FHWA ALF Update
&
Performance Testing

May 2018, ETG

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SES/TFHRC-FHWA

Outline

- ALF Density Study
  - Laboratory performance testing
  - ALF field testing
- ALF RAP/RAS Study
  - 20% & 40% RBR + additional virgin binder
  - Performance testing
- Stress Sweep Rutting Testing with Small Specimen

AC Field Density and CAB Geosynthetic Reinforcement

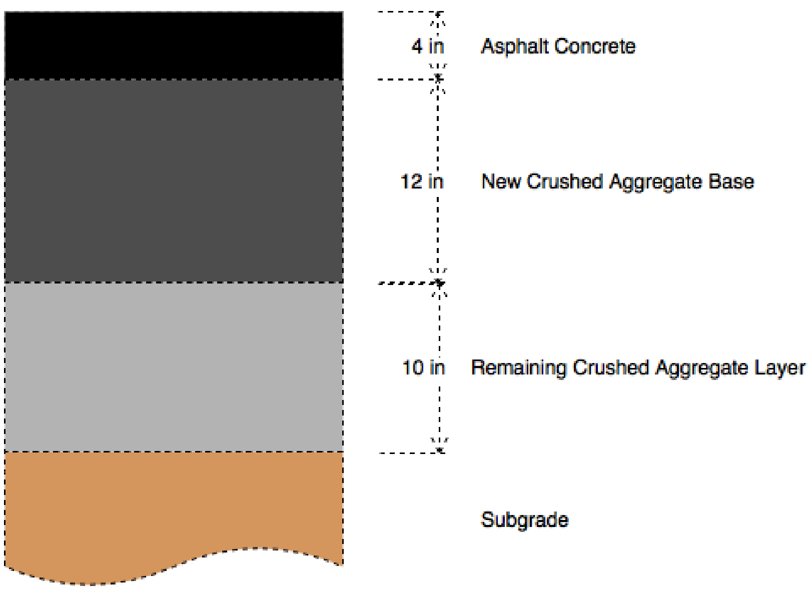
- Objectives
  - Investigation of Asphalt Concrete Compaction and Its Impact on Performance of Pavements Built with and without Geosynthetic Base Reinforcement

The Experiment

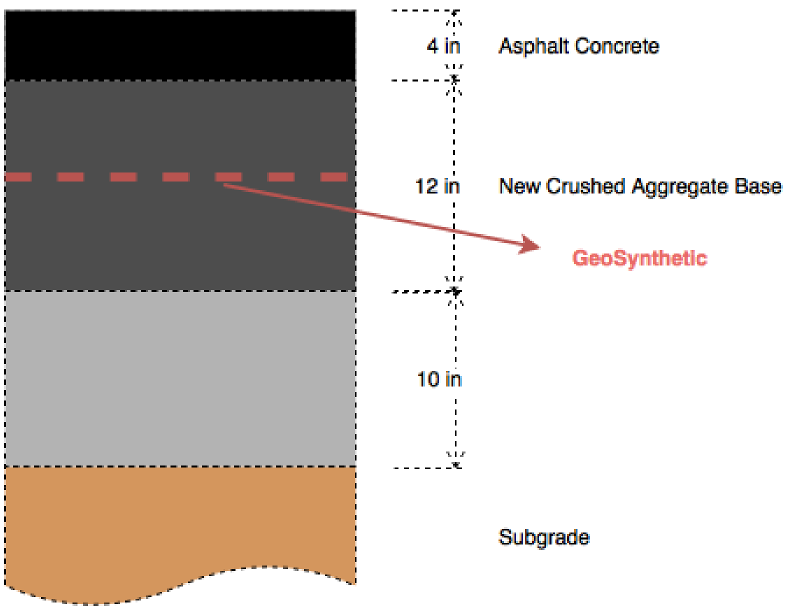
- One AC mixture
- Four Lanes (4 different AC compaction levels)
  - High (>92% compaction)
  - Medium (90-92%)
  - Low (< 90%)
- Two structures per lane
  - Unreinforced
  - Reinforced with a Standard BS-1200
- Performance measures
  - Cracking
  - Rutting

Pavement Structure

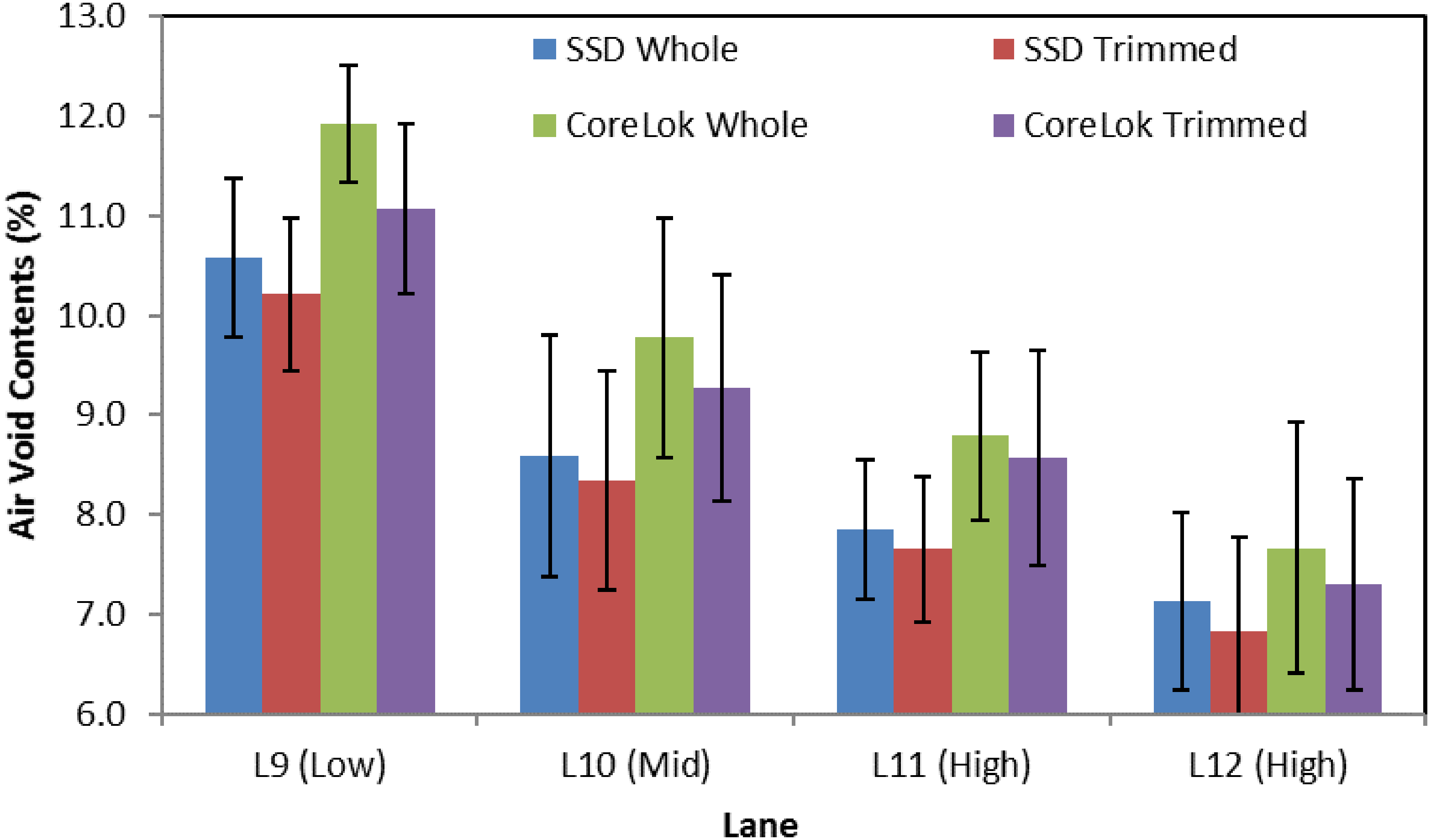
No Reinforcement



With Reinforcement



Air voids of field cores (cont'd)



Air Voids of Field Cores

Lane	SSD Whole		SSD Bottom Trimmed		CoreLok Whole		CoreLok Bottom Trimmed	
	Ave.	St. Dev.	Ave.	St. Dev.	Ave.	St. Dev.	Ave.	St. Dev.
L9 (Low)	10.6	0.8	10.2	0.8	11.93	0.6	**11.1**	0.8
L10 (Mid)	8.6	1.2	8.3	1.1	9.9	1.2	**9.3**	1.1
L11 (High)	7.9	0.7	7.7	0.7	8.8	0.8	**8.6**	1.1
L12 (High)	7.1	0.9	6.8	1.0	7.7	1.3	**7.3**	1.1

