



U.S. Department of Transportation  
**Federal Highway Administration**

# **FHWA MATC: Providing Assistance to the Northeast**

NEAUPG 2020  
October 28, 2020



# Acronyms

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- ▶ ABML-ID: Asphalt binder and mixture laboratory – implementation and delivery
- ▶ ABT: Asphalt Binder Tester
- ▶ BMD: Balanced mix design
- ▶ CalTrans: California Department of Transportation
- ▶  $CT_{index}$ : Cracking index
- ▶  $E^*$ : Dynamic modulus
- ▶ FHWA: Federal Highway Administration
- ▶ FI: Flexibility Index
- ▶ FTIR: Fourier transform infrared spectroscopy
- ▶ HWT: Hamburg wheel tracker
- ▶ I-FIT: Illinois Flexibility Index Test
- ▶ MaineDOT: Maine Department of Transportation
- ▶ MATC: Mobile Asphalt Technology Center
- ▶ mm: millimeter
- ▶  $N_{des}$ : Design gyrations
- ▶ NRRI: Normalized rutting resistance index
- ▶ PG: Performance grade
- ▶ QA: Quality assurance
- ▶ RQL: Rejectable quality limit
- ▶ RSI: stress sweep rutting index
- ▶  $S_{app}$ : cyclic fatigue index parameter
- ▶ SIP: Stripping inflection point
- ▶ TFHRC: Turner-Fairbanks Highway Research Center
- ▶ VBE: Voids filled with effective binder
- ▶ VMA: Voids in the mineral aggregate
- ▶ VTrans: Vermont Agency of Transportation



# Outline

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- ▶ MATC Overview & Mission
- ▶ Ongoing MATC Support to Northeast
  - MaineDOT BMD Data Analysis
  - VTrans BMD Data Analysis
- ▶ What can we do for you?



# Mobile Asphalt Technology Center

- ▶ MATC is on the move to serve the asphalt pavement community!



## MATC Mission:

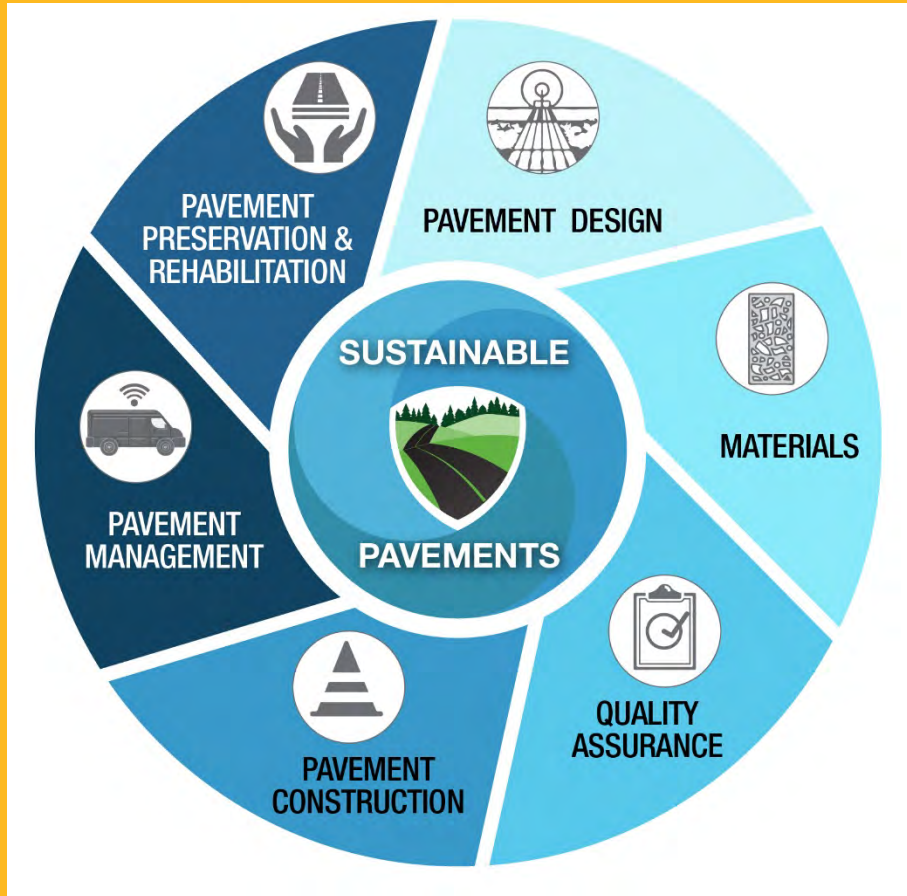
Our mission is to introduce new and emerging asphalt materials and construction technologies to States and industry, which bridges the gap between research and implementation.

## MATC Goal:

These technologies and practices are implemented by agencies and industry to provide longer-lasting, safer, better-performing, and more cost-effective asphalt pavements on our nation's highways.

# MATC Objectives

- ▶ Demonstrate emerging technologies & maintain focus on customer needs
- ▶ Deploy technology from TFHRC, Every Day Counts, other research & development (R&D)
- ▶ Leverage the asset for whole Pavements program & increase MATC's impact



# Core Activities

- ▶ Demonstrating test methods and equipment
- ▶ On-site support Equipment training
- ▶ Case examples developed from innovation trials
- ▶ Specification review (QA, materials, construction)
- ▶ Equipment loan program

## Deployment

- ▶ Quality in Asphalt Paving Workshop: multiday, focused on flexible pavement
- ▶ Recorded video briefs: topical to MATC equipment

## Level of troubleshooting

- ▶ On-site: within scope of standard or agency spec.
- ▶ In-depth: direct to FHWA ABML-ID

## Post-installed pavement

- ▶ Density, sustainability, M&P option selection
- ▶ Surface characteristics (macrotexture, etc.)
- ▶ Monitoring performance (handheld, other)

# MATC Testing Capabilities

Mixture Tests	Materials Tests	Field Tests
AMPT suite of tests ( E* , cyclic fatigue)	X-Ray Fluorescence Spectrometer for binder's or markings' chemical elements	Paver-mounted thermal infrared for real-time mat temperatures
Overlay Test for reflective cracking	ABT (true grade of binder)	MIT-Scan T3 for in-place pavement thickness
Flexibility index test for fracture resistance	* FTIR looks at molecules in binder (lime, polymers,...)	Circular Track Meter for measuring mean profile depth
IDEAL-CT for crack resistance	* Binder performance testing	Dielectric profiling system for in-place density
IDEAL-RT for rutting resistance	* Done at TFHRC	Laser-based measurement of mean profile depth

## Other support activities:

AASHTOWare Pavement™ ME Design analysis

Asphalt pavement specification review

Construction density spec review (mat and joints)



# MATC – Technology Transfer

- ▶ Use MATC as a communication vehicle to stakeholders
- ▶ Use short communication bursts (1-pagers, social media, etc.) to raise awareness on FHWA efforts
- ▶ Current Topics:
  - Enhancing in-place density
  - In the works: Ohio DOT experience with dielectric profiling systems





# MATC Virtual Support Activities

## Technical Assistance

Specification reviews (SC, VT, RI, FL)  
Performance test analysis (VT, ME)

