USE OF THE AMPT TO EVALUATE PAVEMENT PERFORMANCE

ASPHALT MIXTURE ETG MAY 9TH, 2018

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MaineDOT

Integrity – Competence - Service

Disclaimer / Acknowledgements

MaineDOT has not yet gained expertise in the AMPT and the analysis methods… yet.

Thanks to the following for their assistance:

- Dr. Kim & NC State Students / Staff
- FHWA
- MaineDOT lab staff

Talking Points

Purpose: To give the motivation, methodology, early results, and lessons learned from Maine's work with the AMPT

How?

- Maine's overall plan for AMPT
- Proficiency Test Results
- Performance-Related Specification Shadow Project
- PEMD

Background - MaineDOT

- Responsible for over 8,400 centerline miles of the 24,000 total miles in Maine
- Average capital program of $269 million per year
- Superpave mix design – full QA system based upon on volumetrics

Motivation for Change

Why doesn't the HMA of today perform as well as it did in the past?

Are all mixes at the same NMAS / gyration created equal?

Is our current way of assessing payfactors effective?

Is 4% voids the right target for all mix designs?

Is this design optimized for payfactor or performance?

Background – HMA Process

- HMA acceptance program based upon PWL Volumetric requirements (Voids, VMA, VFB, AC)
- Most mix designs blend different combinations of aggregates
  - Crushed ledge product (granite, sandstone, limestone, etc.)
  - Crushed gravel product
  - Natural sands
  - RAP (10% - 20%)

12 Desert Rd, Freeport MaineDOT TESTING LABORATORIES 219 Hogan Rd, Bangor

MaineDOT

HOT MIX ASPHALT PAY FACTOR REPORT
ACCEPT (METHOD A)

Description: HMA MIX-12.5MM (FINE-GRADED WITH 20% RAP) Spec: 01/01/17 Item No.: 403.2081 Lot No 3

WIN: 020425.00 Town: Dyer Brook, Island Falls

JMN: LAN-SM17-75D-12R-AS64E

Ref. No.	Sub-lot	12.5	2.36, %	0.600, %	0.300, %	0.075, %	PGAB, %	Voids, %	VMA, %	VFB, %	F/Be	In-Place Density		Comp., %
	USL	100	43	21	12	6.0	6.2	5.5		84	1.2	Ref. No.	Sub-lot	97.5
	Target	99	39	18	10	5.2	5.8	4.0						
	LSL	92	35	15	8	3.2	5.4	2.5	15	65	0.6			92.5
321753	1	99	41	18	10	4.8	5.9	4.2	16.7	75	0.9	321756	1	94.2
												321757	2	94.0
												321758	3	92.5
												321759	4	93.1
321754	2	98	38	18	10	4.7	5.8	3.4	15.8	78	0.9	321760	5	93.0
												321763	6	93.5
												321764	7	95.4
												321765	8	95.0
												321766	9	95.9
321761	3	99	40	17	10	4.8	6.0	3.9	16.5	76	0.9	321767	10	95.7
321762	4	99	42	18	10	4.9	6.0	4.8	17.2	72	0.9	321768	11	94.4
												321826	12	93.8
												321828	13	91.6
												321830	14	92.5
321817	5	99	38	14	8	4.5	5.9	5.4	18.1	70	0.8	321833	15	96.0
												321836	17	95.4
												321837	18	95.0
321818	6	100	40	16	9	5.3	6.2	4.5	17.5	74	0.9	321835	16	95.0

- Using un-calibrated PavementME for design

Maine’s AMPT Objectives

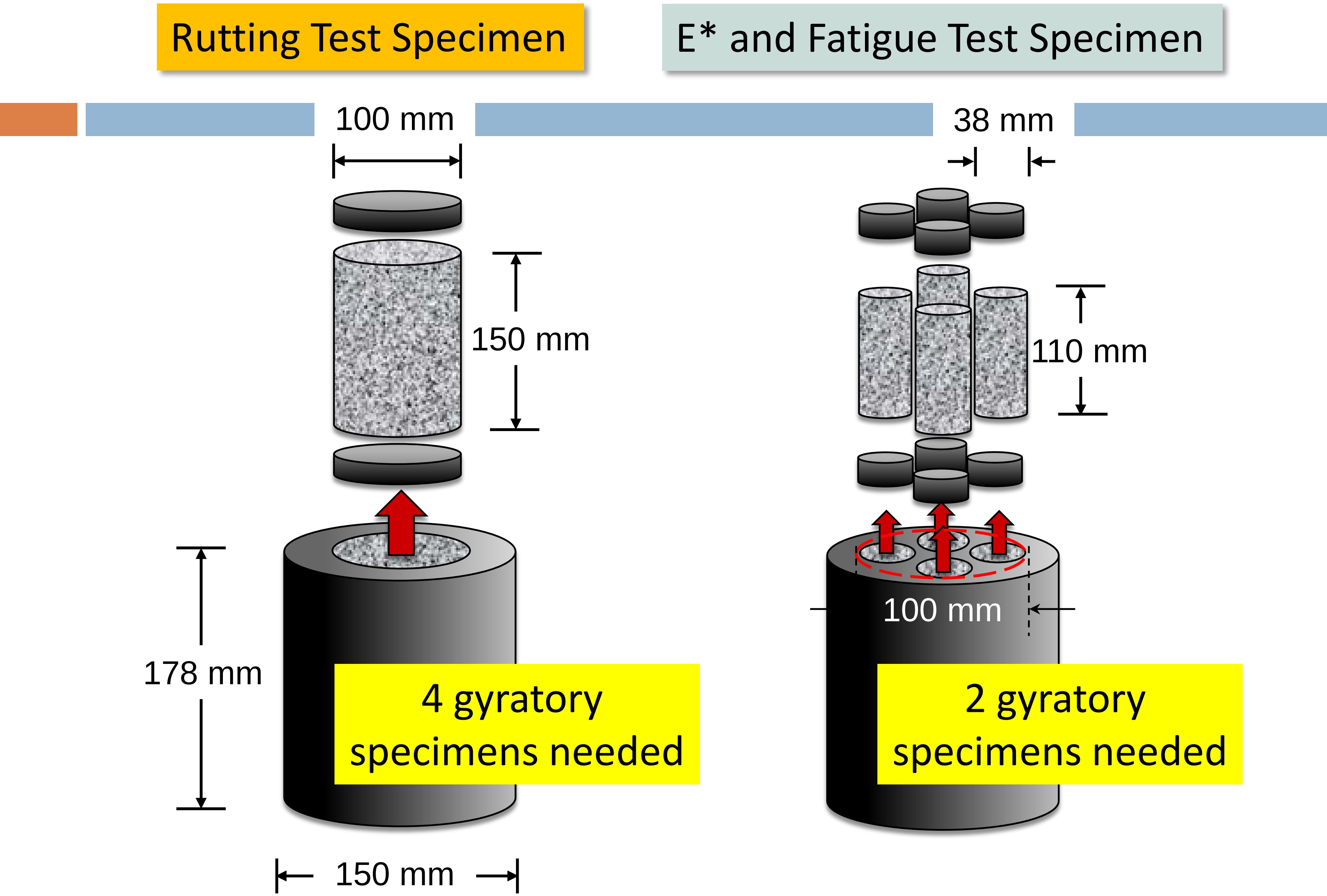
- To provide data to predict pavement performance in the State of Maine, for potential use in the following applications:
  - Pavement design (PavementME, FlexPave, etc.)
  - Performance-Related Specification (PRS) development
  - Performance-Engineered Mixture Design (PEMD)

Asphalt Mixture Performance Tester Series

Dynamic Modulus, Cyclic Fatigue, and Stress-Sweep Rutting

AMPT Performance Test Methods

- **Modulus**
  - Axial compression dynamic modulus test (AASHTO T 378)
  - Dynamic modulus mastercurve and time-temperature shift function
- **Cracking Resistance**
  - AMPT cyclic fatigue test (AASHTO TP 107)
  - C vs. S (damage characteristic curve)
  - Energy-based failure criterion
  - Sapp cracking index parameter
- **Rutting Resistance**
  - Stress Sweep Rutting (SSR) test (spec under review by Asphalt Mixture and Construction ETG)
  - Reduced load time and stress shift factors
  - Shift model coefficients
  - Permanent strain index parameter



Rutting Test Specimen
E* and Fatigue Test Specimen
100 mm
38 mm
150 mm
110 mm
100 mm
178 mm
4 gyratory specimens needed
2 gyratory specimens needed
150 mm

AMPT 38 mm Specimens

AMPT 38 mm Specimens

How?

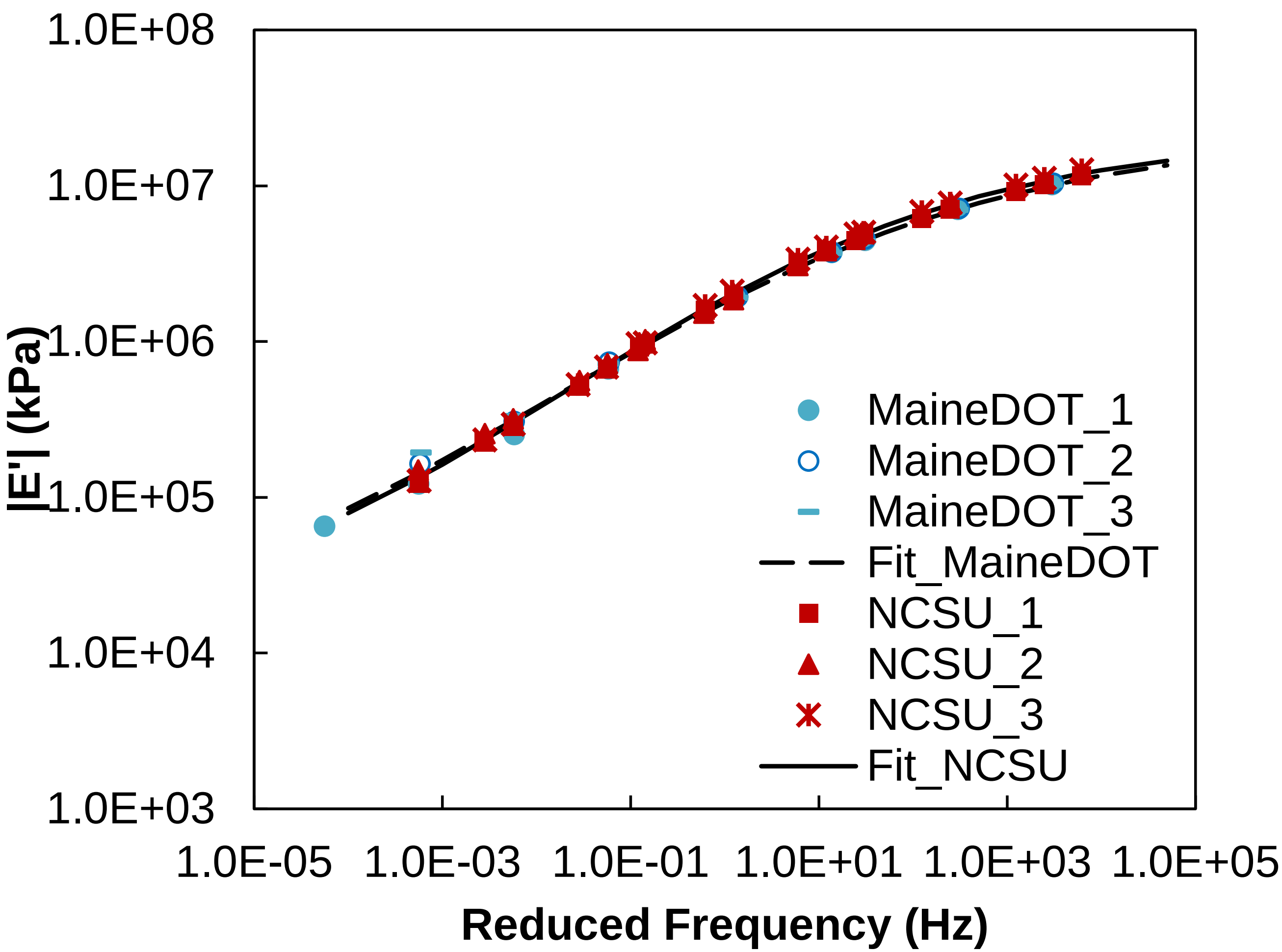
- Setting up "calibration" projects all over the state (4-5 per year)
  - Acquire samples of all materials in all lifts – some to be tested and some to be retained indefinitely
  - Test all HMA lifts in the AMPT series
    - DM, CF, & SSR @ 5.0% air voids
    - DM @ 7.0% air voids
  - Will monitor performance for years
  - Will also build a library of different mixes across the state
- Target other projects for PRS or PEMD testing – same mix design at different volumetrics

