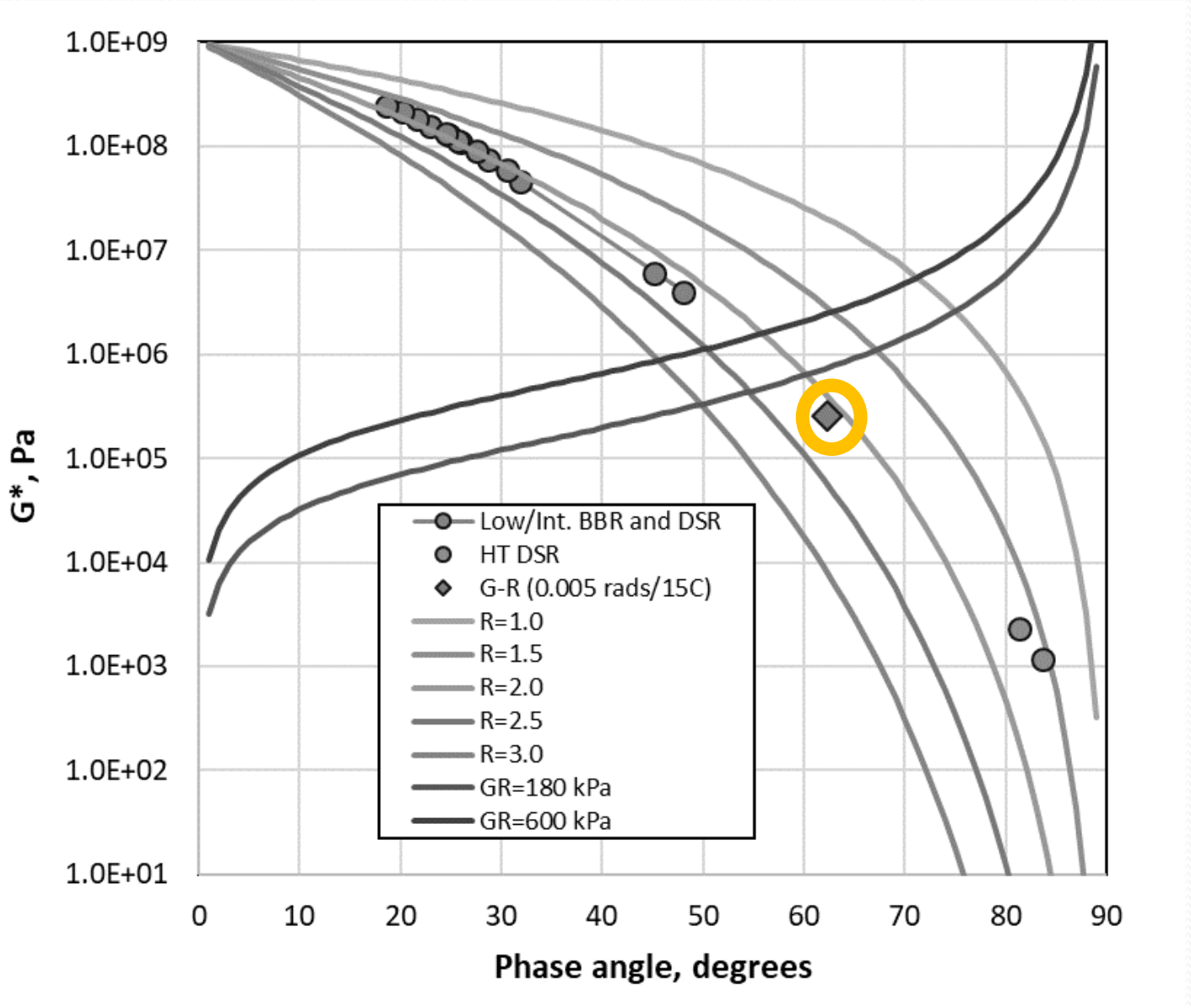
Recovered Binder Master Curve



Glover Rowe


1.0E+09
1.0E+08
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
G*, Pa
0
10
20
30
40
50
60
70
80
90
Phase angle, degrees
R=1.0
R=1.5
R=2.0
R=2.5
R=3.0
GR=180 kPa
GR=600 kPa