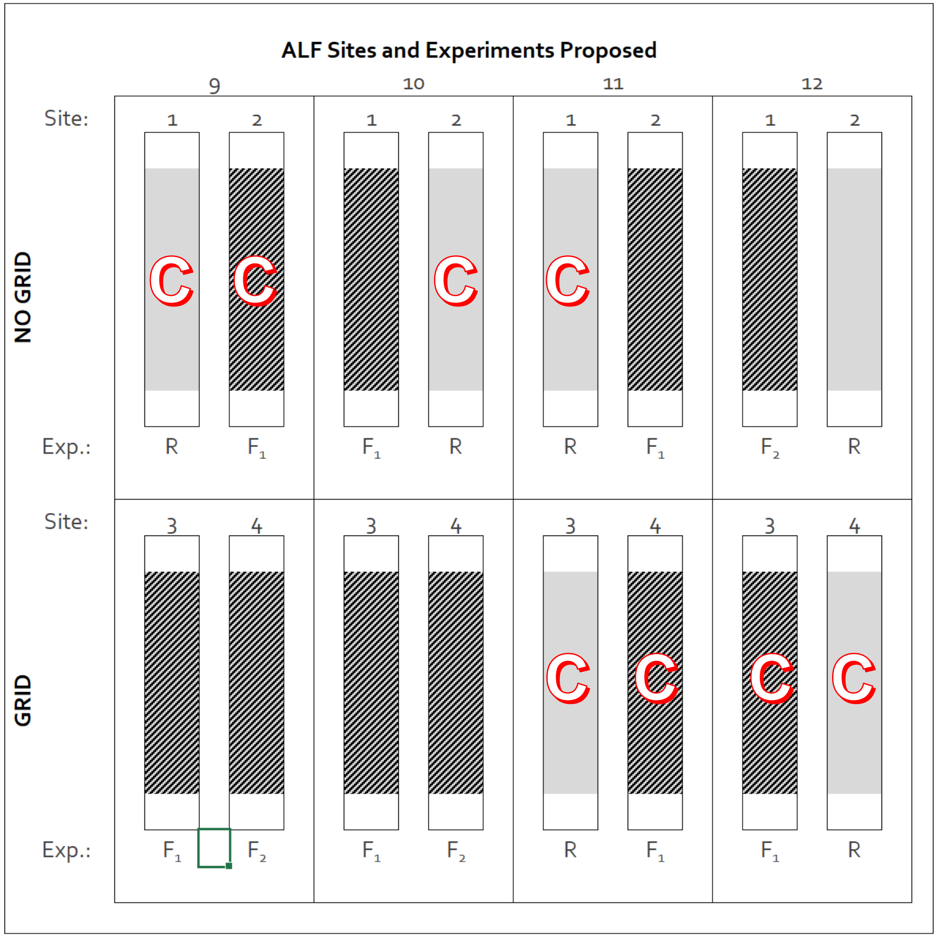
Loading Specs

- **Rutting**
  - Terminal state: 1.5 to 2 inches of total permanent deformation
  - Loading temperature:
    - Variable temperature:
      - 10K passes at 40°C
      - 10K passes at 50°C
      - Cycle until terminal state is reached

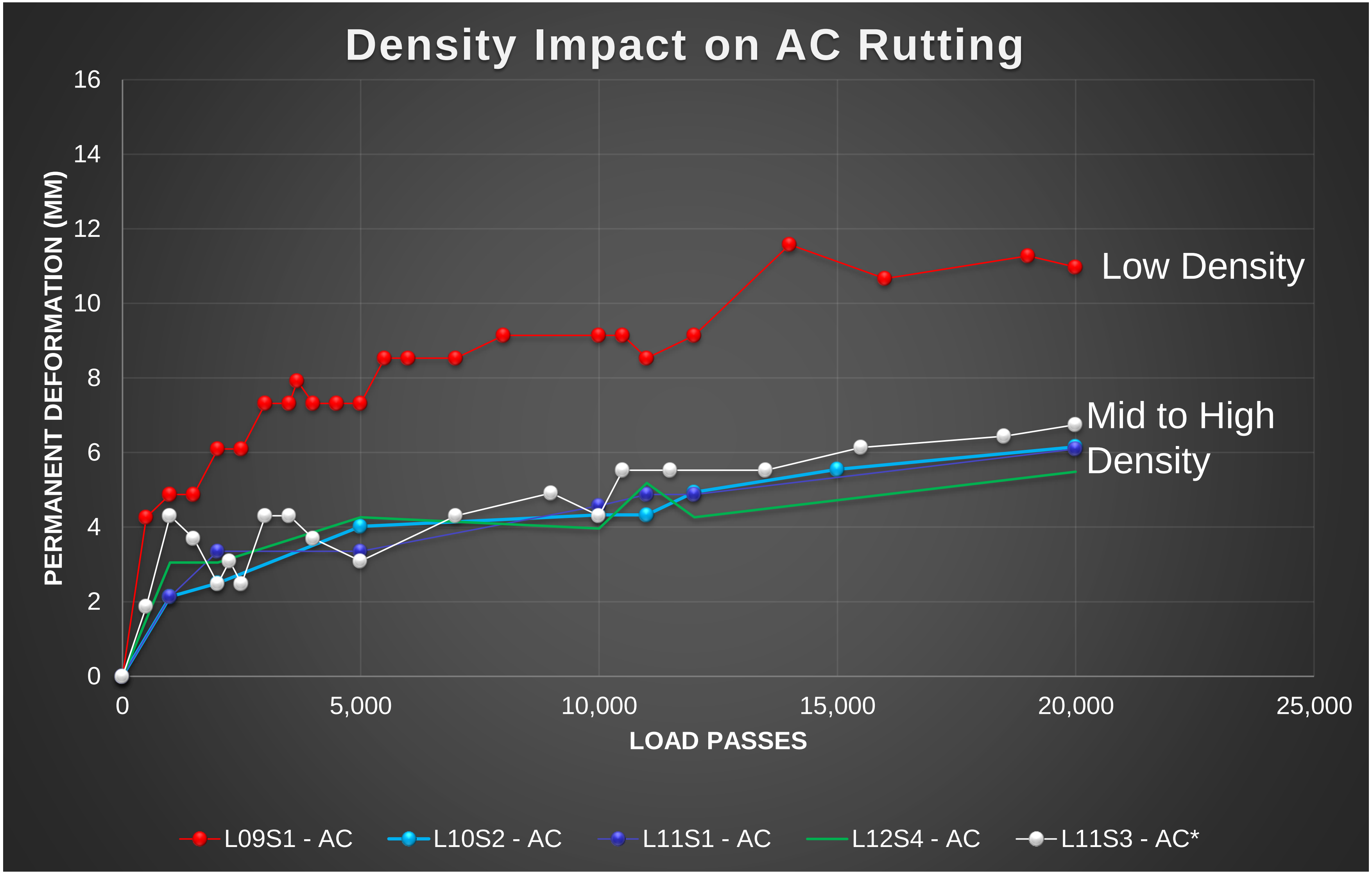
Loading Specs (Cont'd)

- Cracking
  - Loading temperature: 20°C
  - Terminal state: total cracking length > 1,000 inches
    - Early stages of cracking in which preventive maintenance would be optimum intervention in real pavements