Proficiency Tests

- First step = ensure that MaineDOT labs can perform the testing
- One large sample of plant produced mix was obtained from one truck
  - MaineDOT fabricated specimens and shipped to NCSU
  - The same mixture were tested at MaineDOT and at NCSU
  - The test results were compared

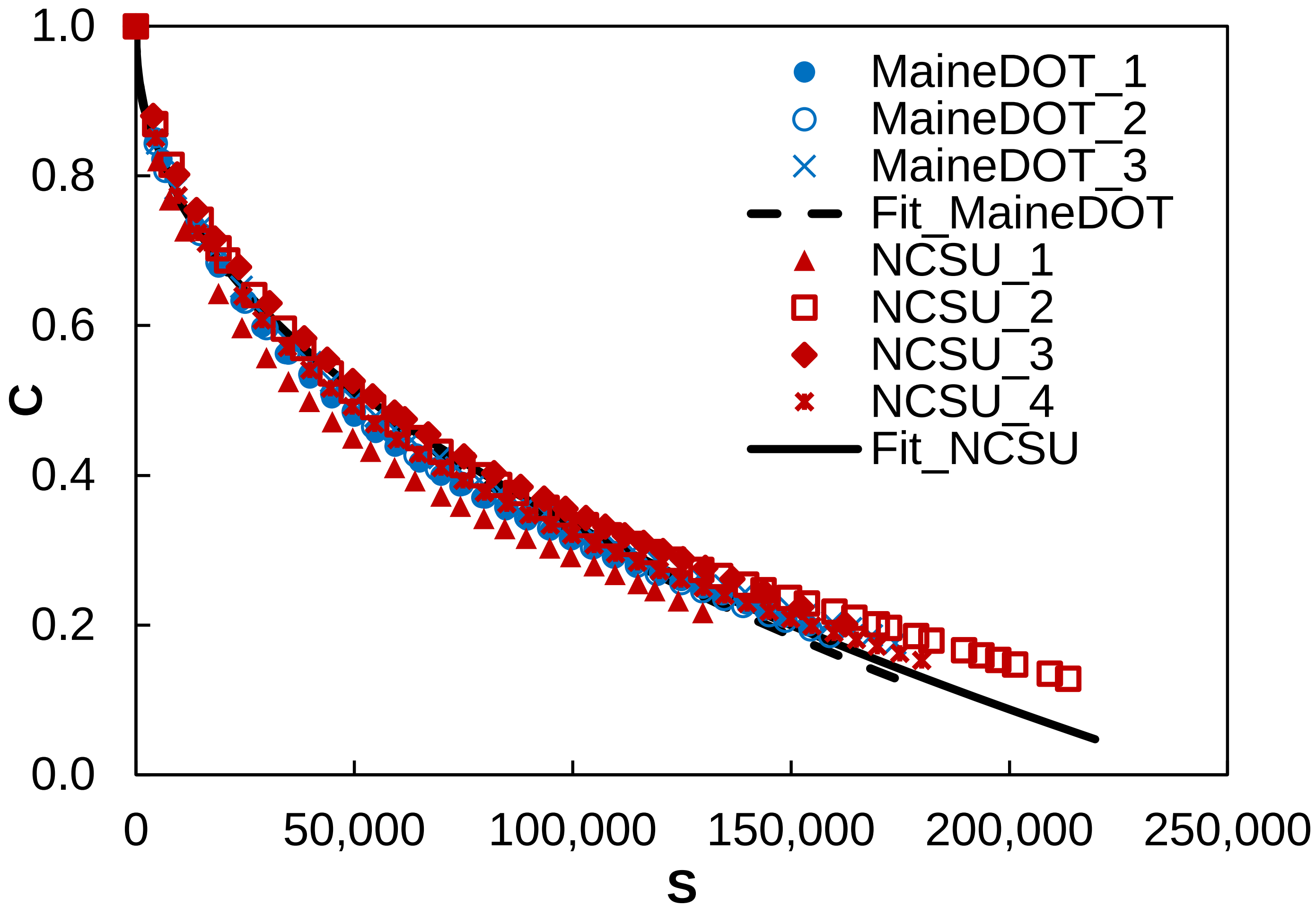
Proficiency Test Results

- Dynamic Modulus Tests



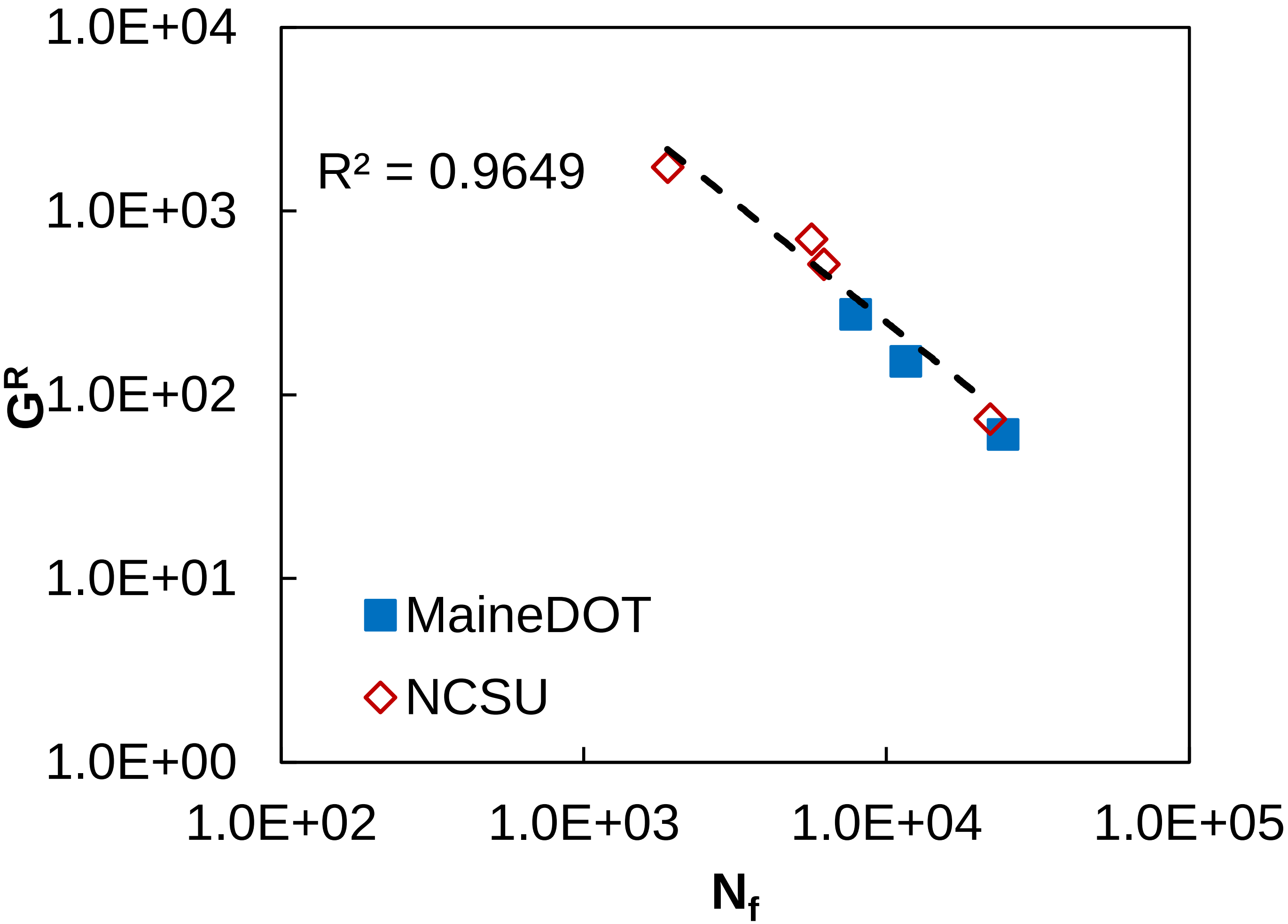
Proficiency Test Results

- Cyclic Fatigue Tests - Damage Characteristic Curve



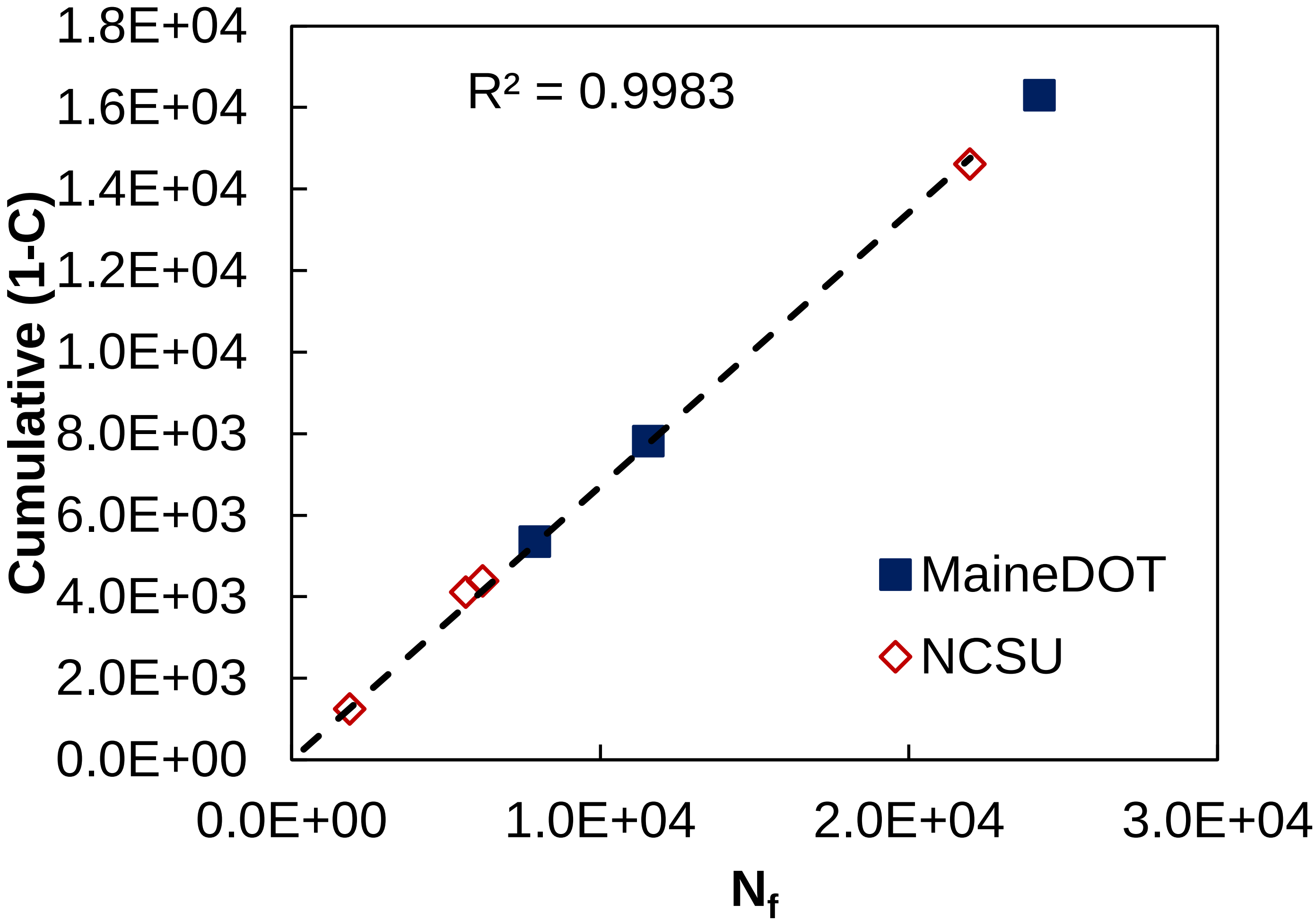
Proficiency Test Results

- Cyclic Fatigue Tests - Failure Criteria



Proficiency Test Results

- Cyclic Fatigue Tests - Failure Criteria



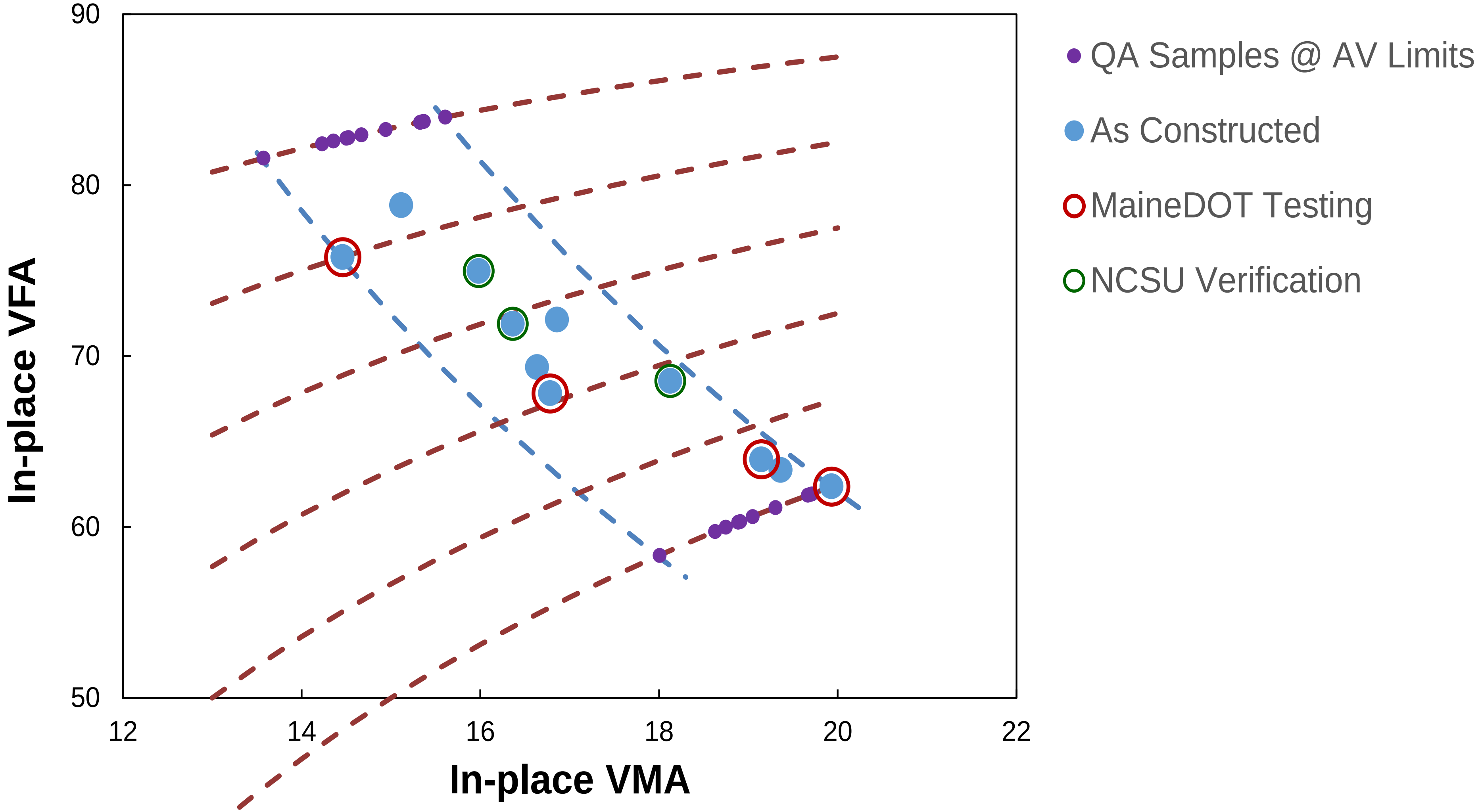
PRS Shadow Project