## Testing Plans

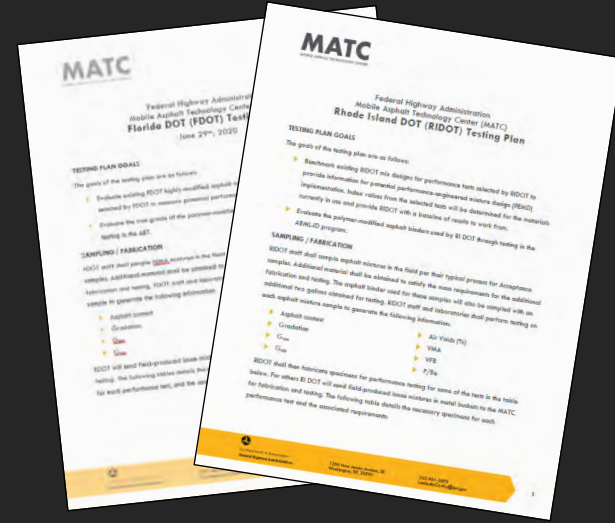
BMD cracking tests (FDOT)  
Macrotexture measuring (FDOT)  
BMD Introduction (RIDOT)  
IDEAL-RT evaluation (MaineDOT)  
I-FIT Round Robin Testing (Caltrans)  
Binder testing & analysis (VTrans)

## Technology Transfer

Communication bursts (1-pagers, social media, etc.) on FHWA efforts

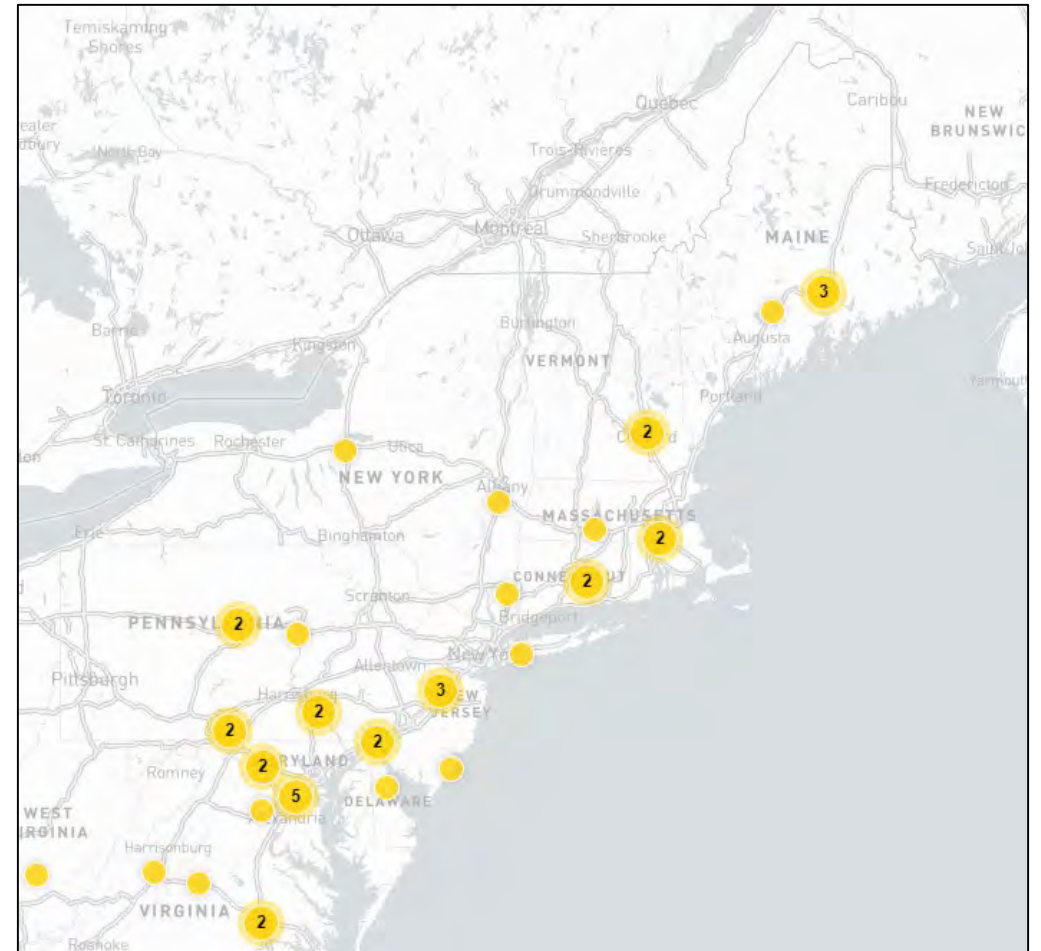
## Marketing Plan

Social media posts  
New brochure  
Website updates



# Ongoing MATC Support to the Northeast

- ▶ MATC project visits
  - ME: 2017
  - PA: 2017
  - VT: 2021
- ▶ BMD Testing Analysis
  - ME & VT
- ▶ Specification Review
  - RI & VT
- ▶ Testing Plans
  - RI & VT
- ▶ ABML-ID Project Involvement
  - MD, ME, & NH



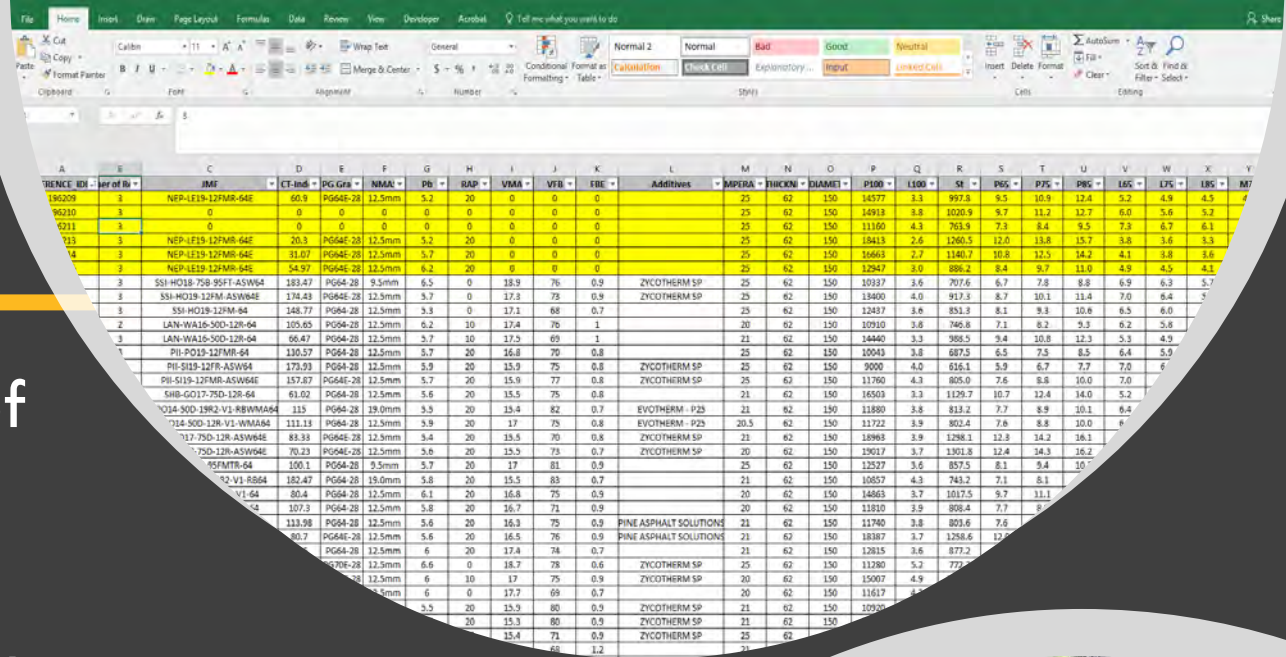


# MaineDOT Data Analysis



# Data Shared by MaineDOT

- ▶ Database from multiple years of testing:
  - Ideal Cracking Test ( $CT_{index}$ )
  - Hamburg Wheel Tracking (rut depth, SIP, NRRI)
  - AMPT – Stress Sweep Rutting (SRI)
  - AMPT - Cyclic Fatigue ( $S_{app}$ )
  - Volumetric data
- ▶ Field produced mix sampled at project site – reheated and tested