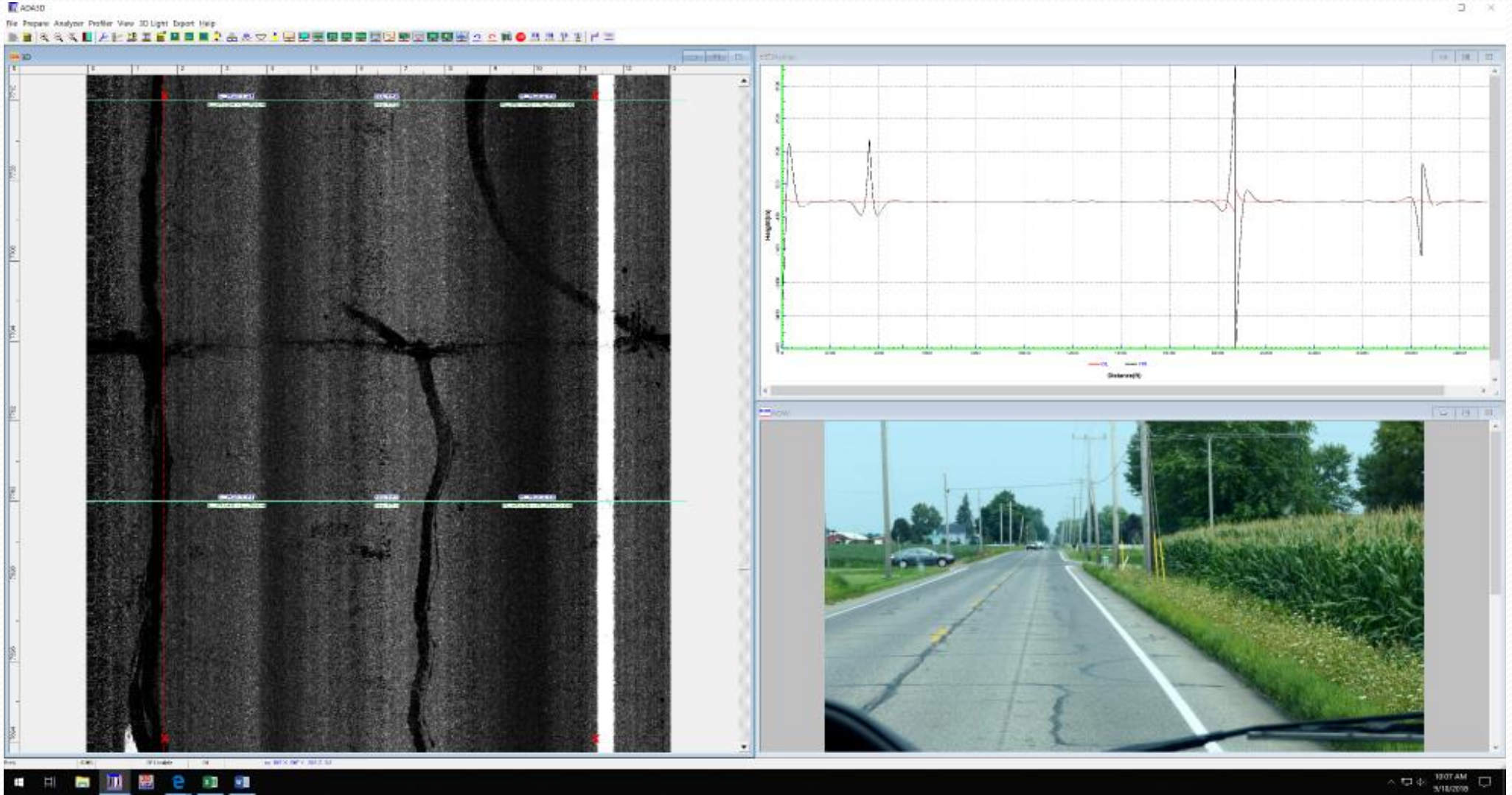
Glover Rowe, SP5, Location 3



Glover Rowe Results

		Glover Rowe Value	Expected Performance
Superpave4	Location 1	880	Should crack
	Location 2	363	Might Crack
	Location 3	858	Should crack
Superpave5	Location 1	170	Should Not Crack
	Location 2	315	Might Crack
	Location 3	69	Should Not Crack