- **Objective: Use AMPT predictive models to show the impact of volumetric changes**
- 10 samples were acquired in the field from the same mix design on the same project
- Volumetric acceptance tests were performed on each
- Performance tests were conducted on 4 of the 10 samples at MaineDOT
- 3 samples were shipped to NCSU.

Sample Volumetric Properties

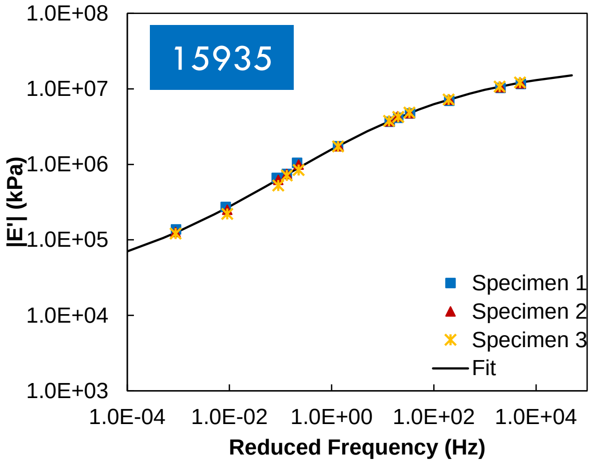
	Sample ID	Air Voids	VMA	Gmb	Gmm	% Binder	In-place Density	Test AV	Status
Maine DOT	352	4.7	15.5	2.426	2.546	5.3	96.5	7.5	Done
	355	4.4	15.9	2.412	2.524	5.2	94.6	2.5	Done
	360	3.9	16.8	2.404	2.502	5.9	92.5	2.5	Done
	361	4.7	17.3	2.391	2.509	5.9	92.9	7.5	Done
NCSU	353	4.5	16.4	2.406	2.519	5.5	96.0	4	On-going
	358	4.6	16.4	2.402	2.518	5.3	95.4	4.6	On-going
	362	4.4	17	2.396	2.507	5.8	94.3	5.7	Done