REFERENCE	EDI	ser of Ba	JMF	CT-Ind	PG Grd	NMAA	Pb	RAP	VMA	VFB	FBE	Additives	MP1RA	THICKN	DIAMET	P100	L100	SI	P65	P75	P85	L65	L75	L85	M7
186209	3		NFP-LF19-12FM-64E	60.9	PG64-28	12.5mm	5.2	20	0	0	0		25	62	150	14577	3.3	997.8	9.5	10.9	12.4	5.2	4.9	4.5	4.1
186210	3		0	0	0	0	0	0	0	0	0		25	62	150	14913	3.8	1020.9	9.7	11.2	12.7	6.0	5.6	5.2	4.8
186211	3		0	0	0	0	0	0	0	0	0		25	62	150	11160	4.3	763.9	7.1	8.4	9.9	7.3	6.7	6.1	5.5
186212	3		NFP-LF19-12FM-64E	20.3	PG64-28	12.5mm	5.2	20	0	0	0		25	62	150	18413	2.6	1260.5	12.0	13.8	15.7	3.8	3.6	3.3	2.9
186213	3		NFP-LF19-12FM-64E	31.67	PG64-28	12.5mm	5.7	20	0	0	0		25	62	150	10663	2.7	1140.7	10.8	12.5	14.2	4.1	3.8	3.6	3.2
186214	3		NFP-LF19-12FM-64E	54.97	PG64-28	12.5mm	6.2	20	0	0	0		25	62	150	12847	3.0	898.2	8.4	9.7	11.0	4.9	4.5	4.1	3.7
186215	3		SSI-HO18-75FT-ASW64	183.47	PG64-28	9.5mm	6.5	0	18.9	76	0.9	ZYCOTHERM SP	25	62	150	10937	3.6	207.6	6.7	7.8	8.8	6.9	6.3	5.7	5.1
186216	3		SSI-HO18-12FM-ASW64E	174.43	PG64-28	12.5mm	5.7	0	17.3	78	0.9	ZYCOTHERM SP	25	62	150	13400	4.0	917.3	8.7	10.1	11.4	7.0	6.4	5.8	5.2
186217	3		SSI-HO18-12FM-64	148.77	PG64-28	12.5mm	3.3	0	17.1	88	0.7		25	62	150	12437	3.6	851.3	8.1	9.3	10.6	6.5	6.0	5.5	4.9
186218	2		LAN-WA16-50D-12R-64	105.65	PG64-28	12.5mm	6.2	10	17.4	76	1		20	62	150	10910	3.6	746.8	7.1	8.2	9.3	6.2	5.8	5.4	4.9
186219	3		LAN-WA16-50D-12R-64	66.47	PG64-28	12.5mm	5.7	10	17.5	69	1		21	62	150	14440	3.3	985.5	9.4	10.8	12.3	5.3	4.9	4.5	4.1
186220	3		PII-PO19-12FM-64	136.57	PG64-28	12.5mm	5.7	20	16.8	70	0.8		25	62	150	12043	3.8	873.5	6.5	7.8	8.9	6.4	6.0	5.6	5.2
186221	3		PII-SI19-12FM-ASW64	172.93	PG64-28	12.5mm	5.9	20	15.9	75	0.8	ZYCOTHERM SP	25	62	150	3000	4.0	616.1	5.9	6.7	7.7	7.0	6.4	5.9	5.4
186222	3		PII-SI19-12FM-ASW64E	157.87	PG64-28	12.5mm	5.7	20	15.9	77	0.8	ZYCOTHERM SP	25	62	150	11760	4.3	805.0	7.6	8.8	10.0	7.0	6.4	5.9	5.4
186223	3		SHB-GO17-75D-12R-64	61.02	PG64-28	12.5mm	5.6	20	15.5	75	0.8		21	62	150	16503	3.3	1129.7	10.7	12.4	14.0	5.2	4.8	4.4	4.0
186224	3		SI14-50D-19R2-V1-RBWM64	115	PG64-28	19.0mm	5.5	20	15.4	82	0.7	EVOTHERM - P25	21	62	150	11880	3.8	813.2	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186225	3		SI14-50D-12R-V1-WMA64	111.13	PG64-28	12.5mm	3.9	20	17	75	0.8	EVOTHERM - P25	20.5	62	150	11722	3.9	803.4	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186226	3		SI17-75D-12R-ASW64E	83.33	PG64-28	12.5mm	5.4	20	15.5	70	0.8	ZYCOTHERM SP	21	62	150	18968	3.9	1298.1	12.3	14.2	16.1	10.1	9.4	8.7	8.0
186227	3		SI17-75D-12R-ASW64E	70.23	PG64-28	12.5mm	5.6	20	15.5	73	0.7	ZYCOTHERM SP	20	62	150	19017	3.7	1301.8	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186228	3		SI19-12R-ASW64E	100.1	PG64-28	9.5mm	5.7	20	17	81	0.9		25	62	150	12527	3.6	837.5	8.1	9.4	10.7	6.4	6.0	5.6	5.2
186229	3		SI19-V1-R664	182.47	PG64-28	19.0mm	5.8	20	15.5	83	0.7		21	62	150	10857	4.3	743.2	7.1	8.1	9.1	7.0	6.4	5.9	5.4
186230	3		SI19-V1-64	80.4	PG64-28	12.5mm	6.1	20	16.8	75	0.9		20	62	150	14863	3.7	1017.5	9.7	11.1	12.5	6.4	6.0	5.6	5.2
186231	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186232	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186233	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186234	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186235	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186236	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186237	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186238	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186239	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186240	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186241	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186242	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186243	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186244	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186245	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186246	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186247	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186248	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186249	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186250	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186251	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186252	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186253	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186254	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186255	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186256	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186257	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186258	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186259	3		SI19-V1-64	113.98	PG64-28	12.5mm	5.6	20	16.3	75	0.9	PINE ASPHALT SOLUTIONS	21	62	150	11740	3.8	803.6	7.8	8.8	10.0	6.4	6.0	5.6	5.2
186260	3		SI19-V1-64	80.7	PG64-28	12.5mm	5.6	20	16.5	76	0.9	PINE ASPHALT SOLUTIONS	21	62	150	18387	3.7	1258.6	12.4	14.3	16.2	10.1	9.4	8.7	8.0
186261	3		SI19-V1-64	107.3	PG64-28	12.5mm	5.8	20	16.7	71	0.9		20	62	150	11810	3.9	898.4	7.7	8.9	10.1	10.1	9.4	8.7	8.0
186262	3		SI19-V1																						