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

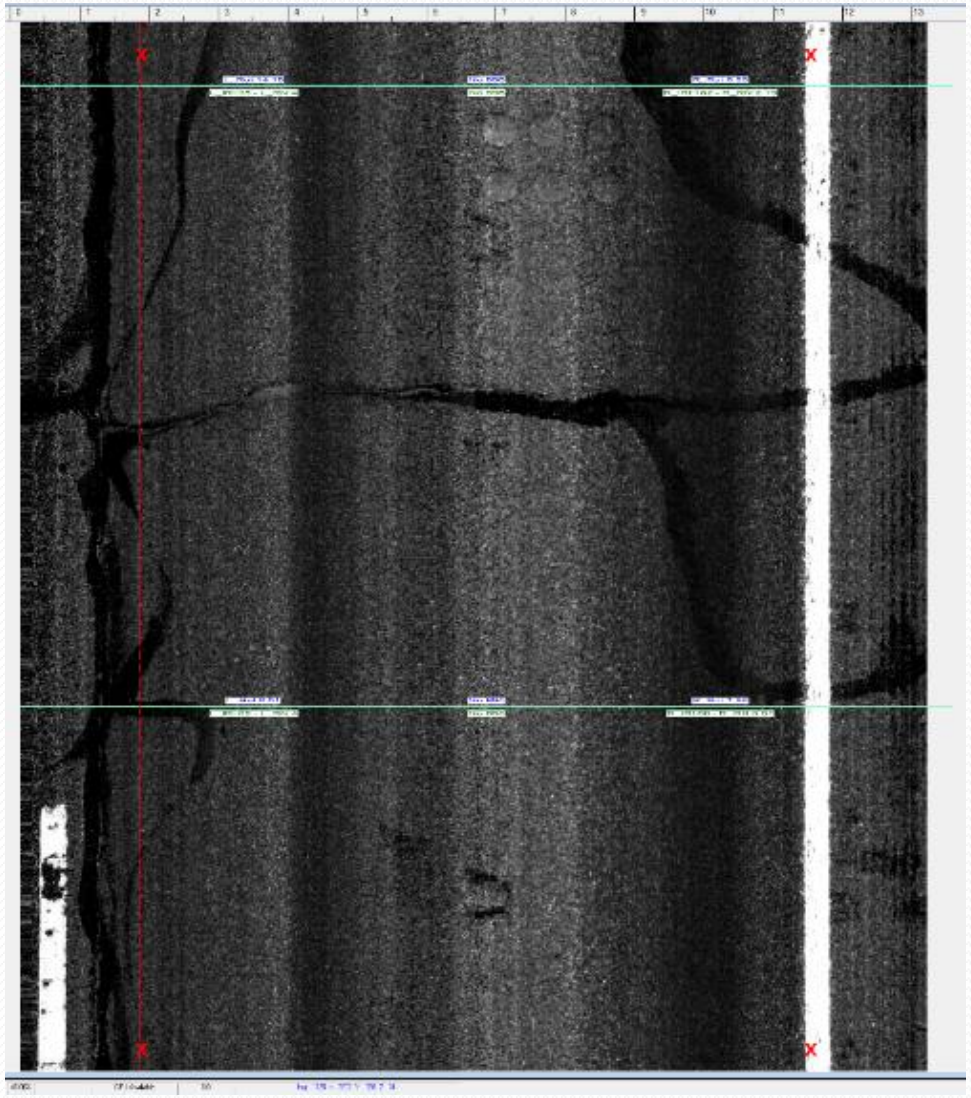
	Superpave4		Superpave5	
Location	Length (ft/100 ft)	Crack Density (% area)	Length (ft/100 ft)	Crack Density (% area)
Average Three Locations	142	1.39	171	2.04
Entire Project	141	1.80	299	1.97