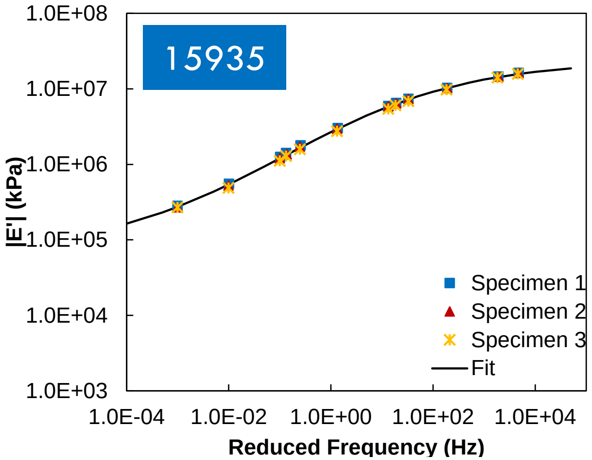
Sample Volumetric Properties

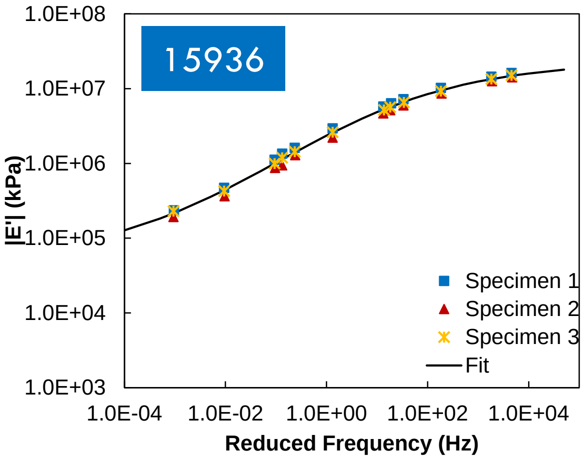


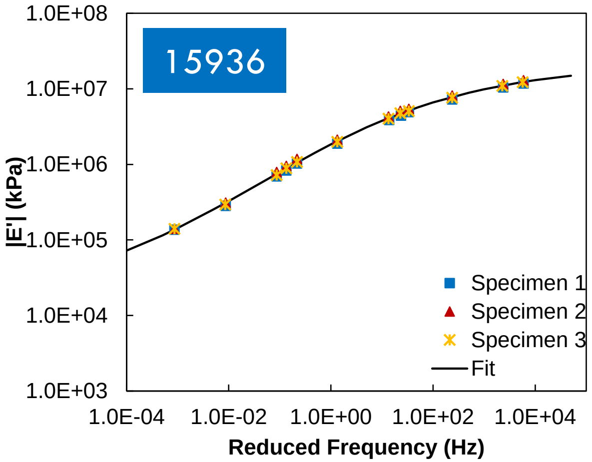
Testing Results

- Dynamic Modulus



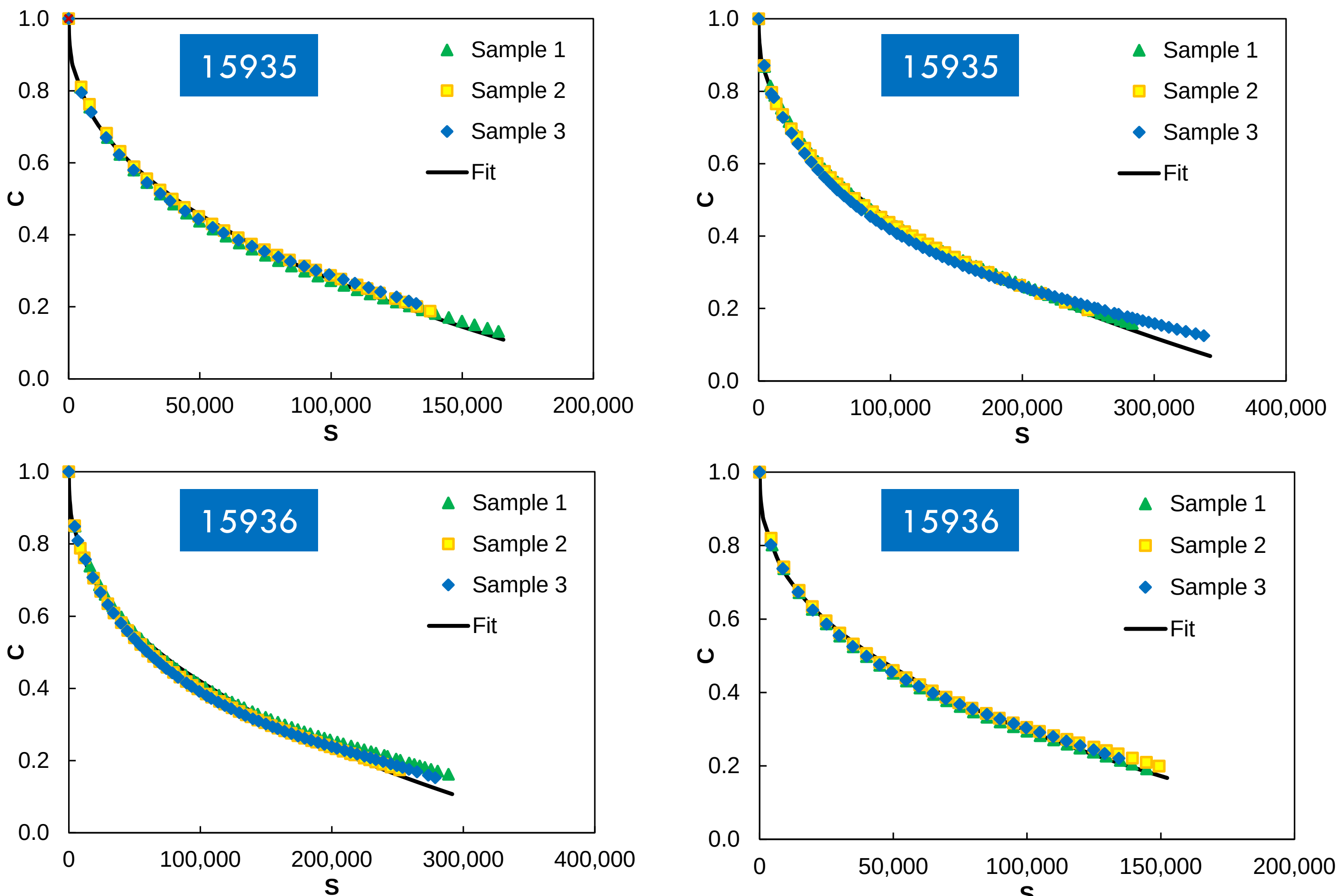




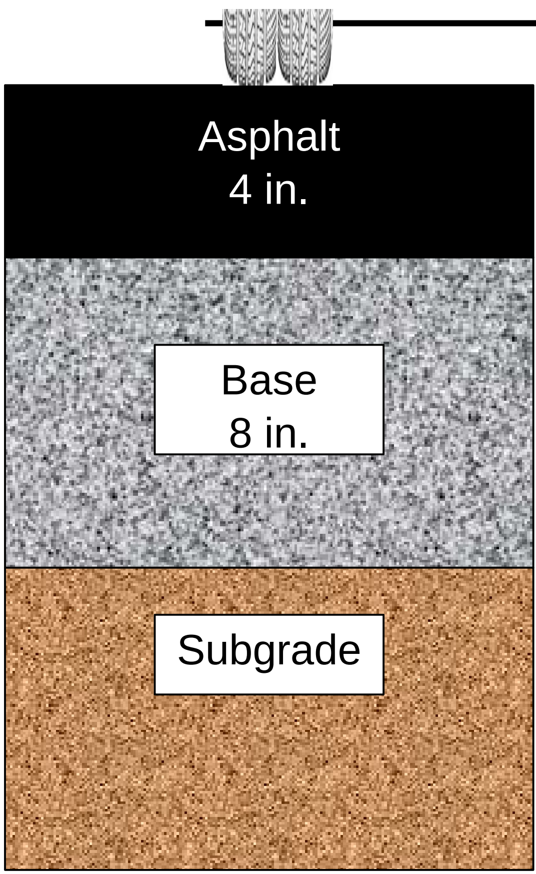


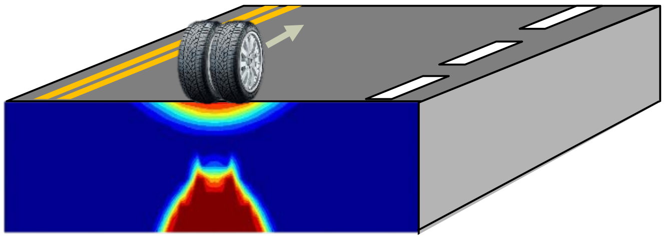
Testing Results

- Cyclic Fatigue Tests

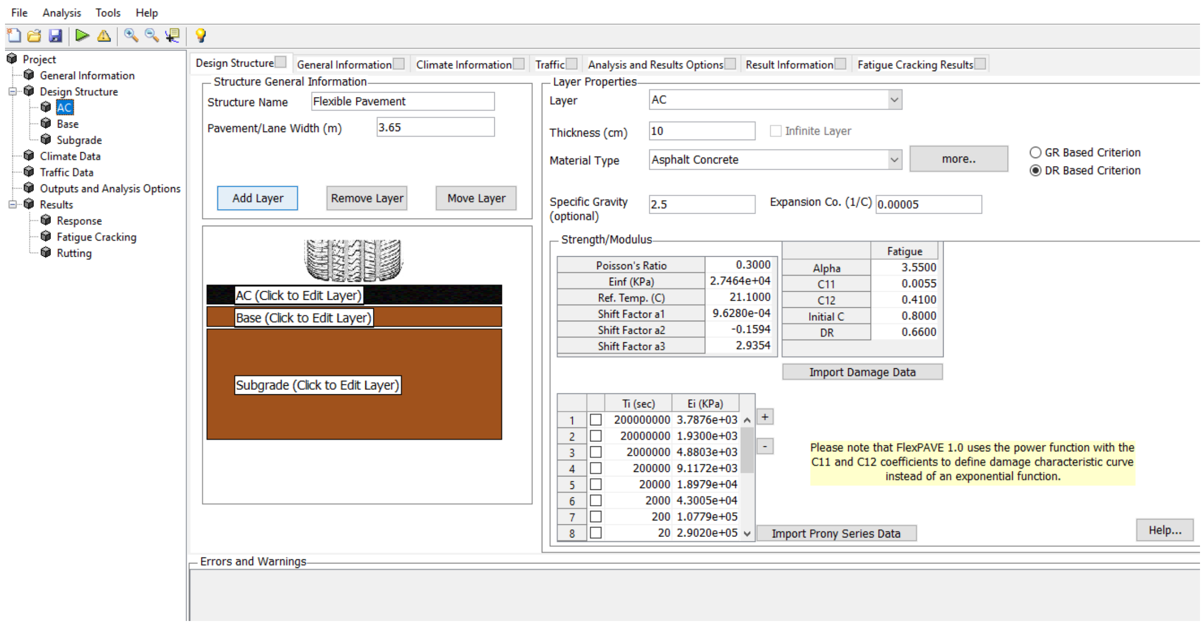


Pavement Performance Prediction