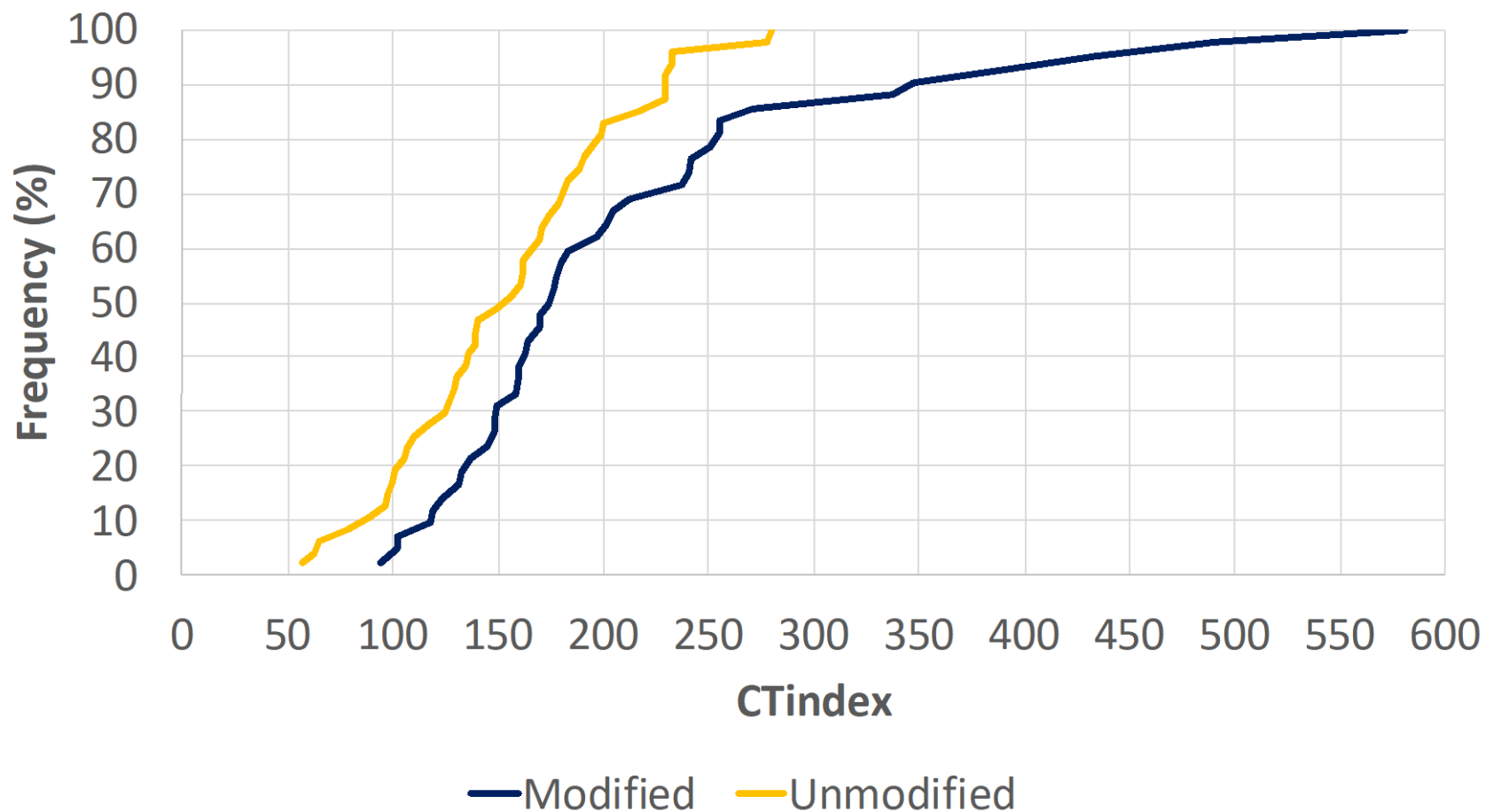


# MaineDOT Questions

- ▶ What are the differences between modified and unmodified asphalt mixtures in Maine?
- ▶ How can changes in volumetric properties affect the performance indexes?
- ▶ What are the correlations between the performance indexes and field performance of MaineDOT mixtures?



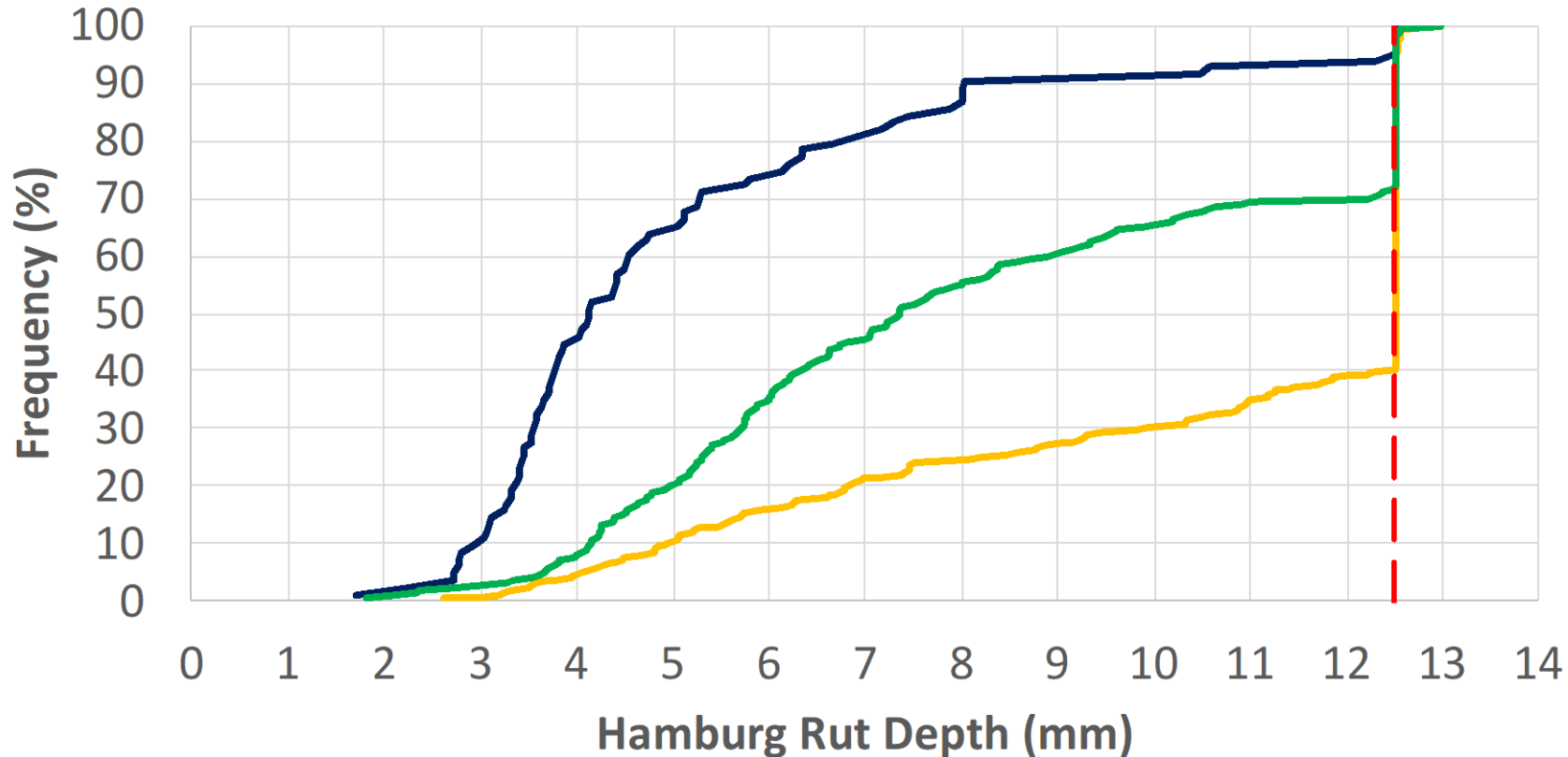
# Modified vs. unmodified mixtures @ 25C