Superpave4
Superpave5

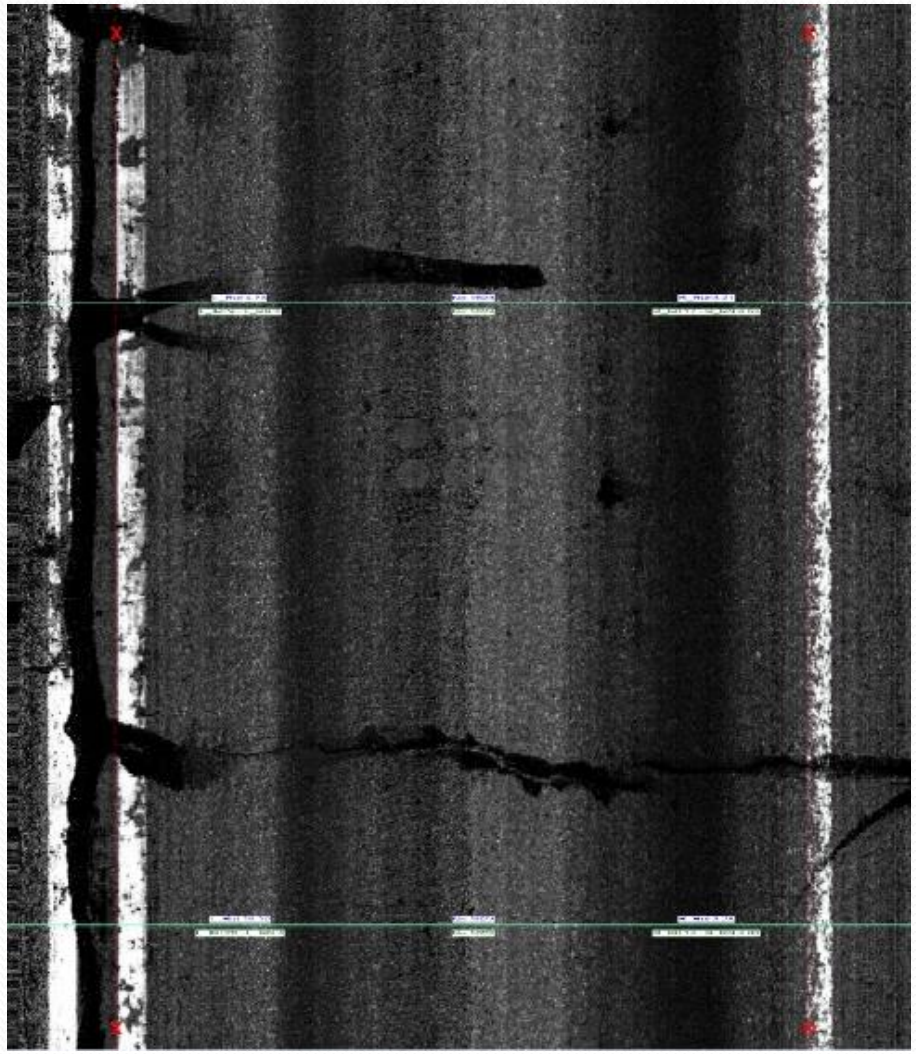

Superpave4


Superpave5

Superpave4



Superpave5



What Did We Learn?

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

Asphalt Binder Properties

- Construction
  - 80% PG 70-22
  - 20% PG 130 -0 (estimated)

- Five Years in Service
  - Superpave4 PG 100-16

  - Superpave5 PG 94-21

Less Aging

=

Longer Life?

US 40, Richmond, Indiana

- 2016 Trial Project
  - 17,800 AADT
  - 5% heavy trucks

FHWA High Density Trial Project

Mix Designs

	Superpave4	Superpave5
#11 Limestone	50.5	46.5
#12 Limestone	10.0	8.0
Stone Sand	22.0	27.0
RAP Fine	14.5	14.1
RAS (Shingles)	3.0	2.9

	Superpave4	Superpave5
Gyration	100	50
Asphalt Content	6.7%	7.1%
Recycled Binder Ratio	0.23	0.21
Air Voids	4.0	5.0
VMA	15.6	16.7

November 2016
5°C to 12°C

Mix Construction Properties

	Superpave4		Superpave5	
	Design	QA	Design	QA
Asphalt, %	6.7	6.48	7.1	6.83
Air Voids, %	4.0	4.76	5.0	5.88
VMA, %	15.6	14.88	16.7	16.69
Density, %Gmm	-	93.3	-	95.4