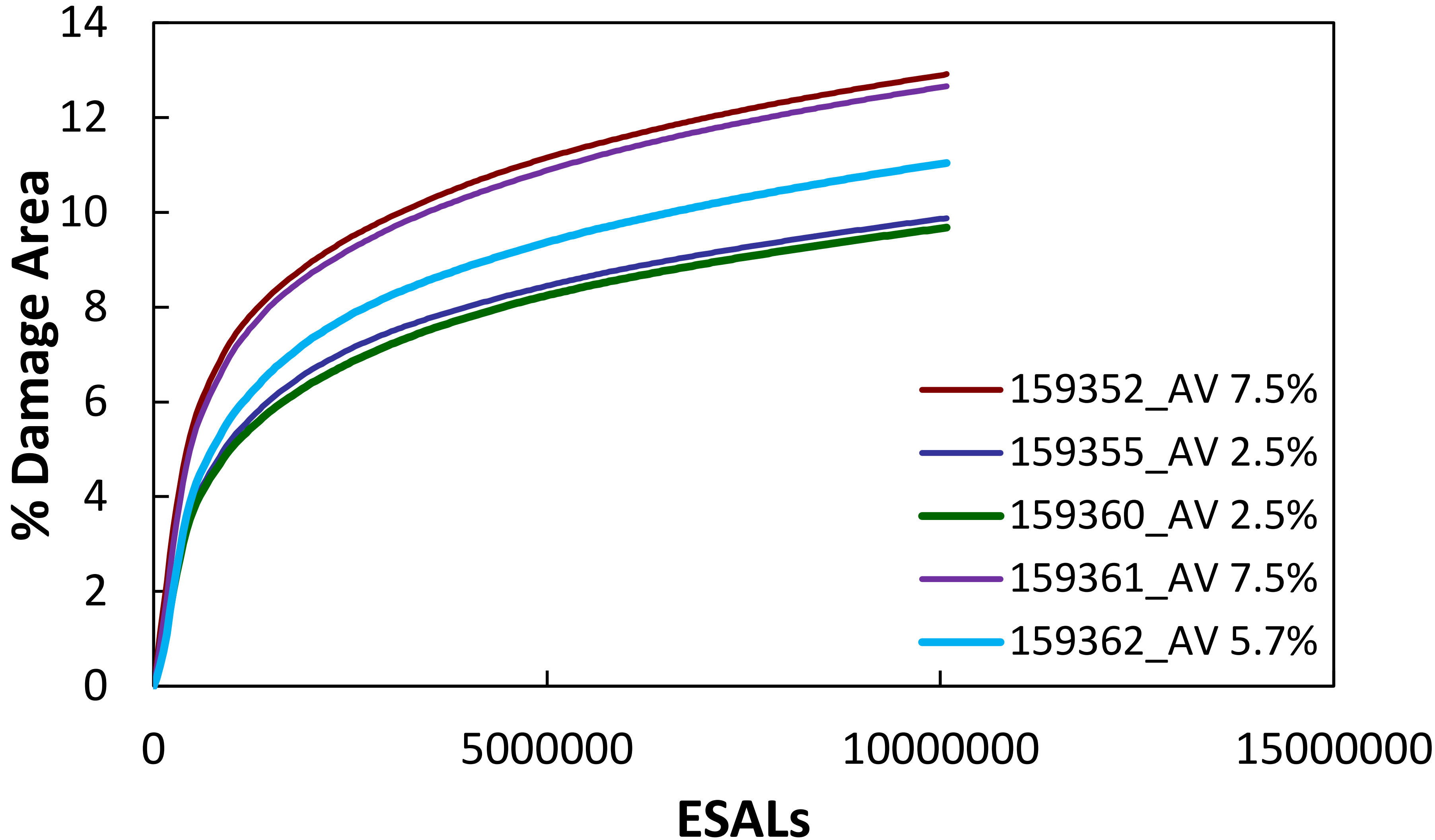




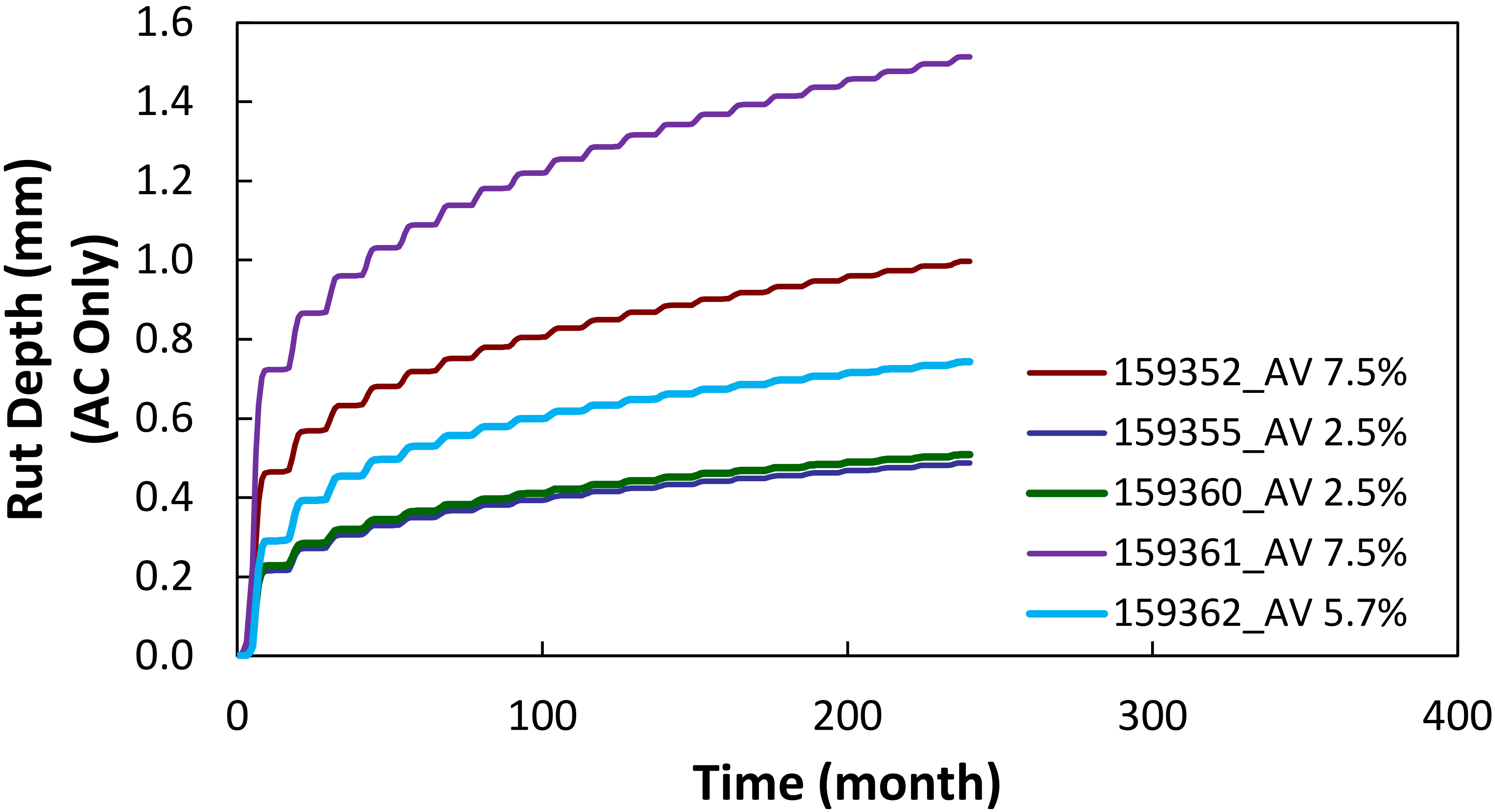
FlexPAVE™ 1.0



Fatigue Damage Prediction



Rutting Depth Prediction

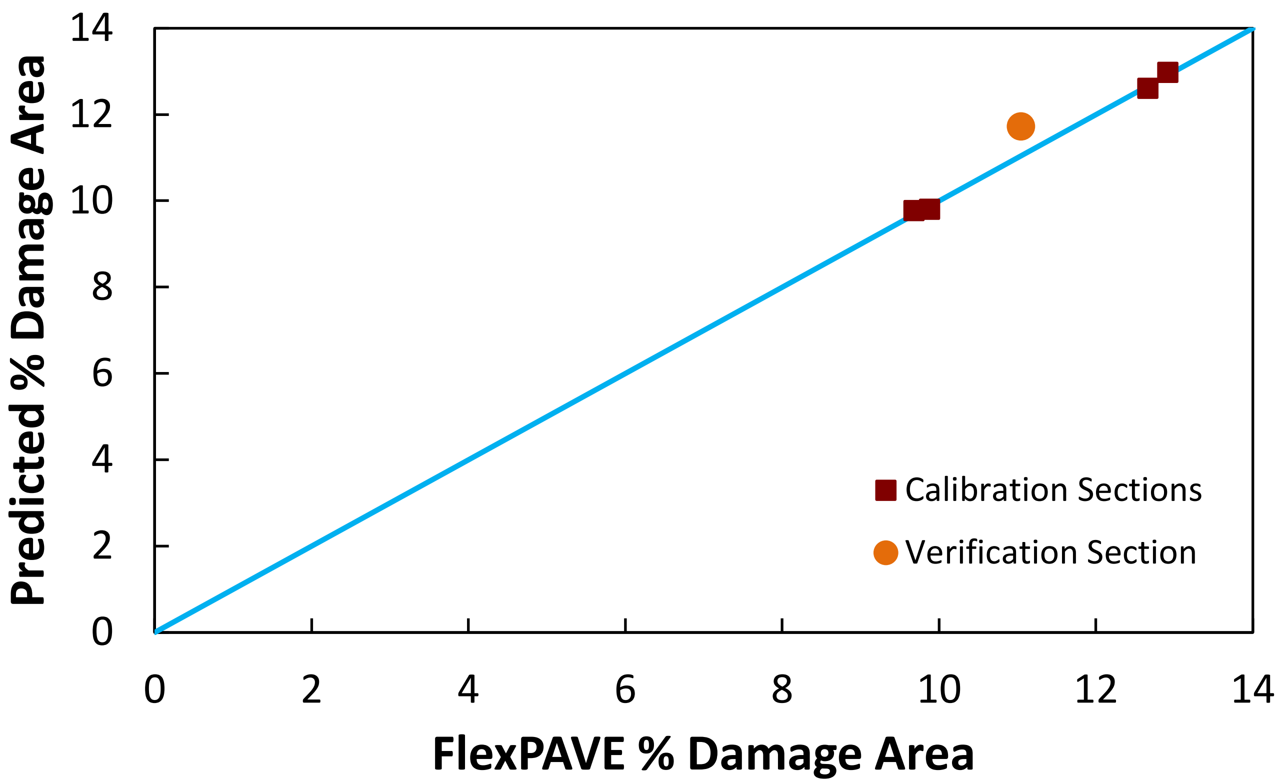


Performance-Volumetric Relationship (PVR)

- The PVR was calibrated using the performance test results generated by MaineDOT.
- PVR was used to predict performance for mixes with different volumetric properties that were tested at NCSU for verification.