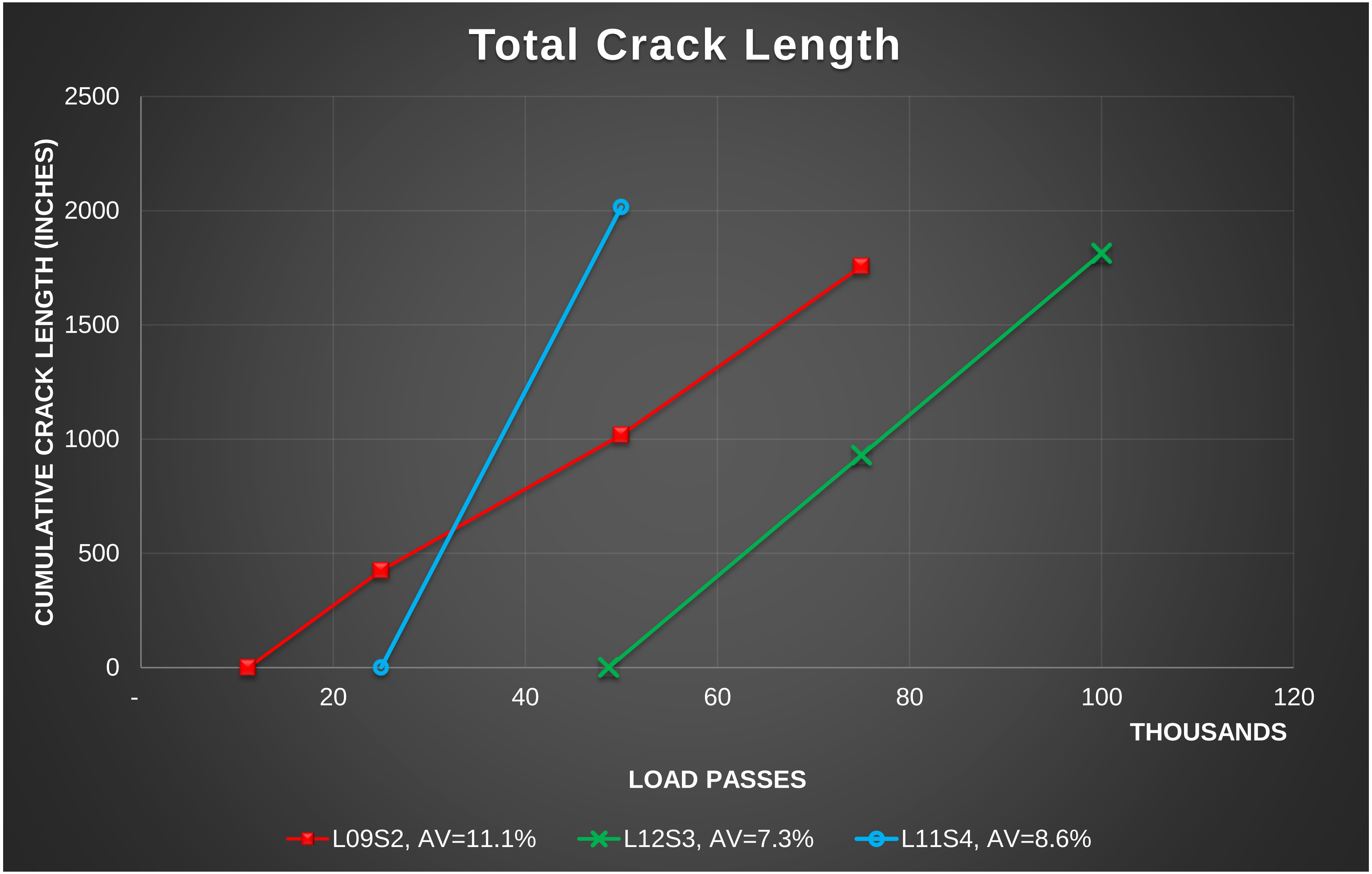
Layout and Current Status



- F_i – Fatigue test at aged conditions
- Completed Rutting
  - All but L12S2
- Completed Cracking
  - L9S2
  - L11S4
  - L12S3
- Next (until end of loading season):
  - L10S1
  - L12S2



* Needs validation (post-mortem)


Total Crack Length
CUMULATIVE CRACK LENGTH (INCHES)
2500
2000
1500
1000
500
0
-
20
40
60
80
100
120
THOUSANDS
LOAD PASSES
L09S2, AV=11.1%
L12S3, AV=7.3%
L11S4, AV=8.6%

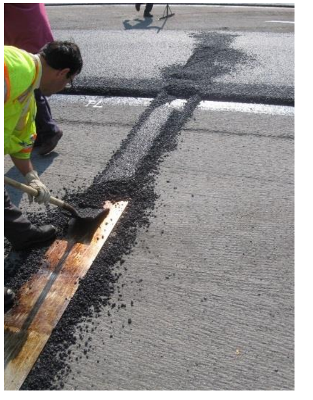
Field Core Sampling + Testing

2016
0 day

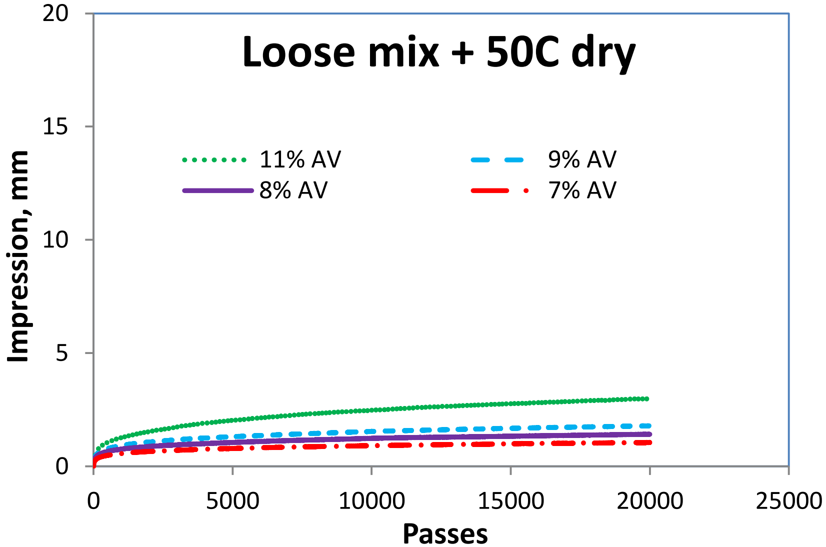
2018
1.5 year

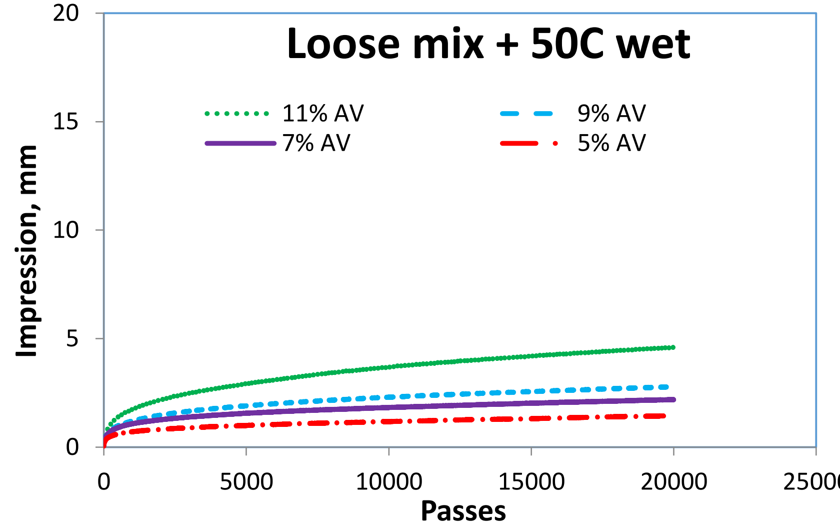
Loose Mix Laboratory Testing

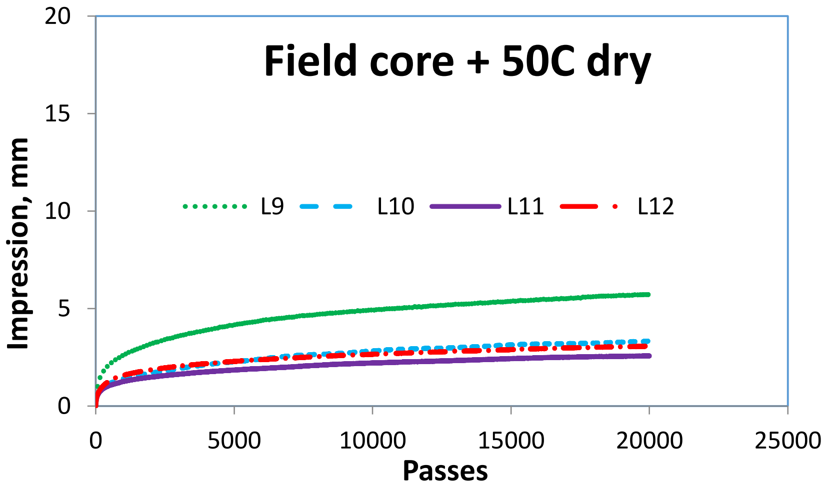
- **HWTD testing**
  - Dry 50ºC + wet 50ºC
- **Flow number**
- **Dynamic modulus**
- **Axial cyclic fatigue test**
- **Stress sweep rutting test**
  - 4 air voids (7%, 8%, 9%, 11%)
  - 2-hour aging
  - 2 LTOA (5-day 85ºC, 7-day 95ºC)