Superpave4
Superpave5


Superpave5
Superpave4
Wayne Bank
Ryder
CHASE
AUCTION
March 9


Superpave5
Superpave4


RICHMOND
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High Speed Internet
Satellite TV
Premium Channels
AUTO PARTS
CHEVEUX
Richmond Inn & Suites
Superpave5
Superpave4

Superpave4

Superpave5

Indiana DOT Implementation

- <3 million ESALs

- 3 million to >30 million ESALs 50 gyrations

Implementation

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

2018 Superpave5 Projects

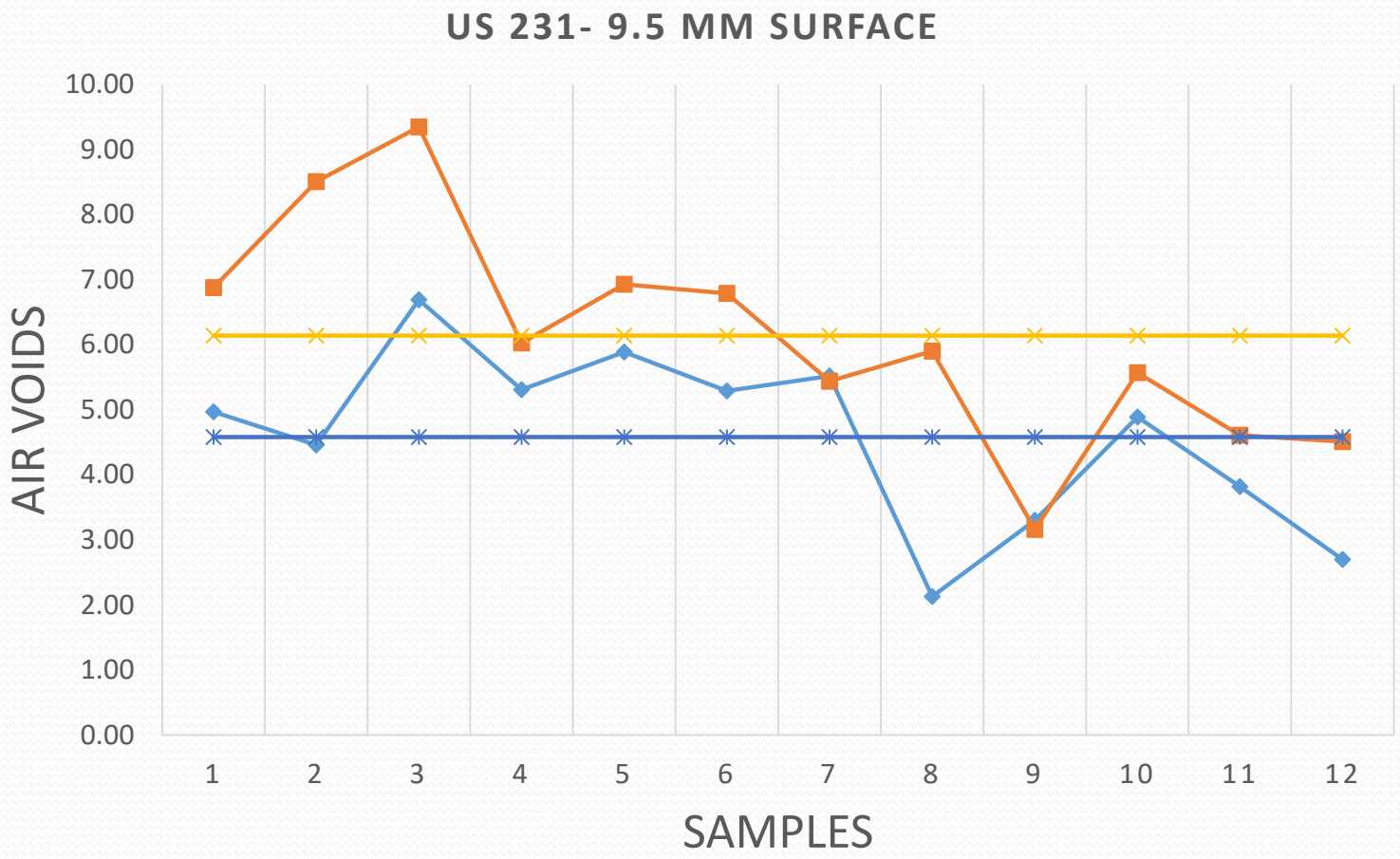
How did they turn out?