MODIFIED			
MEDIAN	AVG	STDEV	COUNT
175.32	210.3	106.1	42

UNMODIFIED			
MEDIAN	AVG	STDEV	COUNT
156.47	155.2	54.4	47

# Hamburg Final Rut Depth

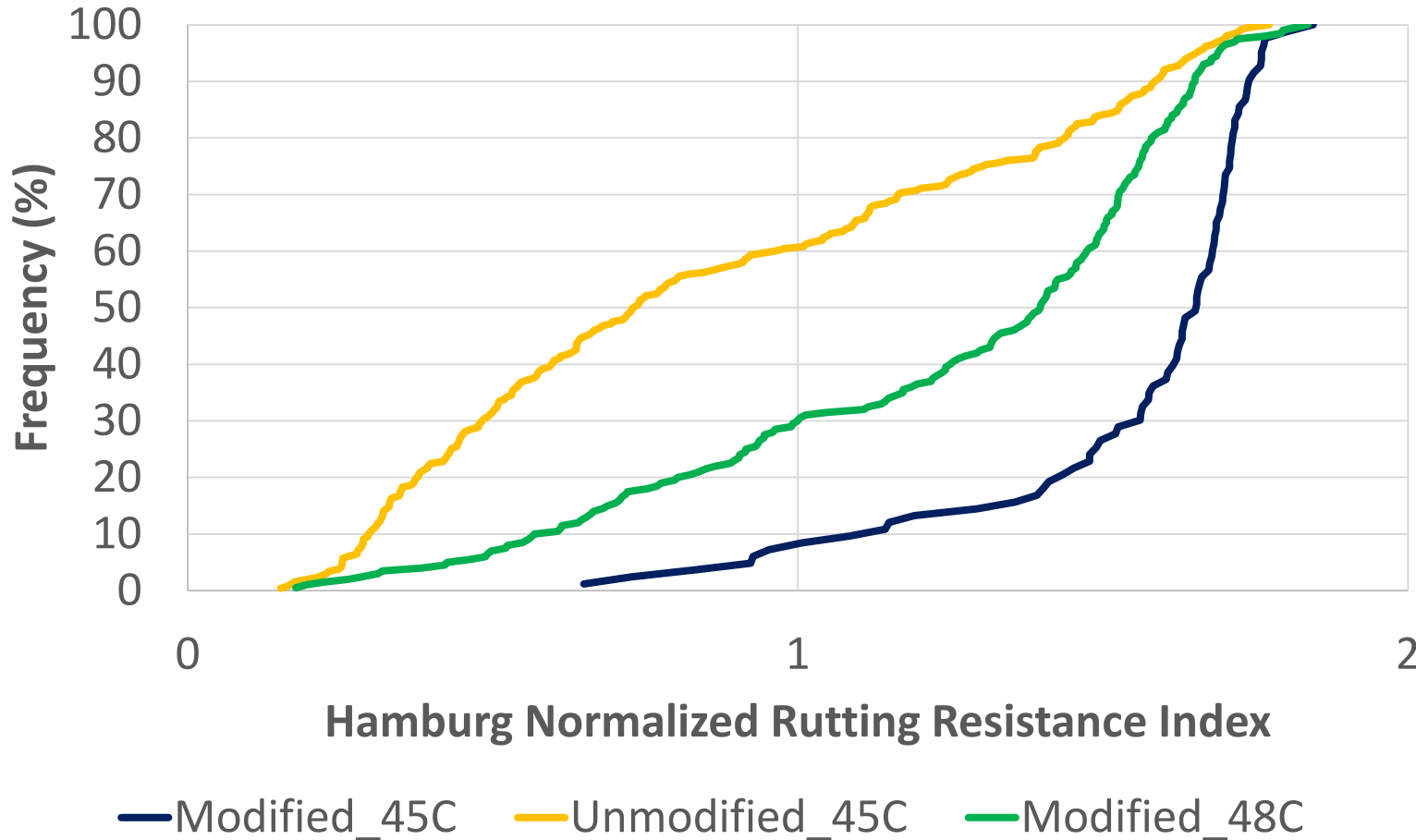


MODIFIED @ 45C		
AVG	STDEV	Count
5.2	2.7	83

MODIFIED @ 48C		
AVG	STDEV	Count
8.2	3.4	200

UNMODIFIED @ 45C		
AVG	STDEV	Count
10.4	3.1	263

# Normalized Rutting Resistance Index (NRRI)



$$RRI = N \times (1 - RD)$$

$N$  = number of passes

$RD$  = final rut depth (inches)

$$NRRI = \frac{\text{Actual RRI}}{\text{Minimum RRI}}$$

$\text{Minimum RRI} = 20000 \times (1 - 0.5)$

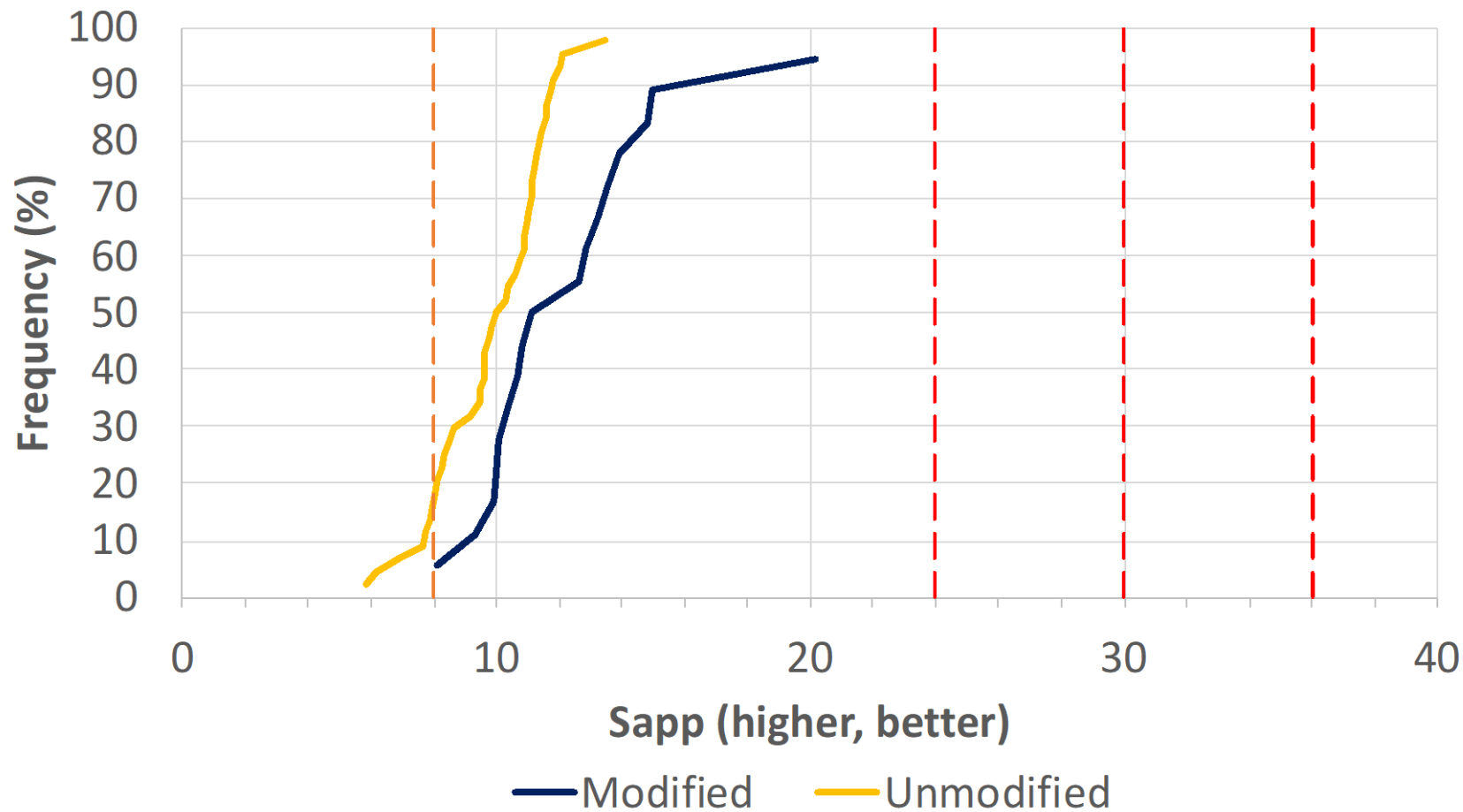
$\text{Minimum RRI} = 10,000$



# Thresholds of $S_{app}$ and RSI

Traffic (million ESALs)	Limits		Tier	Designation
	$S_{app}$	RSI		
Less than 10	$S_{app} > 8$	RSI < 12	Standard	S
Between 10 and 30	$S_{app} > 24$	RSI < 4	Heavy	H
Greater than 30	$S_{app} > 30$	RSI < 2	Very Heavy	V
Greater than 30 and slow traffic	$S_{app} > 36$	RSI < 1	Extremely Heavy	E