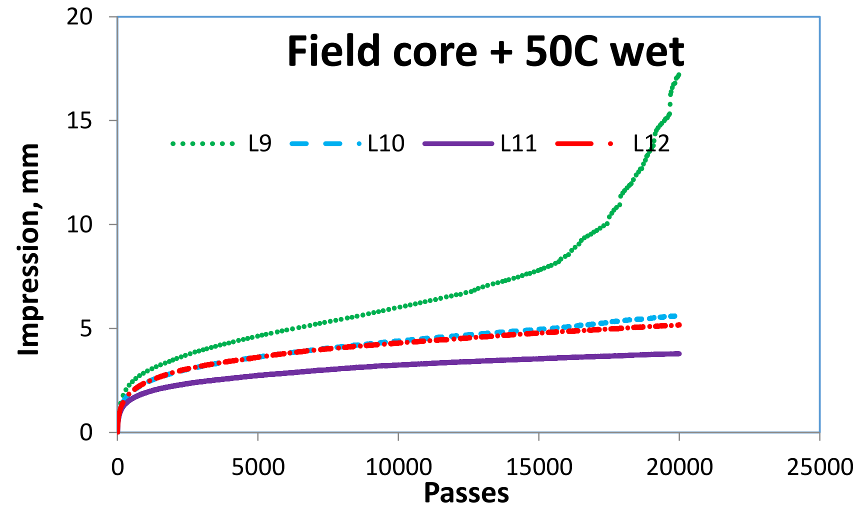


HWDT

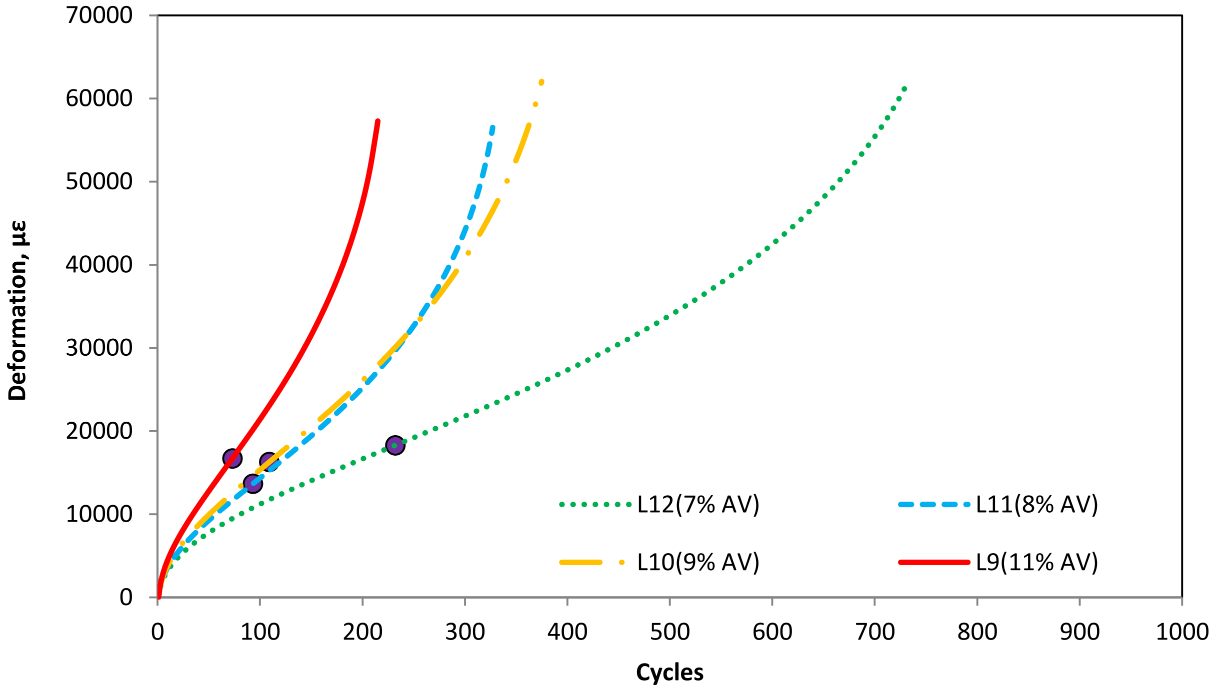

Loose mix + 50C dry
11% AV
9% AV
8% AV
7% AV
Impression, mm
0
5
10
15
20
Passes
0
5000
10000
15000
20000
25000


Loose mix + 50C wet
11% AV
9% AV
7% AV
5% AV
Impression, mm
0
5
10
15
20
Passes
0
5000
10000
15000
20000
25000


Field core + 50C dry
L9
L10
L11
L12
Impression, mm
0
5
10
15
20
Passes
0
5000
10000
15000
20000
25000

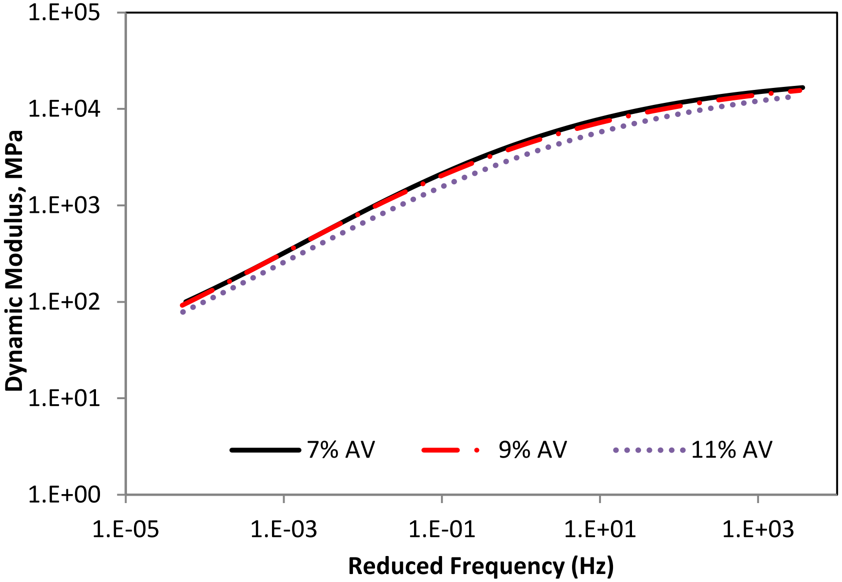

Field core + 50C wet
L9
L10
L11
L12
Impression, mm
0
5
10
15
20
Passes
0
5000
10000
15000
20000
25000

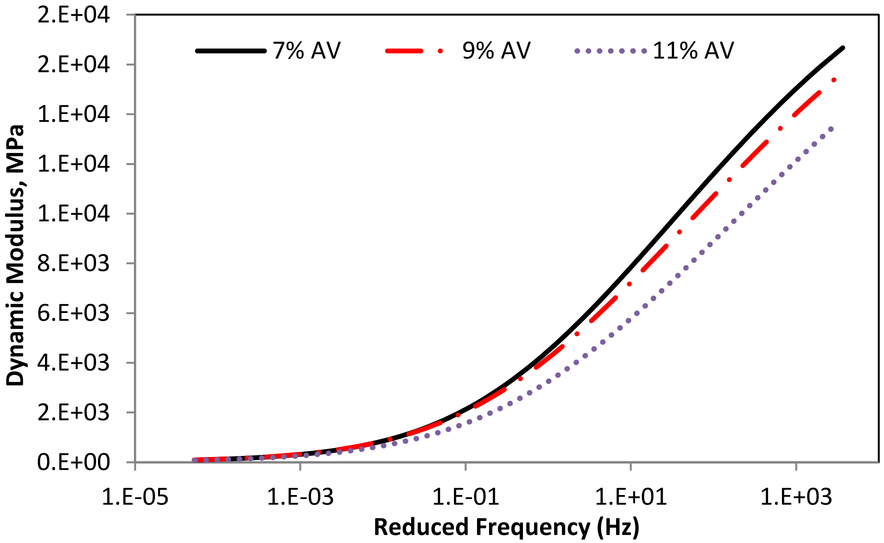
Flow Number



Lane and Va	Flow Number (cycles)
L12 (7%Va)	232
L11 (8%Va)	93
L10 (9%Va)	109
L9 (11%Va)	73