OK.

- Gyratory Voids
  4.58%

- Density
  93.82%
  6.18% voids

  1.50% difference

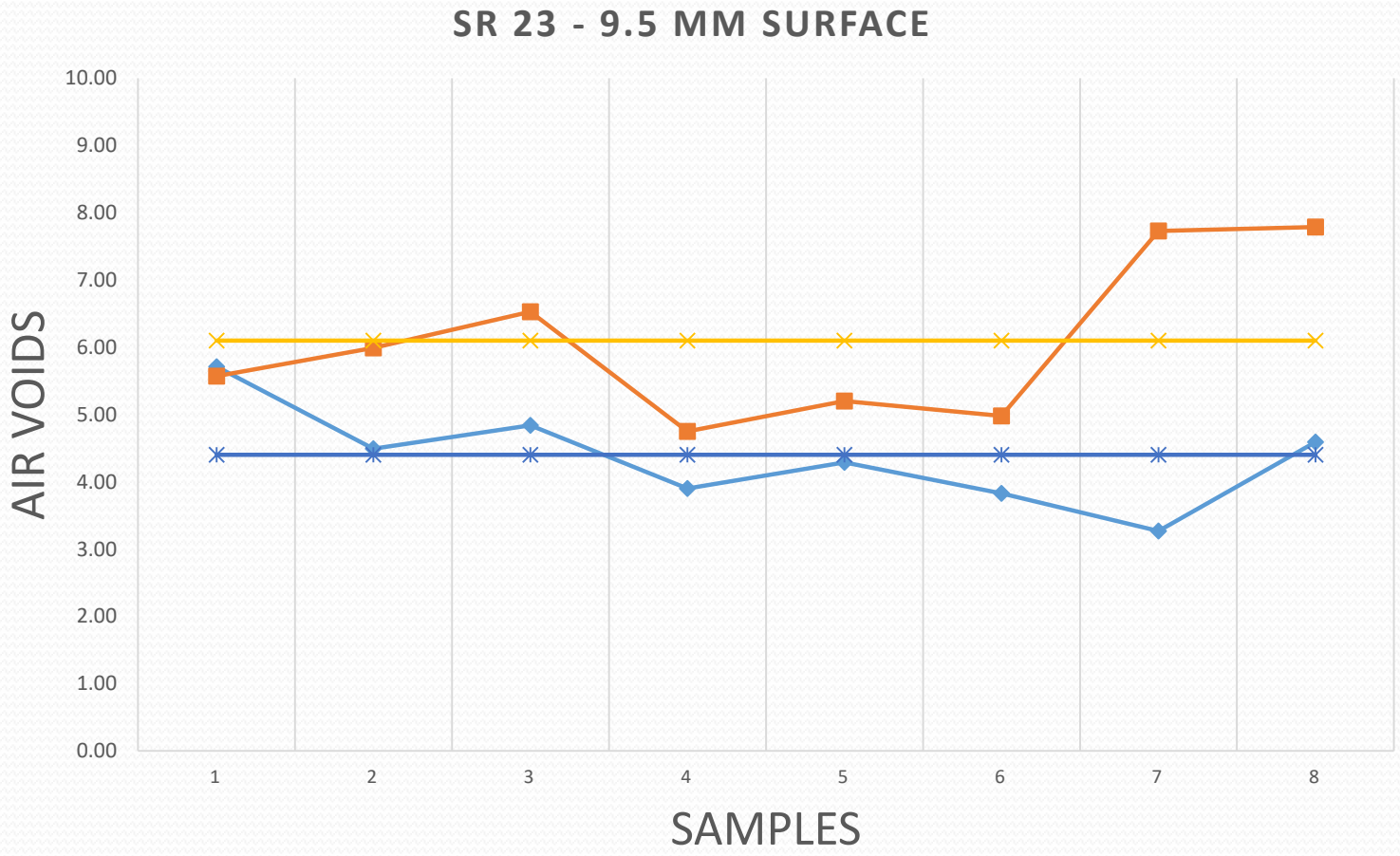


Not so good.