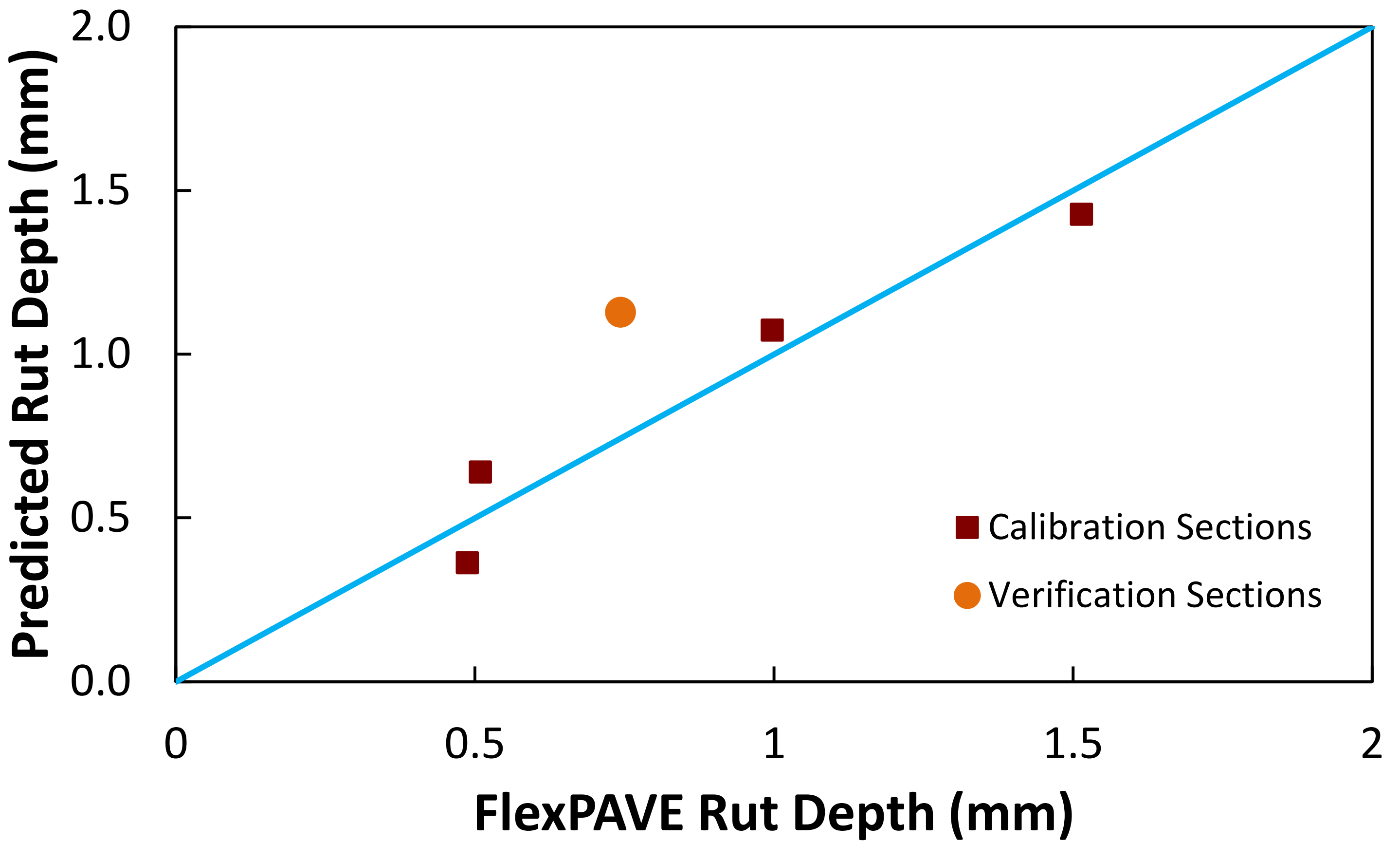
Verification of Cracking PVR

- Fatigue damage in 4-inch asphalt pavement



Verification of Rutting PVR

- Rut depth of the AC layer in the 4 inch pavement

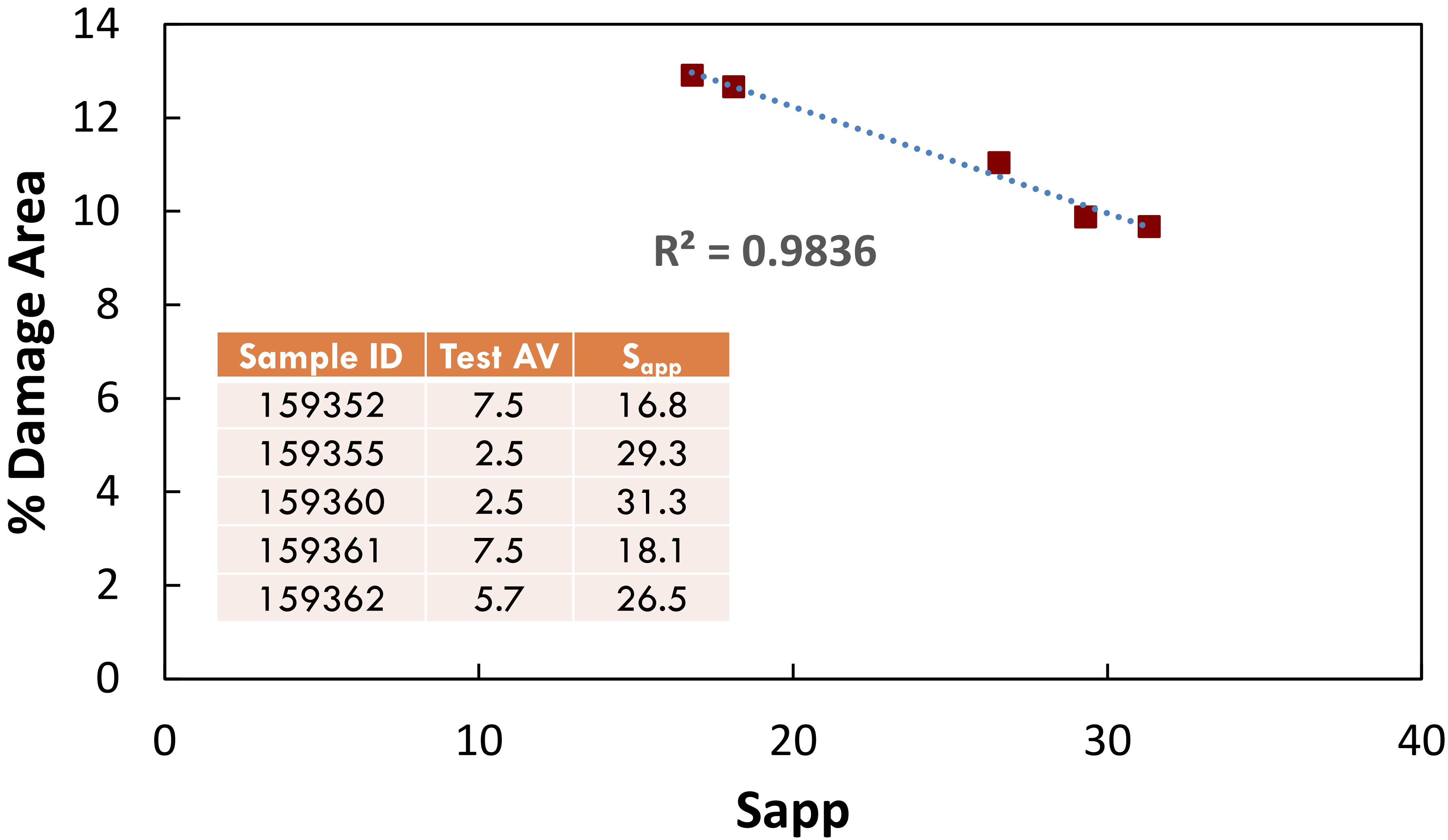


Fatigue Index Parameter

- S_{app}
  - Fatigue resistance index
  - Considers both modulus and ductility

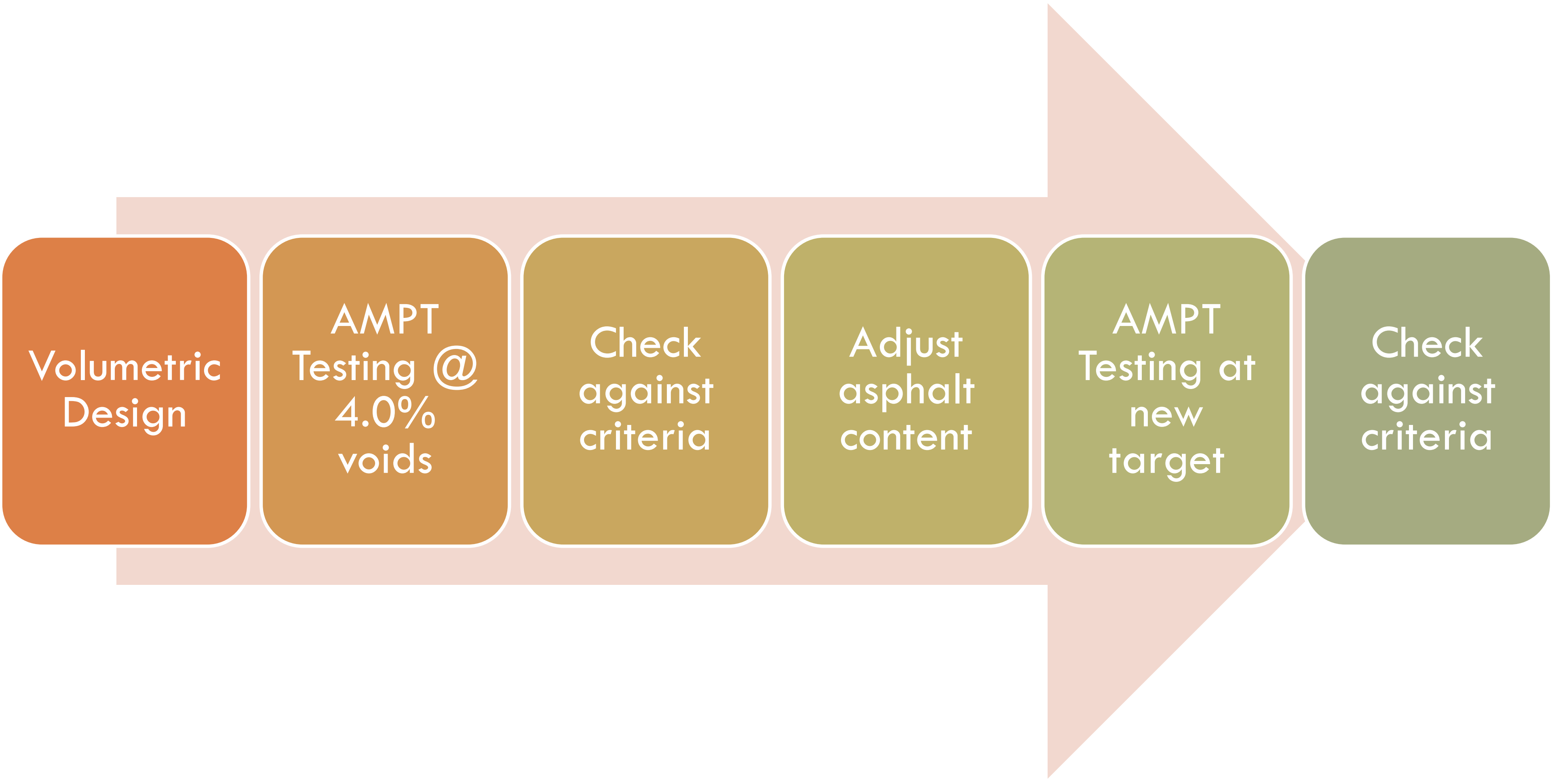
Traffic Level (million ESALs)	S_{app}	Tier	Designation
<= 3	$S_{app} <= 8$	Light	L
>3 and <=10	$8< S_{app} <=18$	Standard	S
>10 and <= 30	$18< S_{app} <=25$	Heavy	H
>30	$25< S_{app} <=30$	Very Heavy	V
>30 and slow traffic	$S_{app} >30$	Extremely Heavy	E

% Damage from FlexPAVE™ vs. Sapp

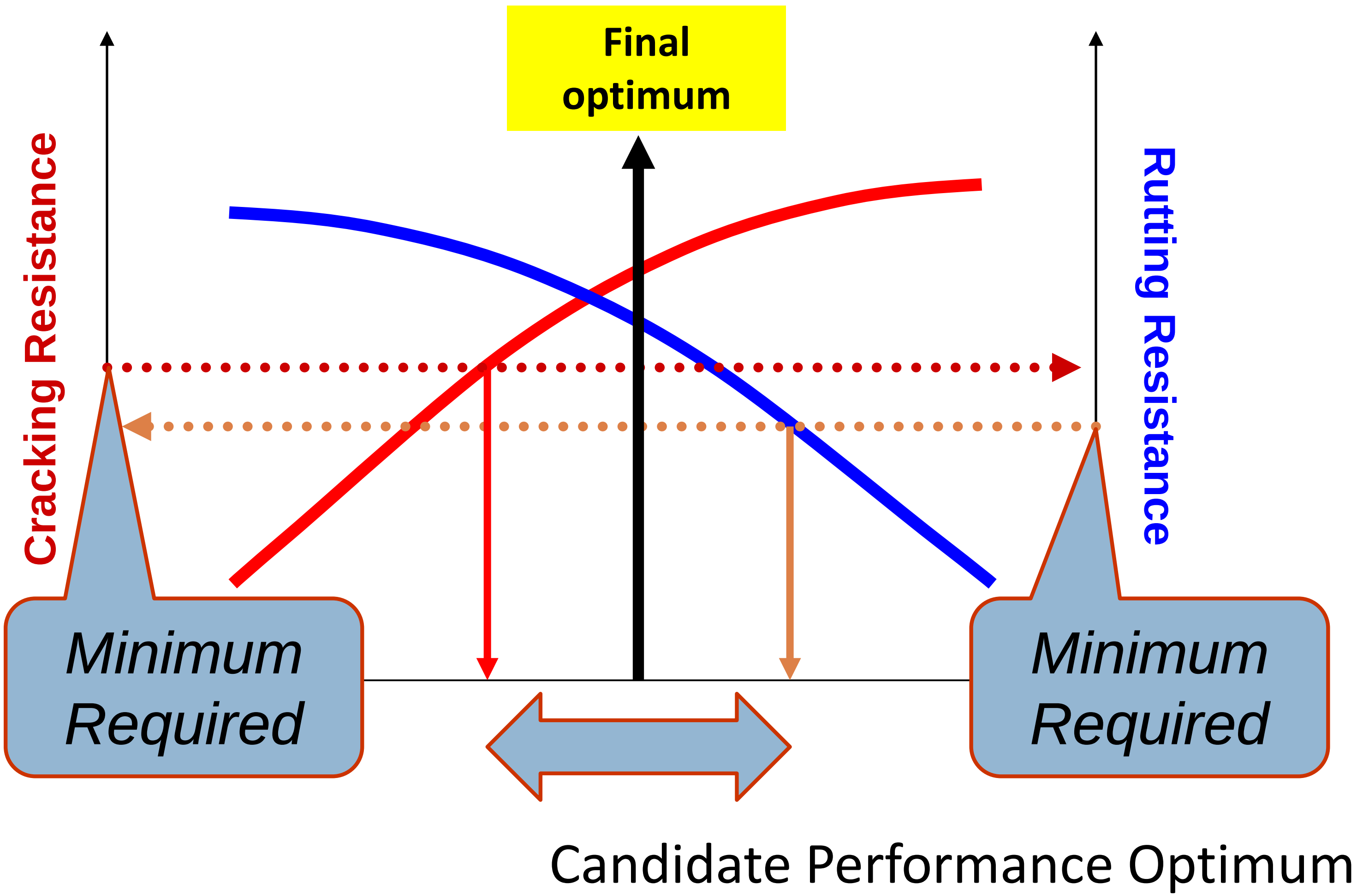


Sample ID	Test AV	S_{app}
159352	7.5	16.8
159355	2.5	29.3
159360	2.5	31.3
159361	7.5	18.1
159362	5.7	26.5