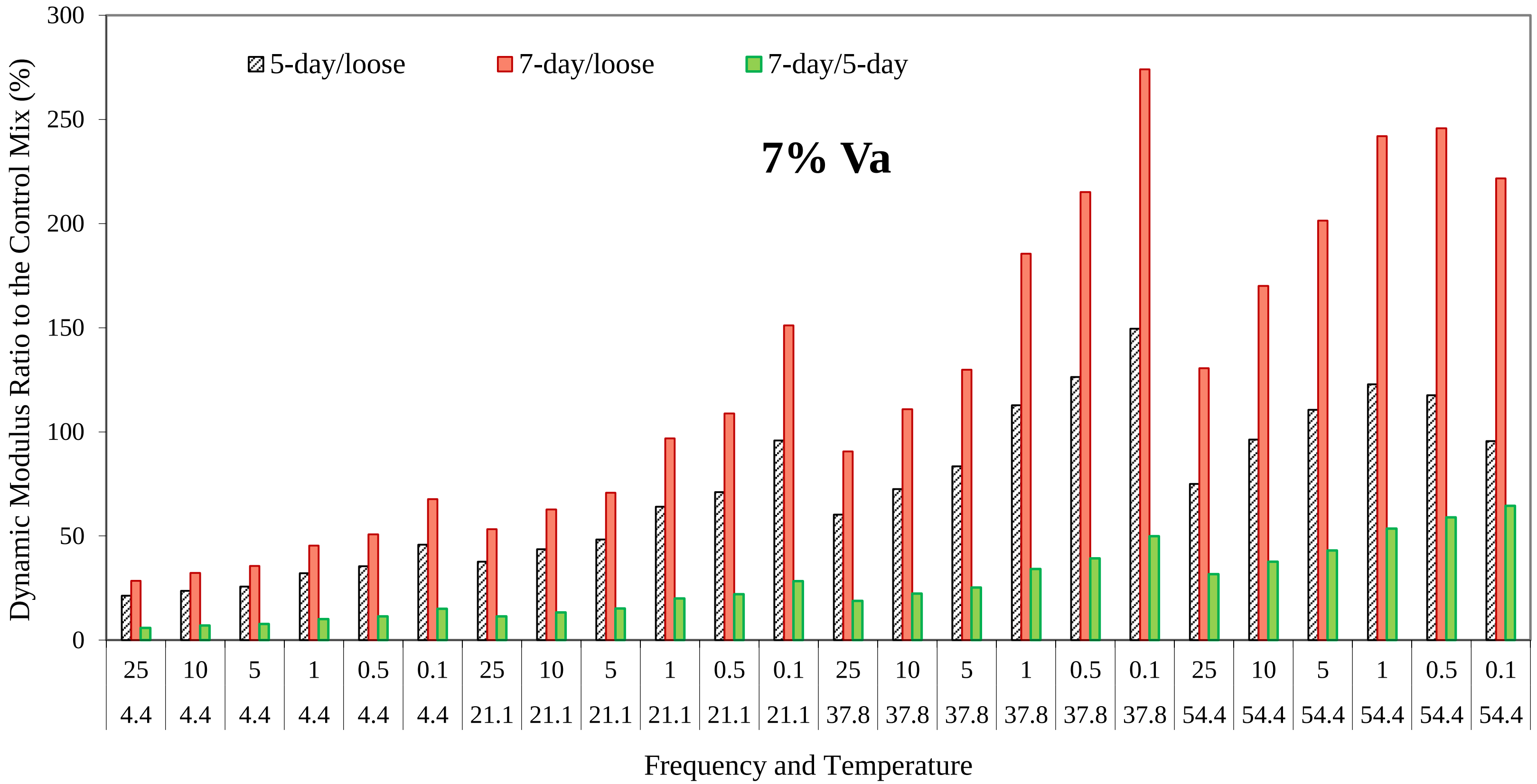
Effect of Air Voids on |E*|



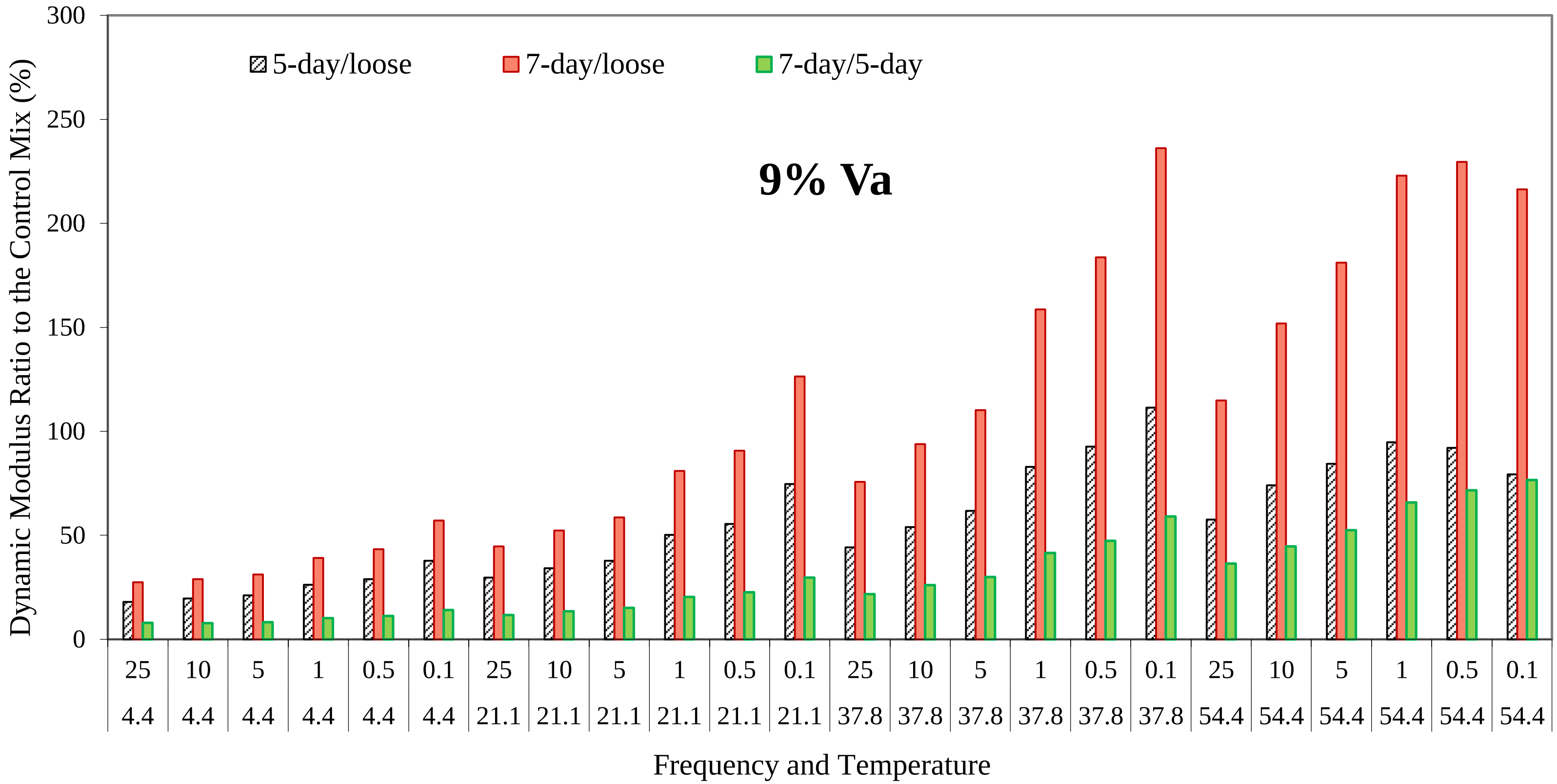


Temperature (°C)	Correction Factor from Each Method		
	Witczak Model	Hirsch Model	Lab Data
4.4	6.0%	3.9%	6.1%
21.1	6.2%	6.5%	7.1%
37.8	N/A	N/A	8.4%
54.4	6.8%	1.3%	9.6%