- Gyratory Voids
  4.37%

- Density
  93.93%
  6.07% voids

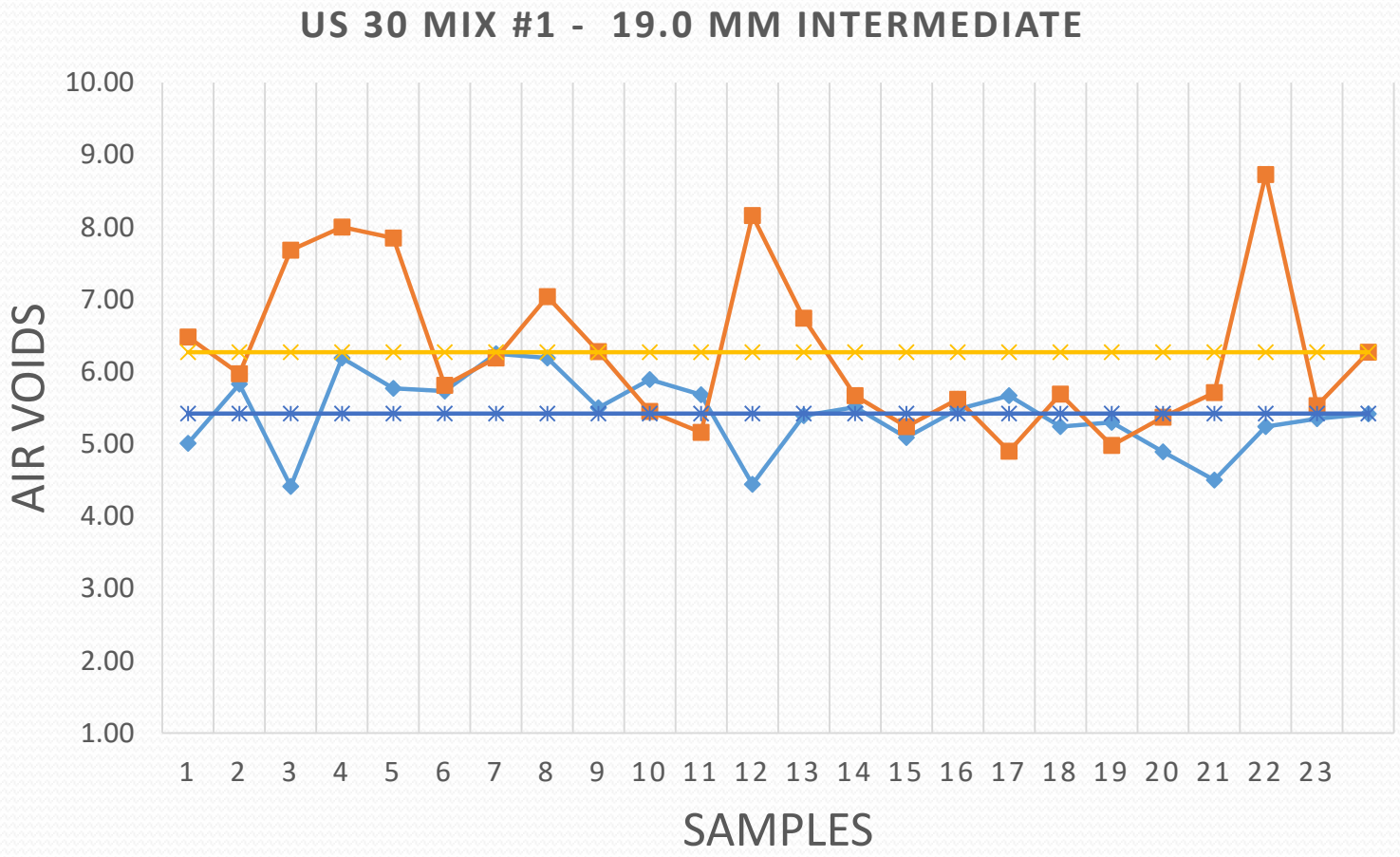
  1.70% difference



Good.