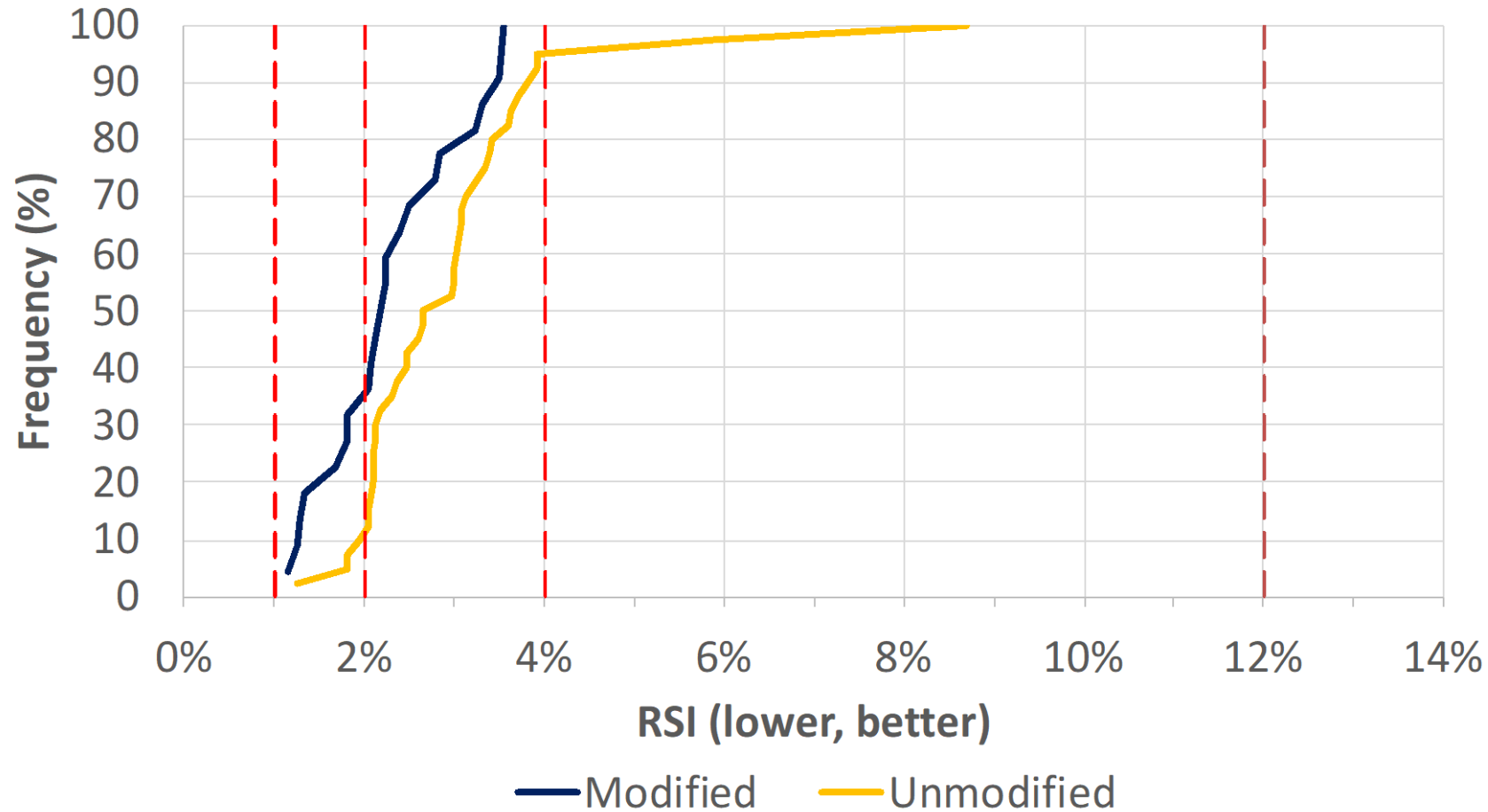
# Cyclic Fatigue ( $S_{app}$ )



MODIFIED @ 48C			
MEDIAN	AVG	STDEV	Count
11.9	12.6	3.51	18

UNMODIFIED @ 48C			
MEDIAN	AVG	STDEV	Count
10.2	10.0	1.86	44

# Stress Sweep Rutting (RSI)



MODIFIED			
MEDIAN	AVG	STDEV	Count
2.2%	2.4%	0.76%	20

UNMODIFIED			
MEDIAN	AVG	STDEV	Count
2.1%	3.0%	1.25%	40

# MaineDOT Summary

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- ▶ No relationship between different indices for cracking and rutting
- ▶ No clear correlation between volumetrics and index properties on global scale analysis
- ▶ Distribution curves show clear improvement in performance testing values with polymer modification
- ▶ Differences seen in NMAAS and producer
- ▶ Continue to investigate correlations between BMD values and field performance



# VTrans Data Analysis



# Data Shared by VTrans

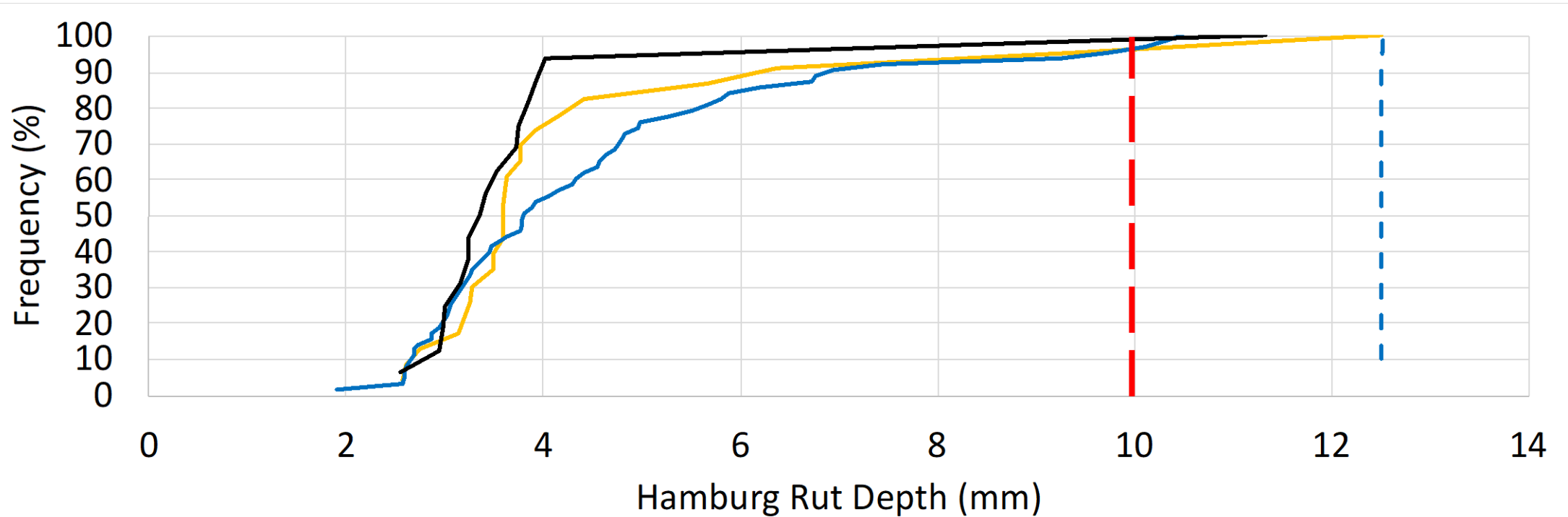
- ▶ Database from multiple years of testing:
  - I-FIT (Flexibility Index)
  - Hamburg Wheel Tracking (rut depth, SIP, NRRI)
  - Volumetric data
- ▶ Field produced mix sampled at plant site – reheated and tested