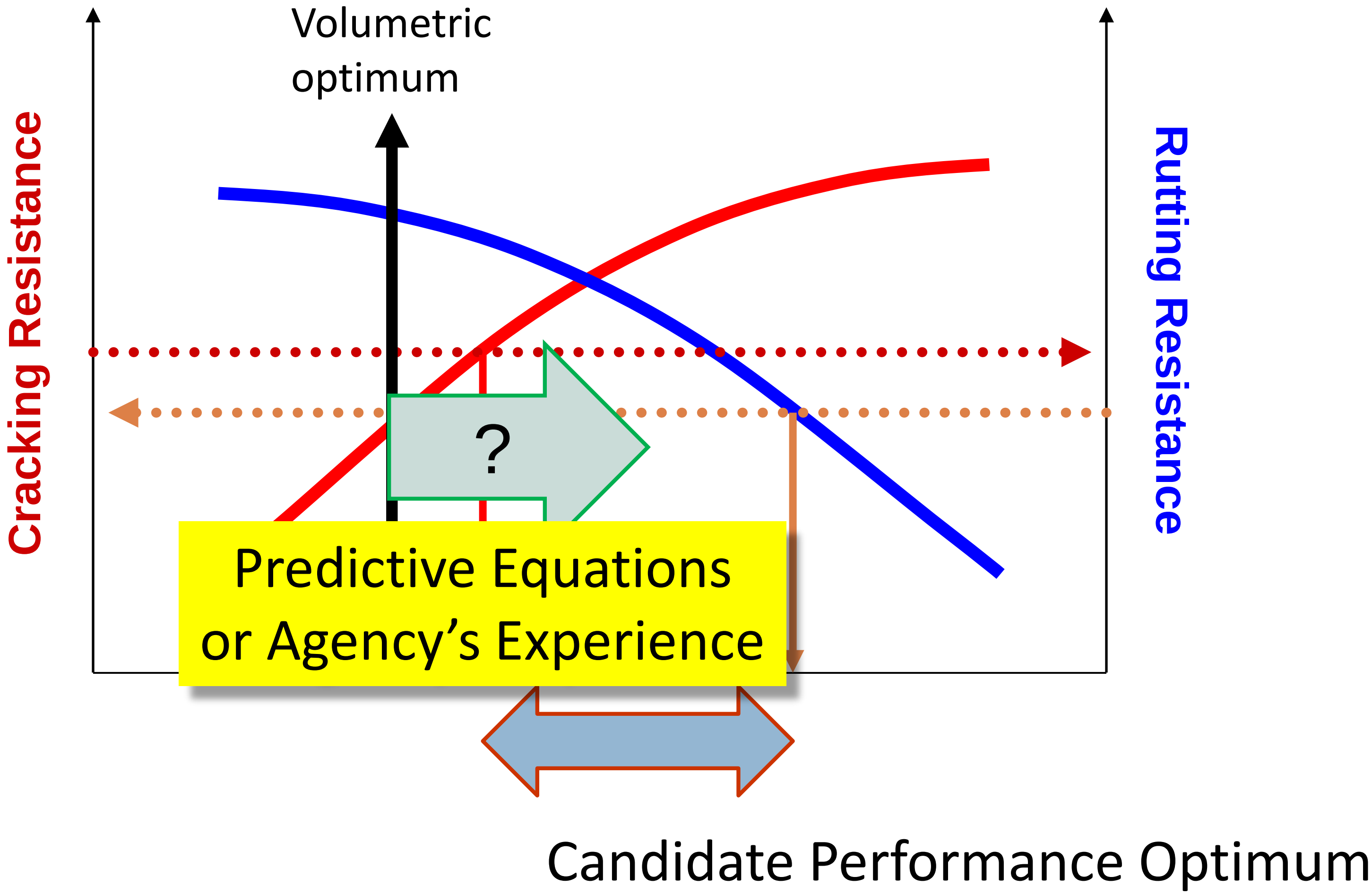
PEMD Concept



Performance-Engineered Mix Design



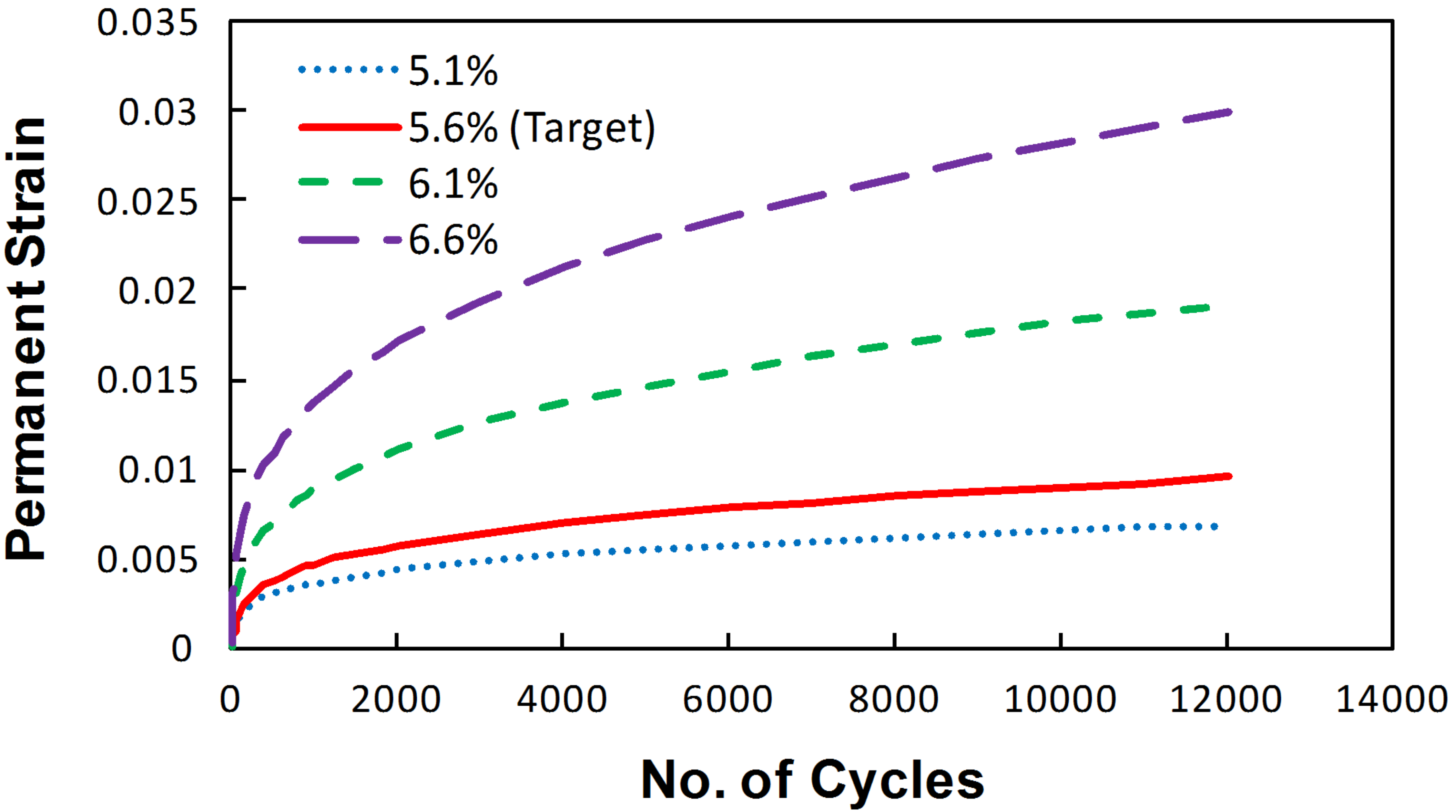
Performance-Engineered Mix Design



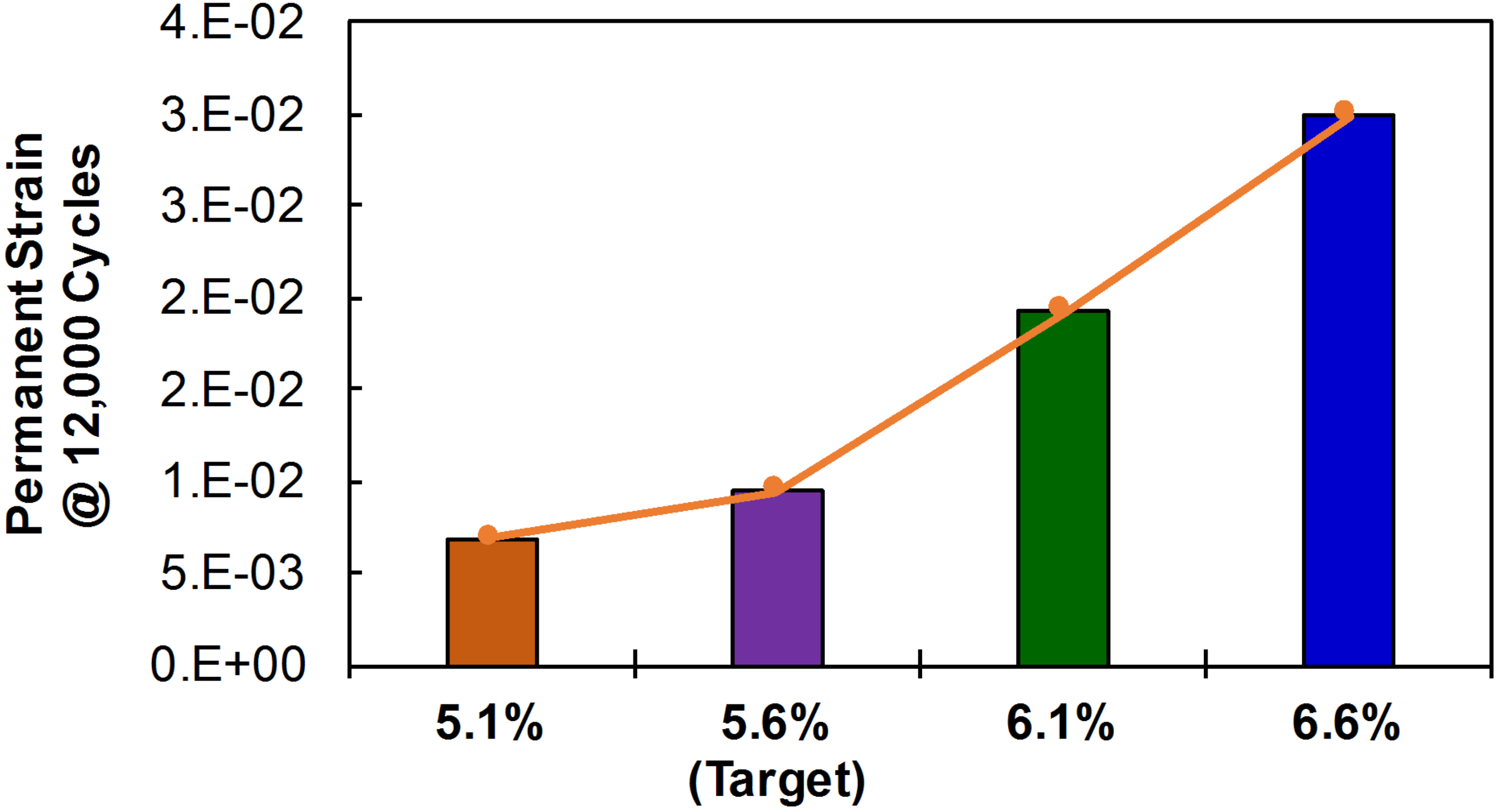
Methodology

- 12.5 mm NMAS – 75 gyration – 20% RAP
- PG 64-28 binder (PPA modified <1%)
- Four different asphalt contents
  - Target - 0.5% (5.1%)
  - Target (5.6%)
  - Target + 0.5% (6.1%)
  - Target + 1.0% (6.6%)