- 19.0 mm Intermediate
  - Gyratory Voids
    5.42%
  - Density
    93.73% Gmm
    (6.27% voids)

    0.85% difference

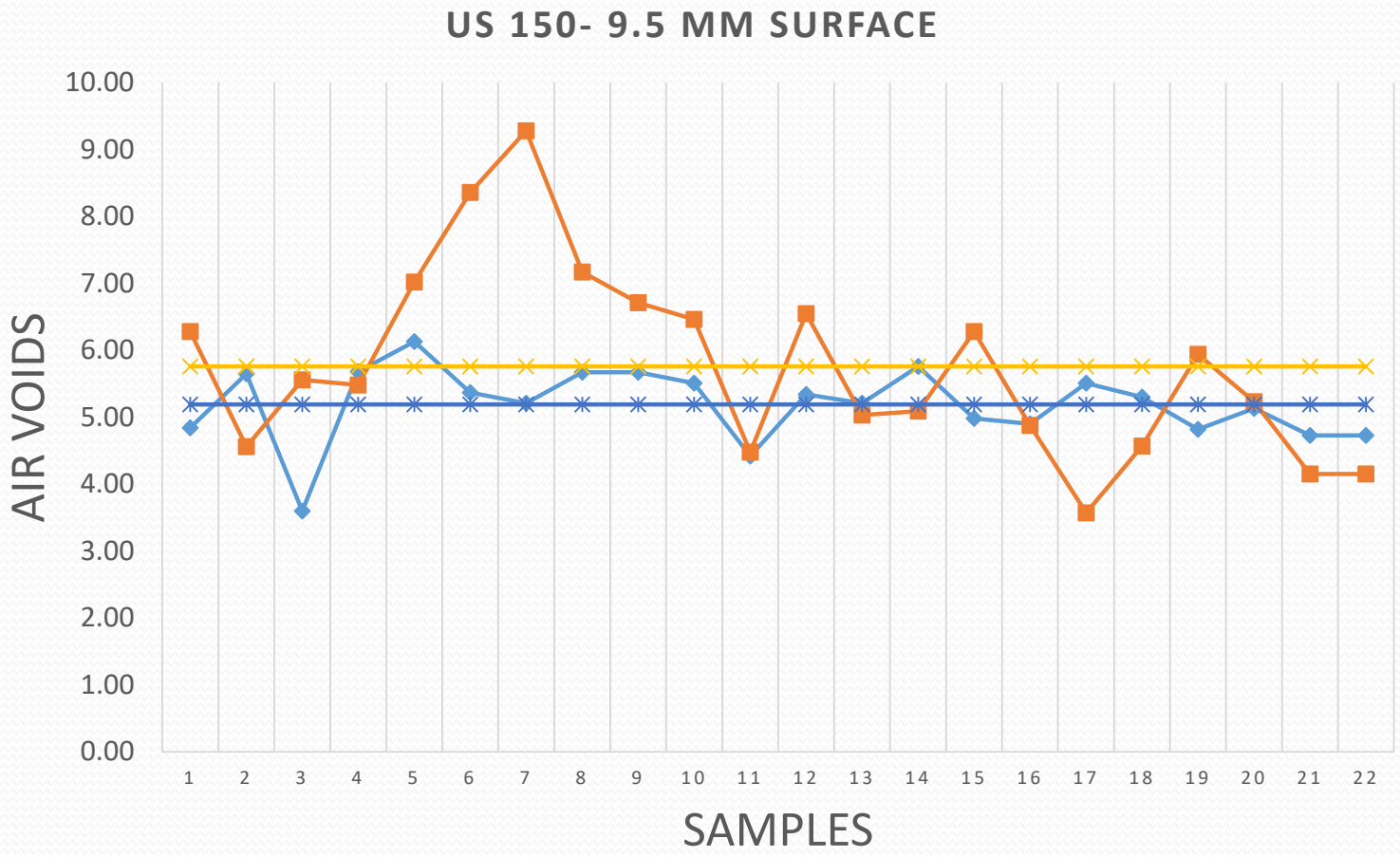


Good.

- Gyratory Voids
  5.19%

- Density
  94.24%
  5.76% voids

  0.57% difference



Superpave5

Reduced Aging

Superpave5

Increased Life

Minimal (No?) Increased Cost

B/C ratio?

Thank You