# VTrans Performance Engineered Mix Design

- ▶ Superpave Type IVS 9.5-mm mixes
- ▶ Hamburg (T 324) criteria @ 45°C and 7.0 ± 0.5 % STA
  - Max average rut depth @ 20,000 passes: 10.0 mm
  - Stripping inflection point (SIP): ≥ 15,000 passes
- ▶ Flexibility Index Test (FIT) (TP 124) @ 25°C and 7.0 ± 1.0 % STA
  - Minimum FI: 10.0
- ▶ Lot size is completed project
  - Sublot size: 3,000 tons
  - A minimum of 3 sublots needed for statistical evaluation
- ▶ Rejectable quality limit (RQL): 60%

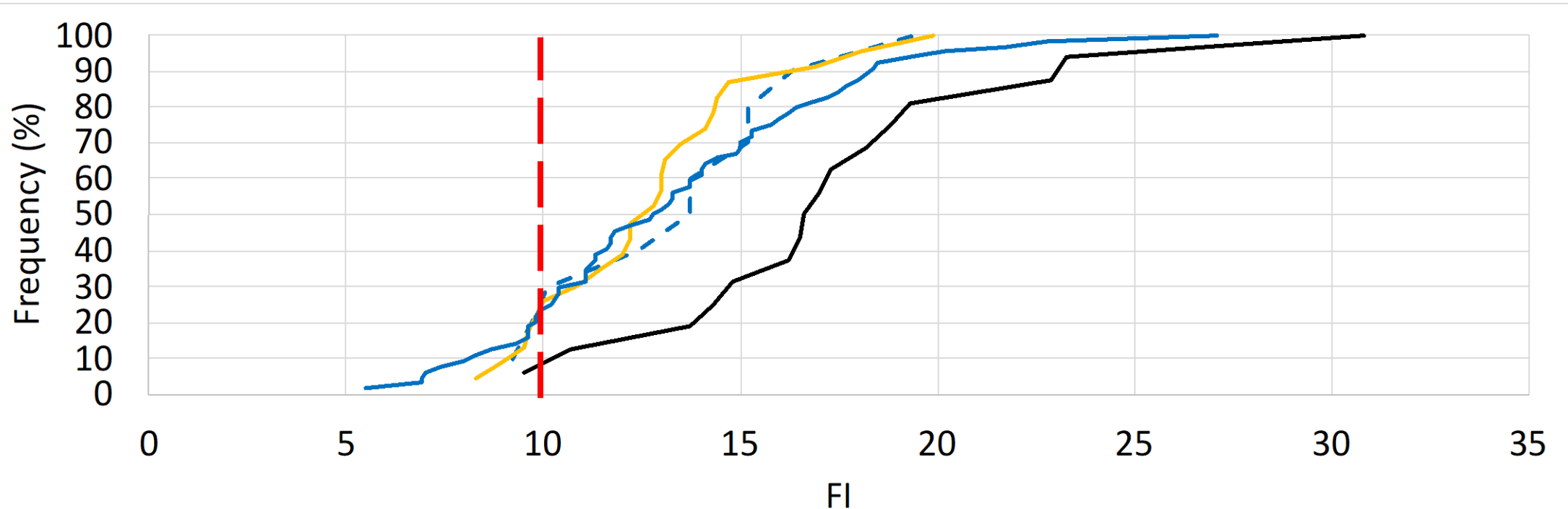
# HWT Cumulative Distribution for 9.5 mm



MIX	BINDER	Ndes	MEDIAN	AVG	STDEV	COUNT
TYPE IVS	58-28	65	12.5	12.5	0.0	10
TYPE IVS	70-28	50	3.6	4.3	2.3	23
TYPE IVS	70-28	65	3.8	4.5	2.0	63
TYPE IVS	70-28	80	3.4	3.9	2.0	16

-- PG 58-28 & Ndes 65     — PG 70-28 & Ndes 50  
— PG 70-28 & Ndes 65     — PG 70-28 & Ndes 80

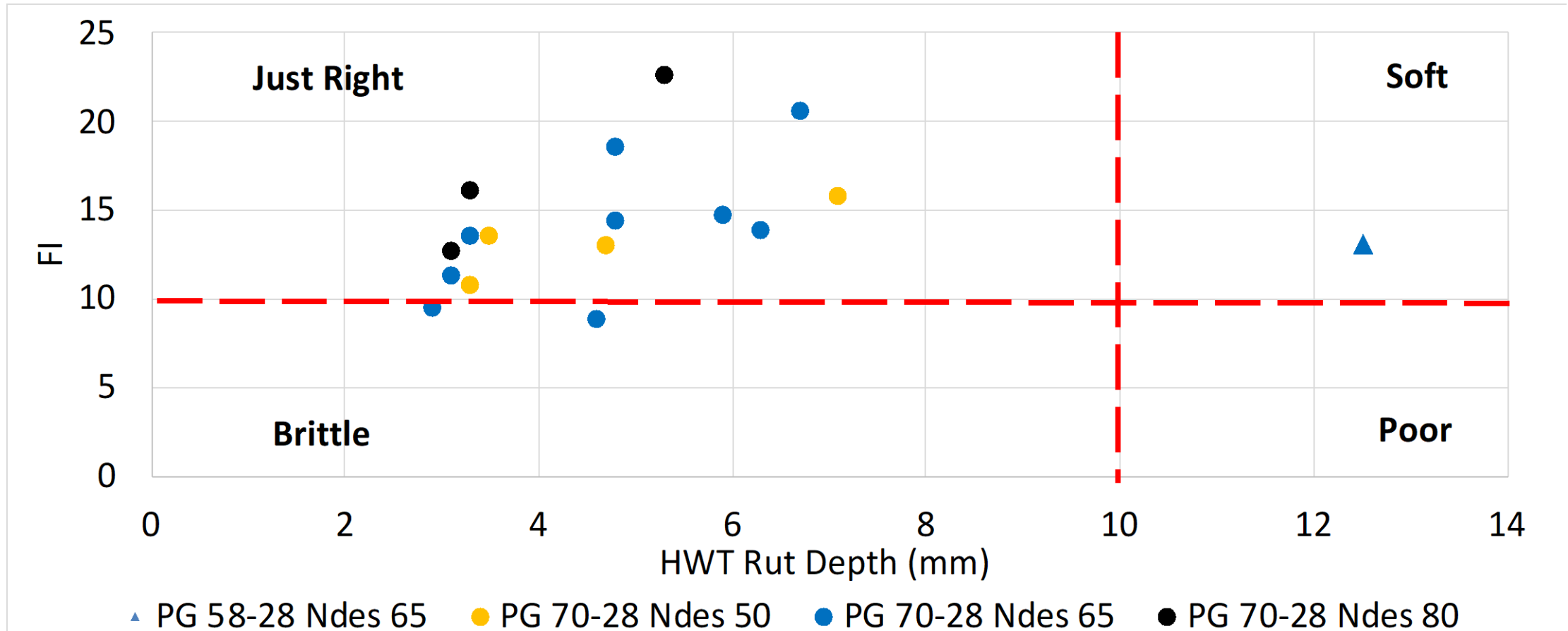
# FI Cumulative Distribution for 9.5 mm



MIX	BINDER	Ndes	MEDIAN	AVG	STDEV	COUNT
TYPE IVS	58-28	65	13.7	13.5	3.2	10
TYPE IVS	70-28	50	12.8	12.7	2.9	23
TYPE IVS	70-28	65	12.9	13.3	4.2	64
TYPE IVS	70-28	80	16.8	17.5	5.1	16