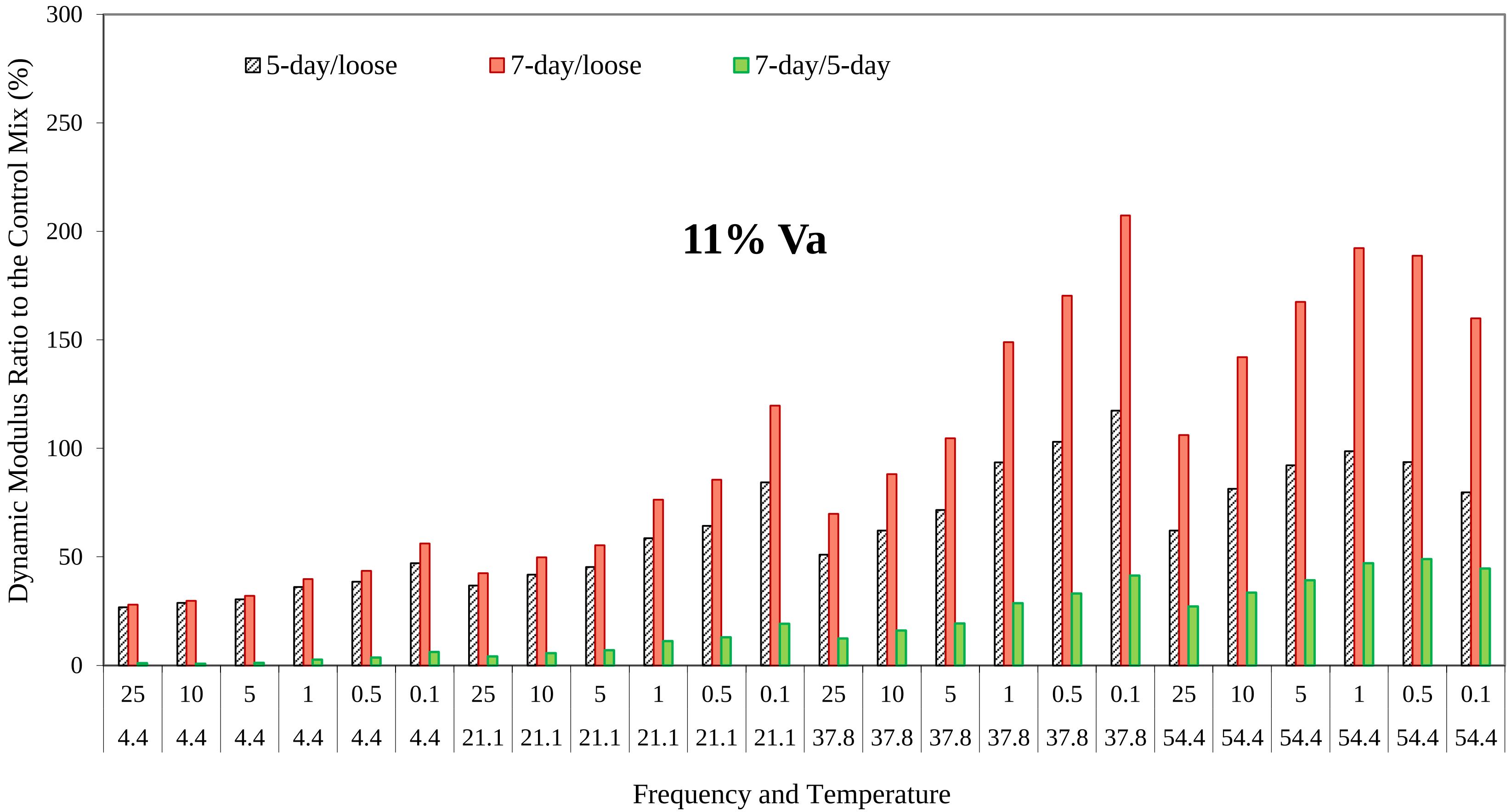
Aging Effect on |E*|



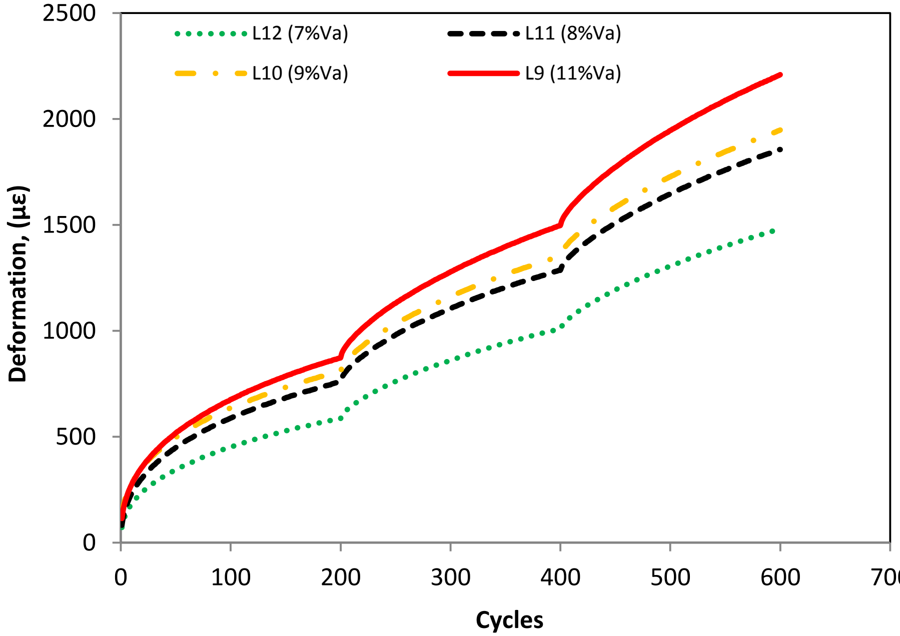
Aging Effect on |E*|



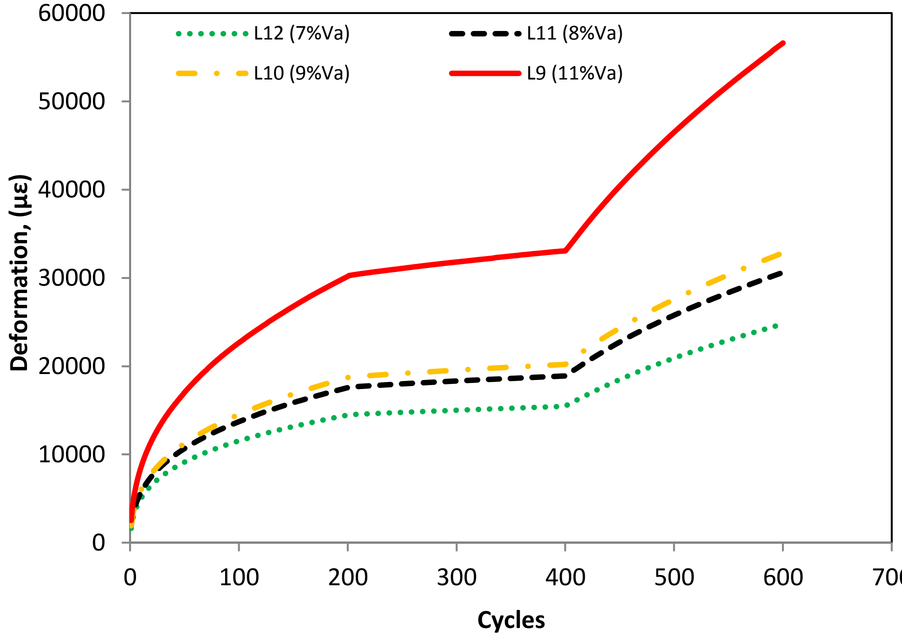
Aging Effect on |E*|



Stress Sweep Rutting Testing



20ºC



54ºC

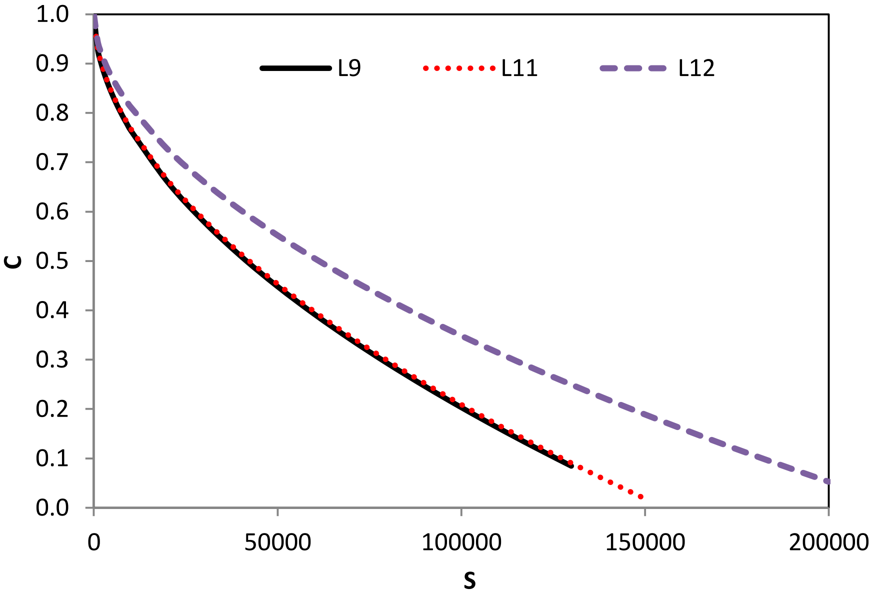
Fatigue Testing Results

- **Axial cyclic fatigue (AASHTO TP107)**
  - fatigue characteristics

Parameters	L9 (11% Va)	L11 (8% Va)	L12 (7% Va)
C11	0.002	0.002	0.001
C12	0.530	0.533	0.540
DR	0.496	0.477	0.493

$$C = 1 - C_{11} \cdot S^{C_{12}}$$

$$D^R = \frac{\int_0^{N_f} (1 - C) dN}{N_f}$$



RAP Mix + More Virgin Binder

ALF RBR Study

Objectives

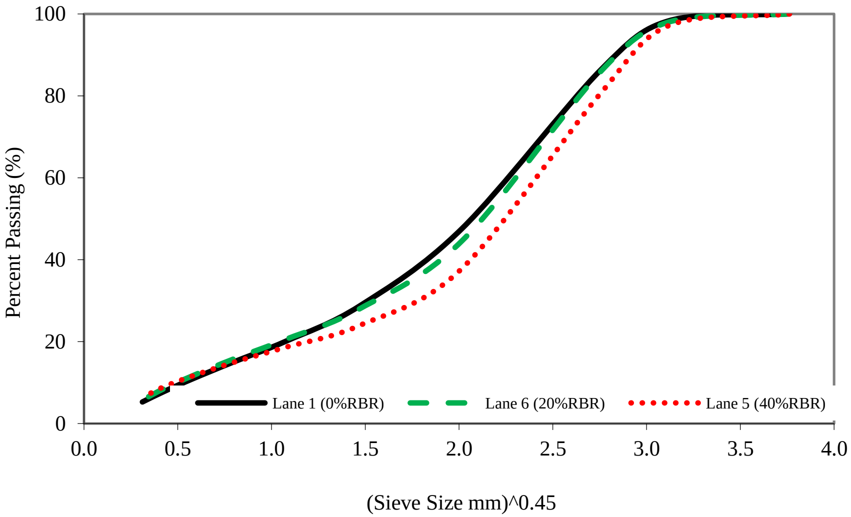
- Examine the effect of asphalt binder replacement in the asphalt mixtures containing RAP
- Determine how much virgin binder needs to be added for the mixes to exhibit equivalent performance
- Improve RAP mix design to ensure satisfactory performance