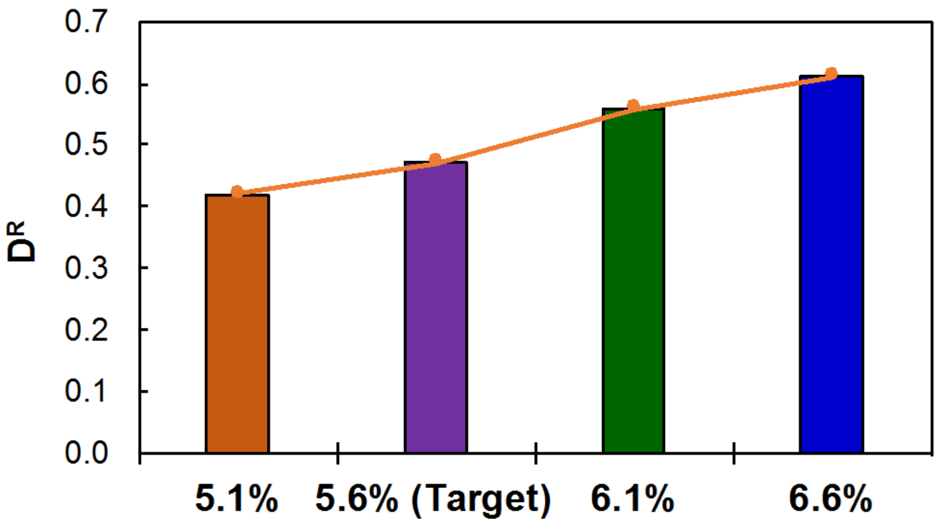
Rutting Performance



Rutting Performance

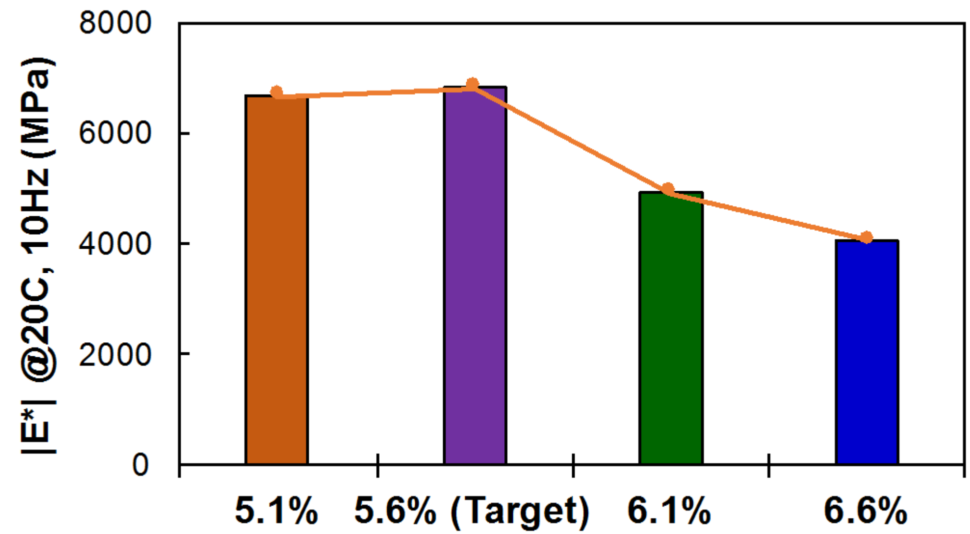


D^R Failure Criterion and Modulus

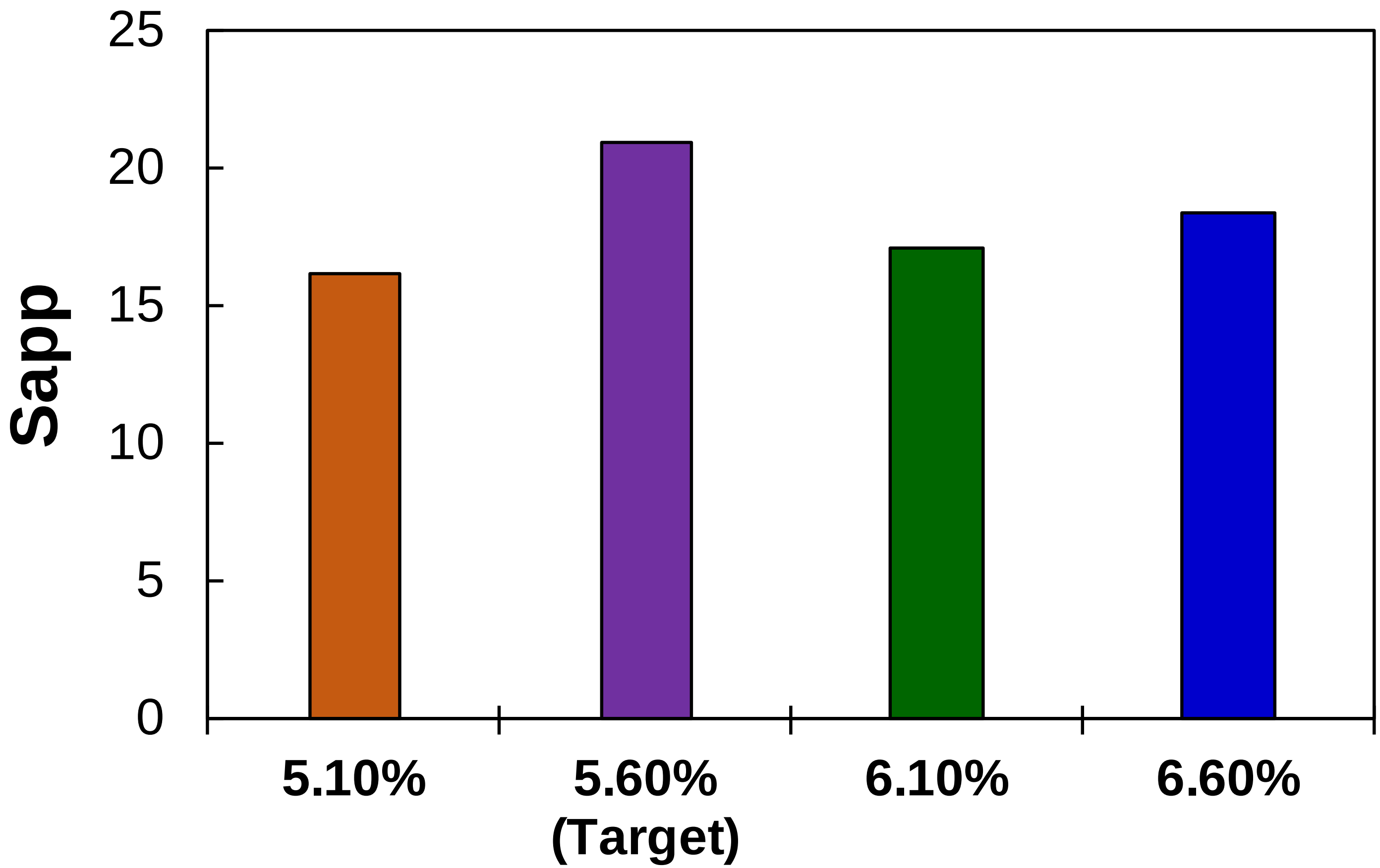


Measure of Toughness

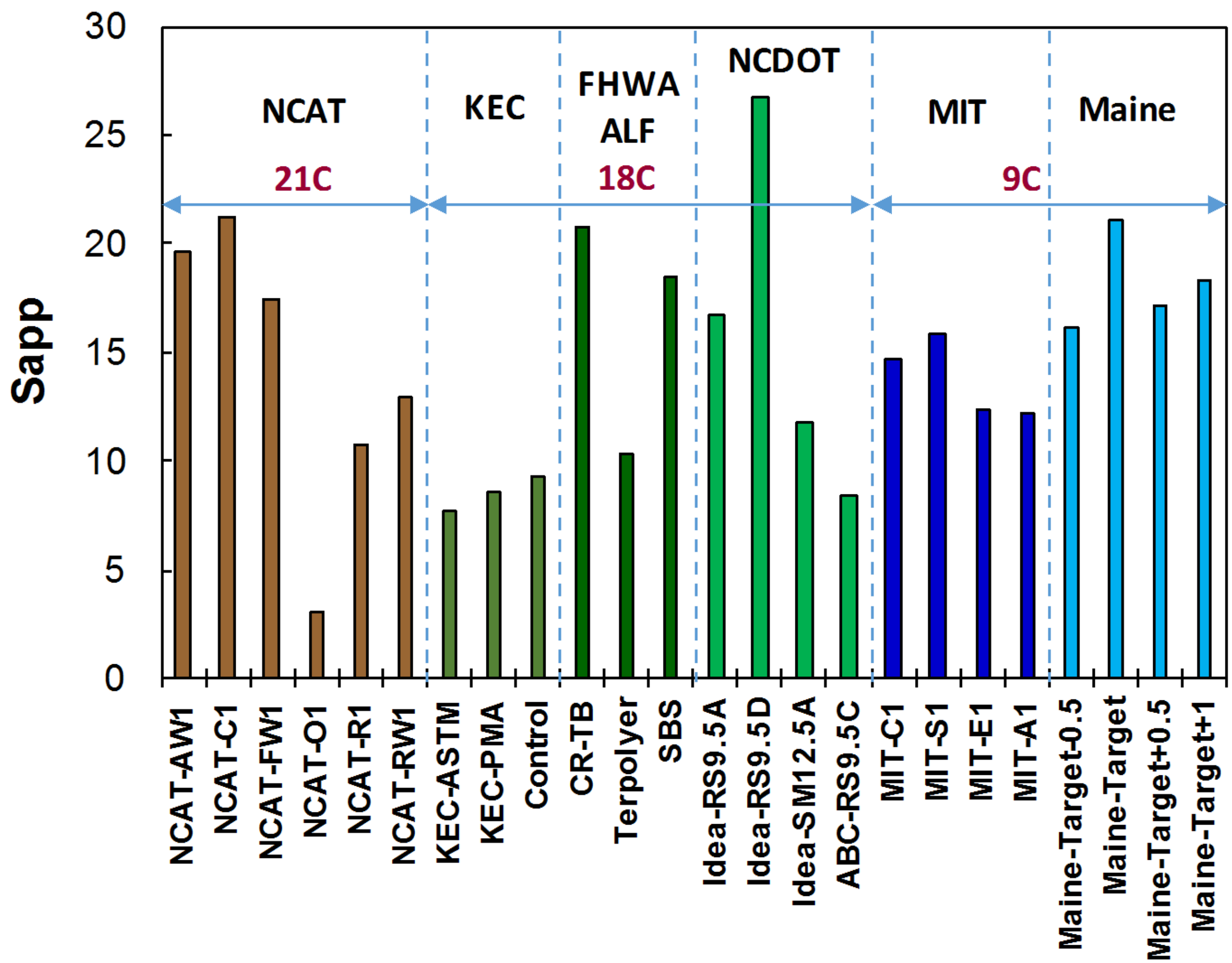
Measure of Stiffness



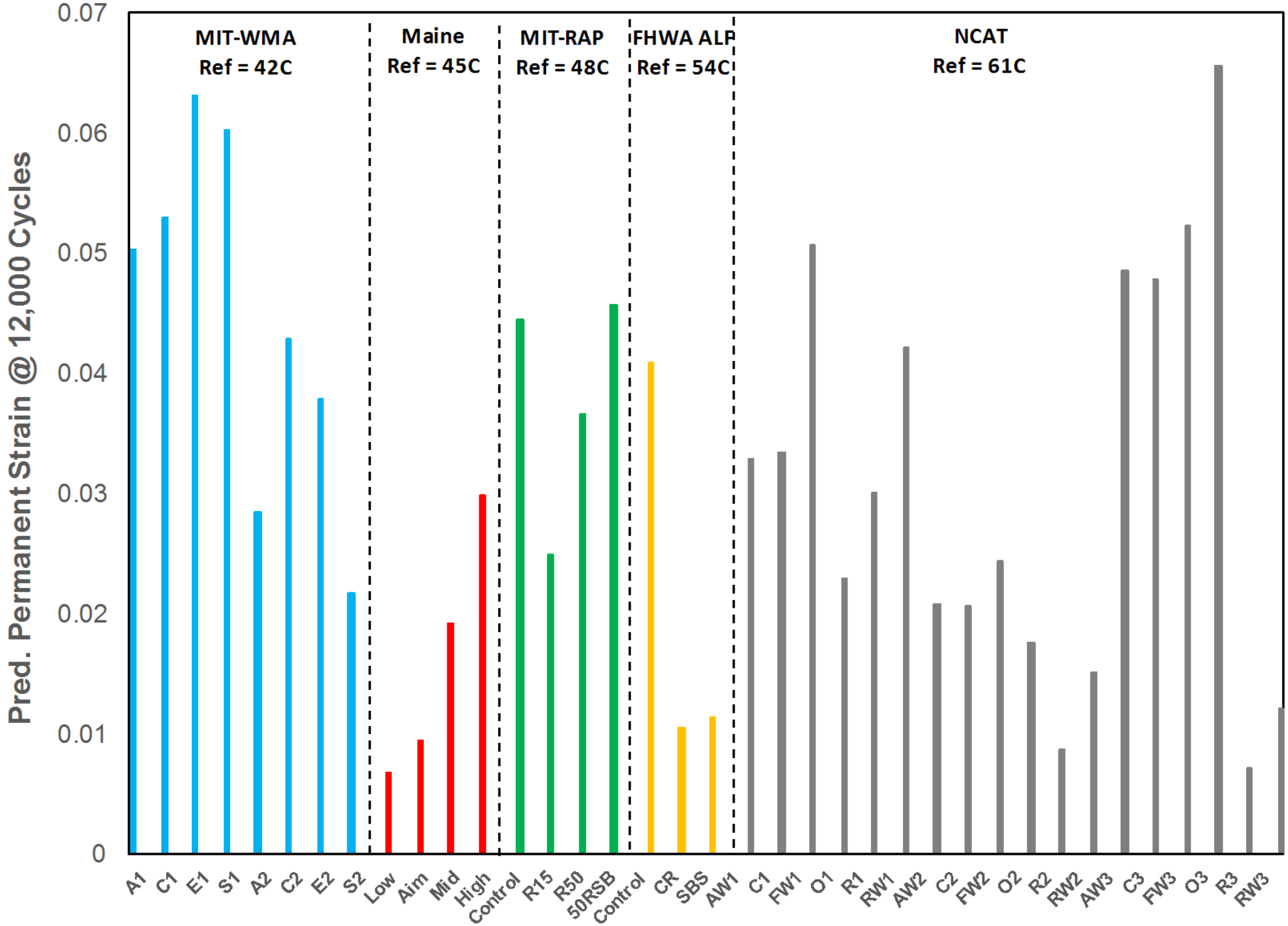
Sapp as a Fatigue Cracking Index



Fatigue Cracking Performance of Maine Mix Compared to Other Mixtures



Rutting Performance of Maine Mix Compared to Other Mixtures



PEMD Lessons Learned - Overall

- Current mix design aim (5.6% AC) appears to optimize performance (fatigue cracking / rutting)
- Data acquired follows logical mix design trends
- Testing time for the PEMD approach is rather long, although it can be reduced
- Steep learning curve with AMPT testing – although it does enhance fundamental understanding of mixes

AMPT Lessons Learned - Testing

- **Cyclic fatigue** – Use bearing with top spacer plate for higher success rate. I suspect some of our failed test are due to stresses during bolt-up due to slightly non-parallel ends.
- **Cyclic fatigue** – Allow 1.5hrs once bolted in AMPT to fully climatize prior to running the dynamic modulus fingerprint test (helps prevent unacceptable errors in the Dynamic Modulus Ratio between the dynamic modulus and cyclic fatigue data).
- **Cyclic fatigue** – Be conservative when selecting the on-specimen strain rate, we had to decrease the on-specimen strain levels in order to stop end failures (failures outside the gauge points).
- **Dynamic Modulus** – It isn't surprising if some of the quality indicators fall slightly outside of the acceptable range, especially at high temp.
- **Tuning** – Take the time at the beginning to work with tuning to get appropriate PID values, defaults were significantly off.
- **Coring** – If your small specimens are coming out slightly ribbed, try decreasing the water pressure feeding the drill.
- **Equipment** – Suggestion to have 6 pairs of cyclic fatigue end plates and 72 Gauge Points (LVDT studs to be able to prepare specimens while climatizing and testing others to maximize efficiency).

AMPT Lessons Learned

- **Its all in the details…**
  - Sealing of samples after receipt
  - Proper storage of samples
  - Selection of air void content
  - Use of CoreLok for air void determination
  - Conditioning of samples

Observations to Date

- The proficiency test results showed MaineDOT was able to perform the AMPT tests and generate high-quality data.
- The test results from the shadow mixes showed the test methods are able to predict the different pavement performance due to changes of AQC parameters.
- The performance-volumetric relationship was used to predict the pavement performance based on AQC data.
- The preliminary mix design and test confirmed the capacity of the mechanistic models and verified the original volumetric design of the mix.

Thank you for the opportunity.

Any Questions?

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