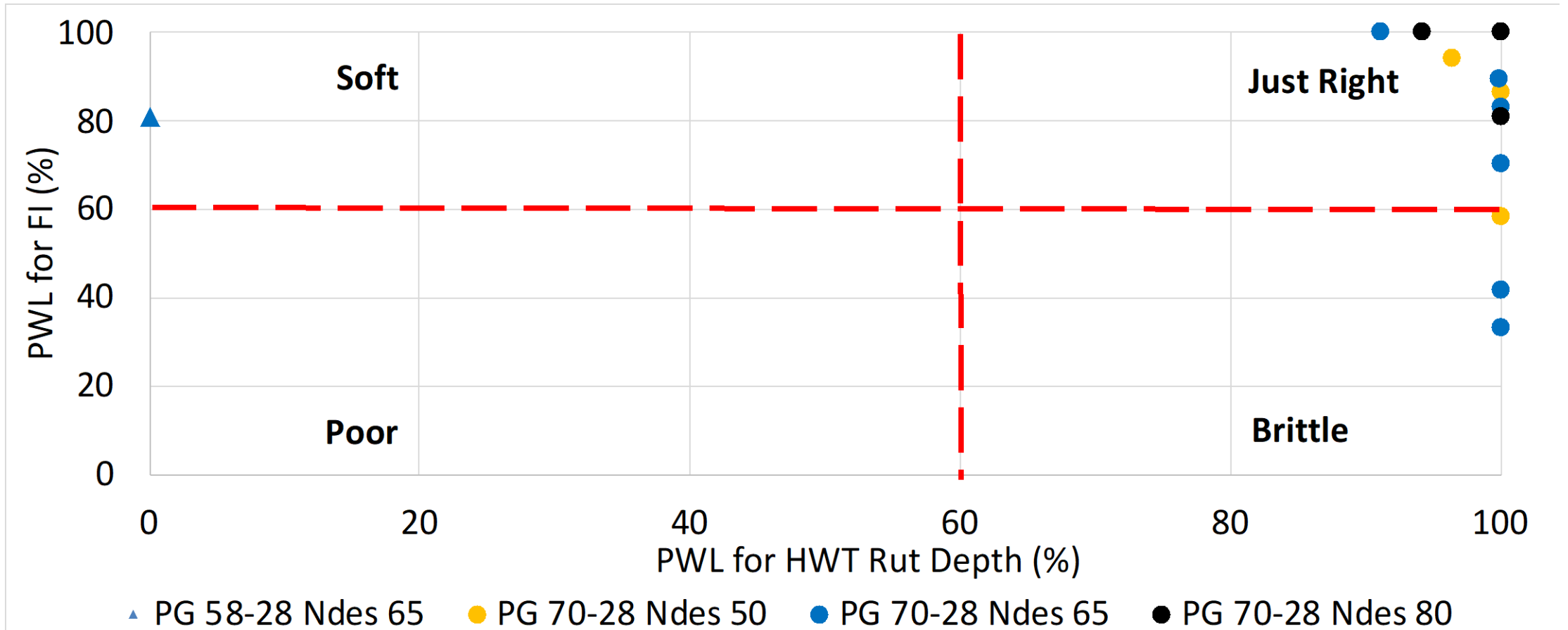
-- PG 58-28 & Ndes 65     — PG 70-28 & Ndes 50  
— PG 70-28 & Ndes 65     — PG 70-28 & Ndes 80

# Lot Average for Type IVS ( $\geq 3$ Sublots)





# PWL for Type IVS ( $\geq 3$ Sublots)



# Statistical Analysis

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- ▶ Conducted in two steps
  - Step 1 was to determine the effect of the following (specifications) categorical parameters on Hamburg and FI test results
    - Mix type
    - Binder grade
    - Ndes
  - Step 2 was to evaluate the effect of the following volumetric properties on Hamburg and FI test results
    - Air Voids
    - VMA
    - Dust/Binder
    - Ignition Oven AC

# Summary of Analysis of Variance ( $\alpha = 0.05$ )

## Effect on average rut depth

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	155.843	25.974	7.10	0.000
Mix Type	3	46.624	15.541	4.25	0.012
Binder Grade	1	96.852	96.852	26.48	0.000
Ndes	2	4.881	2.440	0.67	0.520
Error	32	117.024	3.657		
Lack-of-Fit	2	38.404	19.202	7.33	0.003
Pure Error	30	78.620	2.621		
Total	38	272.867			

## Effect on average FI

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	264.282	44.047	3.29	0.012
Mix Type	3	91.889	30.630	2.29	0.097
Binder Grade	1	1.775	1.775	0.13	0.718
Ndes	2	131.557	65.779	4.92	0.014
Error	32	428.001	13.375		
Lack-of-Fit	2	22.907	11.453	0.85	0.438
Pure Error	30	405.094	13.503		
Total	38	692.283			

# Volumetric Effect on HWT & FI

## HWT – Rut Depth

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	5	186.91	37.381	14.35	0.000
Air Voids	1	35.94	35.944	13.80	0.001
Mix Type	3	38.24	12.747	4.89	0.006
Binder Grade	1	92.22	92.222	35.40	0.000
Error	33	85.96	2.605		
Lack-of-Fit	20	54.56	2.728	1.13	0.420
Pure Error	13	31.40	2.415		
Total	38	272.87			

## I-FIT - FI

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	430.29	71.716	8.76	0.000
Air Voids	1	56.16	56.161	6.86	0.013
VMA	1	63.58	63.578	7.77	0.009
Dust/Binder	1	50.61	50.607	6.18	0.018
Ignition AC (%)	1	34.26	34.262	4.18	0.049
Ndes	2	220.94	110.468	13.49	0.000
Error	32	261.99	8.187		
Total	38	692.28			



# Summary

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- ▶ All the mixes tested had good rutting performance based on the Hamburg test results, except...
  - Type IVS mixes with PG 58-28. These mixtures appeared to be sensitive to moisture damage (SIP) in the Hamburg test
- ▶ Factors significantly affecting Hamburg Rut Depth
  - Mix type (IIS, IIIS, IVS)
  - Binder grade (58-28, 70-28)
  - Air voids (QC/acceptance air voids)
- ▶ Factors significantly affecting FI
  - Ndes (50, 65, 80) with Ndes = 80 resulting in higher FI
  - VBE (= VMA – Air Voids)

# What can the FHWA MATC do for you?

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- ▶ Project Site Visits (Returning in 2021)
- ▶ Specification Review
  - Comparison to “Gold Medal Density” States is popular
- ▶ BMD Data Analysis
- ▶ Technology Transfer
- ▶ ABML-ID program
- ▶ Equipment Loan Program
- ▶ Quality in Asphalt Paving Process Workshop (Coming in 2021)

# Contact Us

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**Thank you!**