Materials and Testing

- **Materials**
  - L1 (0% RBR, control mix, PG 64-22)
  - L6 (20% RBR, PG 64-22)
  - L5 (40% RBR, PG 64-22)
  - L8 (40% RBR, PG 58-28)
- **Additional Binder**
  - +0.25%, +0.5%, +0.75%
- **Testing**
  - Dynamic modulus
  - Direct tension fatigue (AASHTO TP 107)
  - Stress sweep rutting (SSR)

Volumetrics

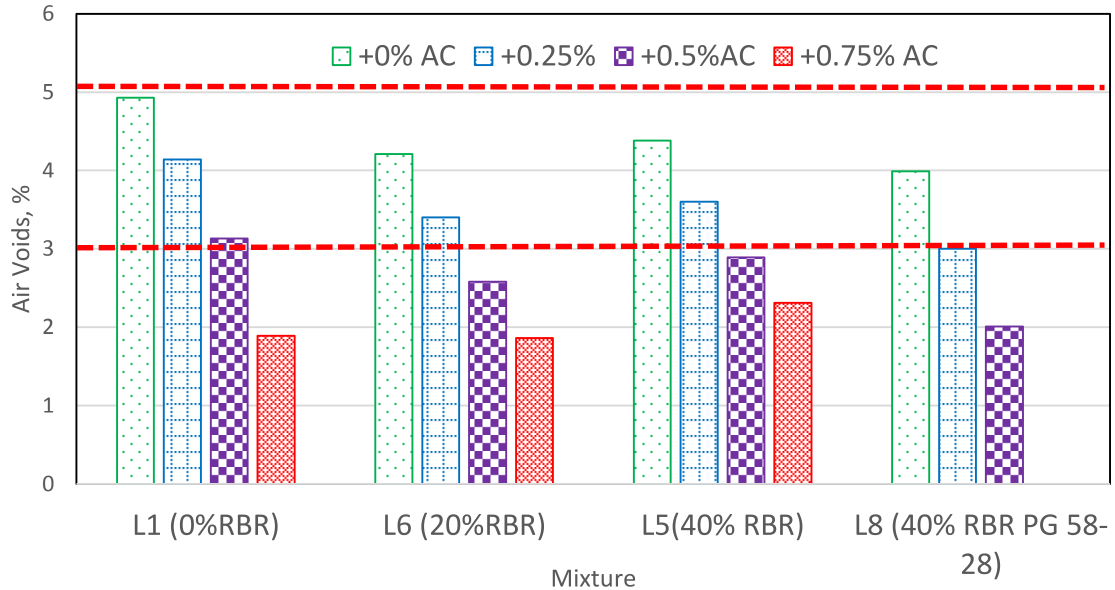
Dimension (mm)	Sieve Size	Lane 1 (0%RBR)	Lane 6 (20%RBR)	Lane 5 (40%RBR)
19	3/4 inch	100	100	100
12.5	1/2 inch	98.3	98.0	97.1
9.5	3/8 inch	86.2	85.8	80.6
4.75	# 4	47.6	44.6	37.9
2.36	# 8	28.8	28.1	24.0
1.18	# 16	20.1	20.6	18.6
0.6	# 30	15.0	15.7	14.9
0.3	# 50	11.0	11.7	11.6
0.15	# 100	7.8	8.5	8.9
0.075	#200	5.3	5.8	6.3

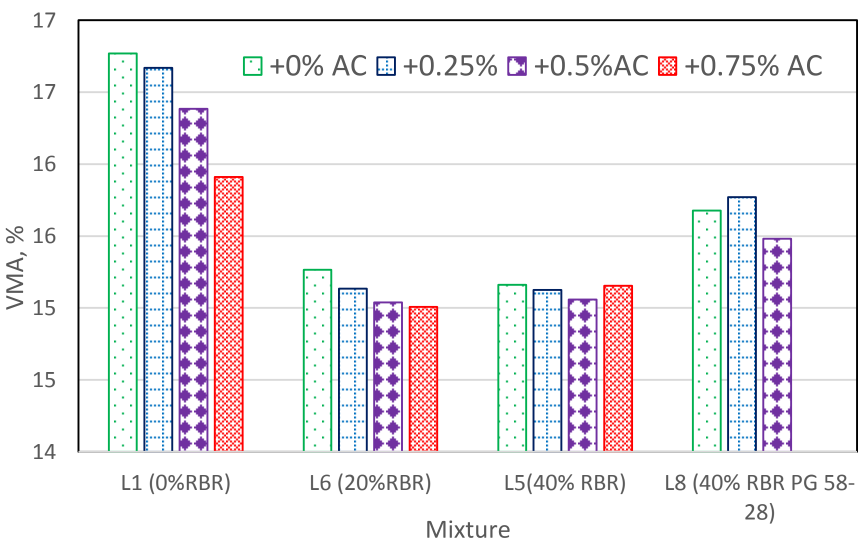


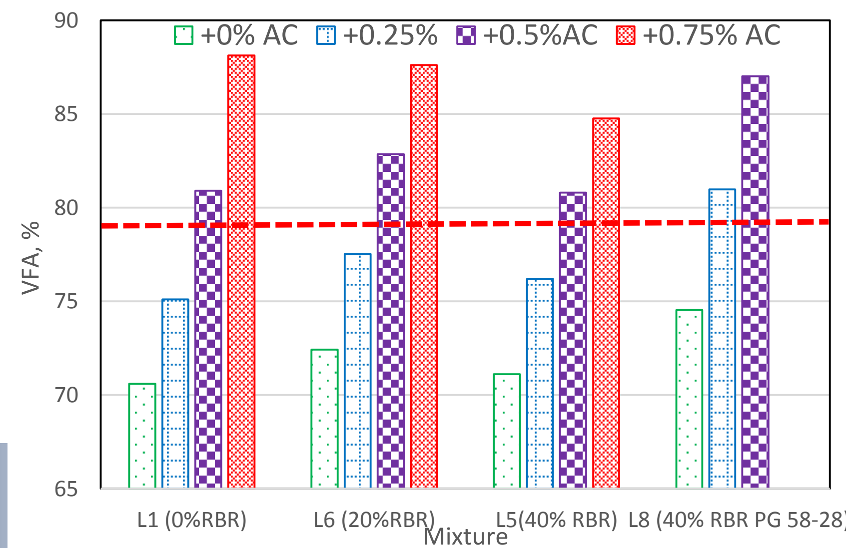
	L1 (0%RBR)				L6 (20%RBR)				L5 (40%RBR)				L8 (40%RBR PG58-28)		
+ AC	+0	+0.25%	+0.5%	+0.75%	+0	+0.25%	+0.5%	+0.75%	+0	+0.25%	+0.5%	+0.75%	+0	+0.25%	+0.5%
G_{mm}	2.747	2.735	2.723	2.711	2.744	2.732	2.72	2.708	2.744	2.732	2.72	2.708	2.715	2.705	2.693
Air Voids	4.93	4.14	3.13	1.89	4.21	3.4	2.58	1.86	4.38	3.6	2.89	2.31	3.99	3	2.01
G_{mb}	2.612	2.622	2.638	2.66	2.629	2.64	2.65	2.658	2.624	2.632	2.641	2.645	2.619	2.623	2.639
P_b	5.14	5.39	5.64	5.89	4.92	5.17	5.42	5.67	4.62	4.87	5.12	5.37	5.02	5.27	5.52
P_{be}	4.63	4.89	5.14	5.39	4.30	4.55	4.80	5.05	4.20	4.45	4.70	4.95	4.71	4.96	5.21
VMA	16.8	16.7	16.4	15.9	15.3	15.1	15.0	15.0	15.2	15.1	15.1	15.2	15.7	15.8	15.5
VFA	70.6	75.1	80.9	88.1	72.4	77.5	82.8	87.6	71.1	76.2	80.8	84.8	74.5	81.0	87.0
% dust	5.3	5.3	5.3	5.3	5.8	5.8	5.8	5.8	6.3	6.3	6.3	6.3	5.7	5.7	5.7
DB Ratio	1.14	1.08	1.03	0.98	1.35	1.28	1.21	1.15	1.50	1.42	1.34	1.27	1.21	1.15	1.09

Volumetrics

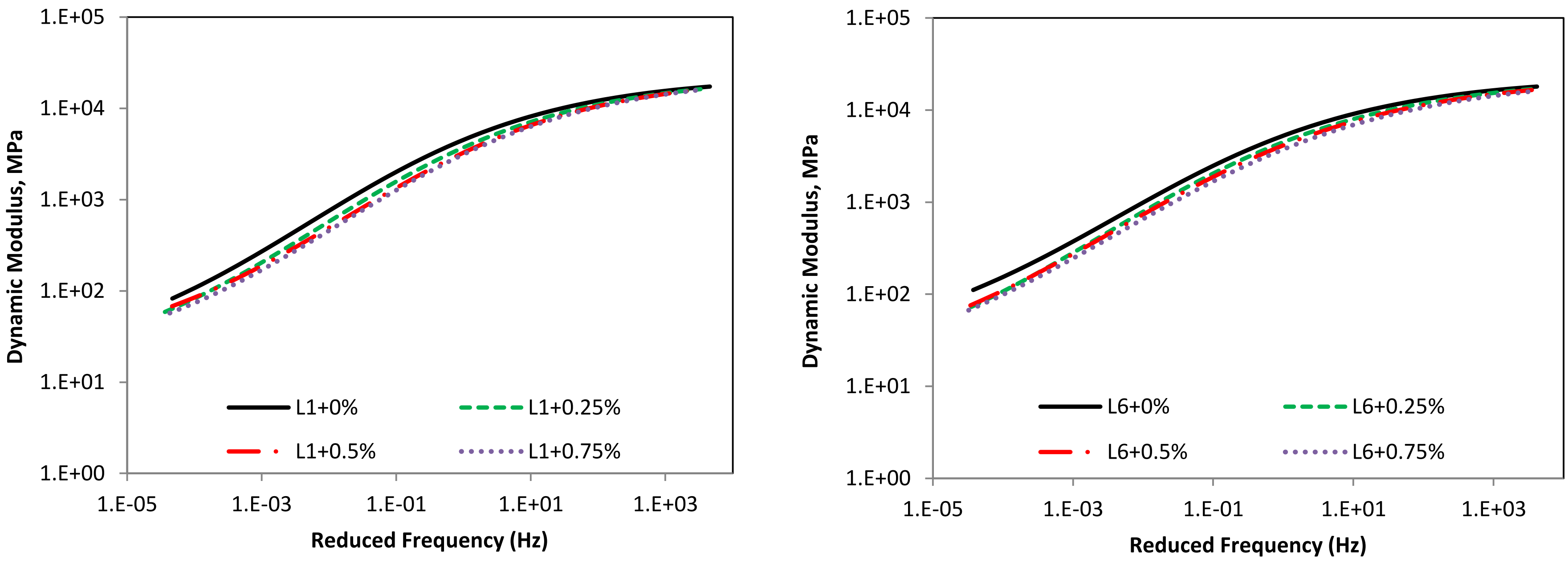
Requirements	
Air Voids	**3%-5%**
VMA	**> 14%**
VFA	**65%-78%**



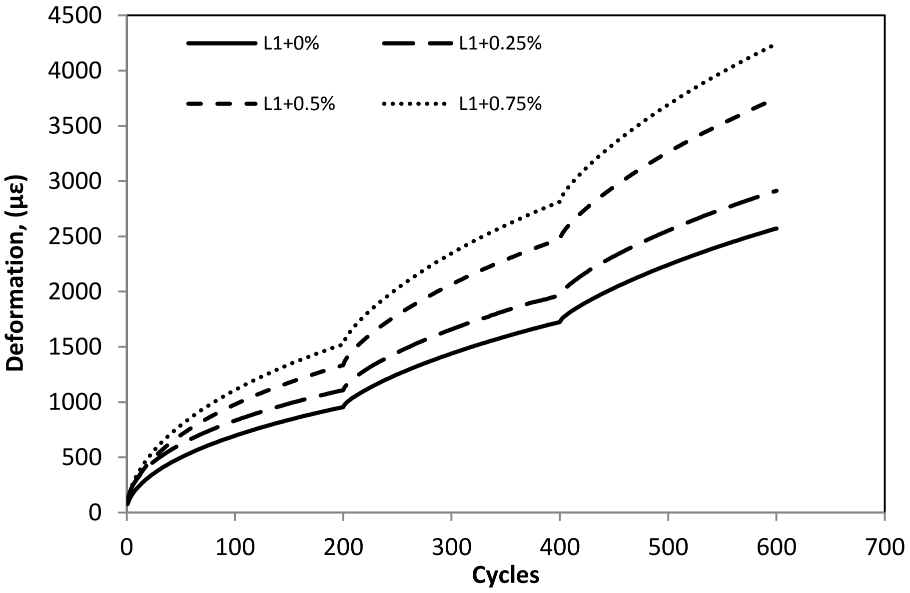


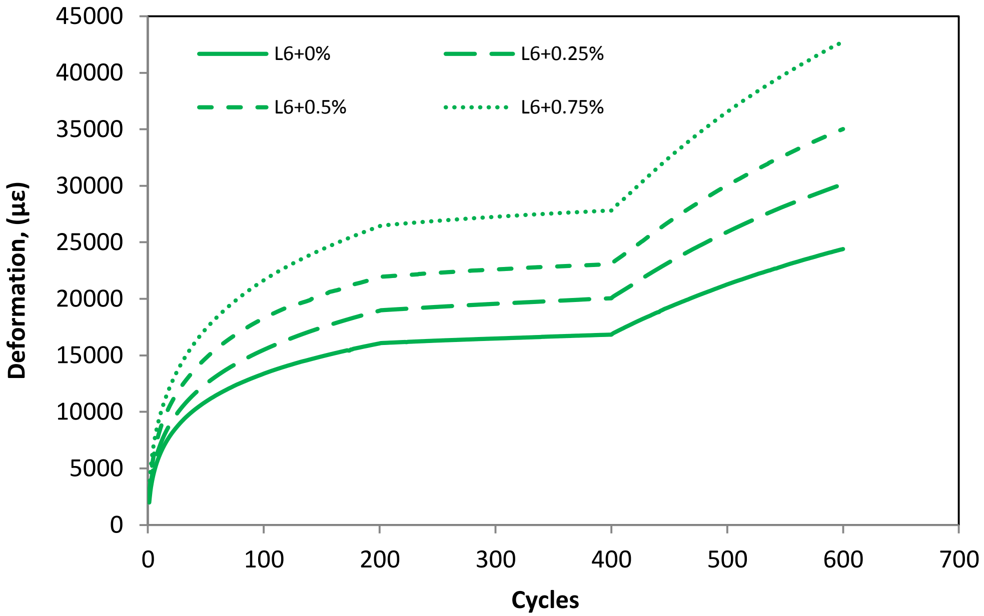


Dynamic Modulus



Stress Sweep Rutting Results





Fatigue Testing Results

Under Analysis

Stress Sweep Rutting Testing

with

Small Geometry Specimen

AMPT Performance Tests

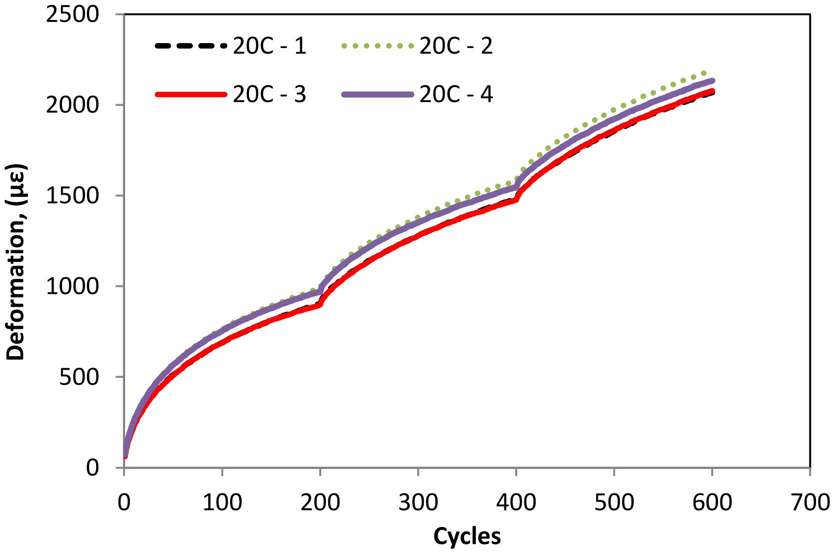
- **TFHRC using AMPT/SPT for 14 years**
- **Dynamic modulus test**
  - full size + small size specimens
- **Axial direction tension cyclic fatigue test**
  - full size + small size specimens
- **Direct tension monotonic test**
  - Small size specimens
- **Stress sweep rutting test**
  - full size + small size specimens
- **Flow number test**

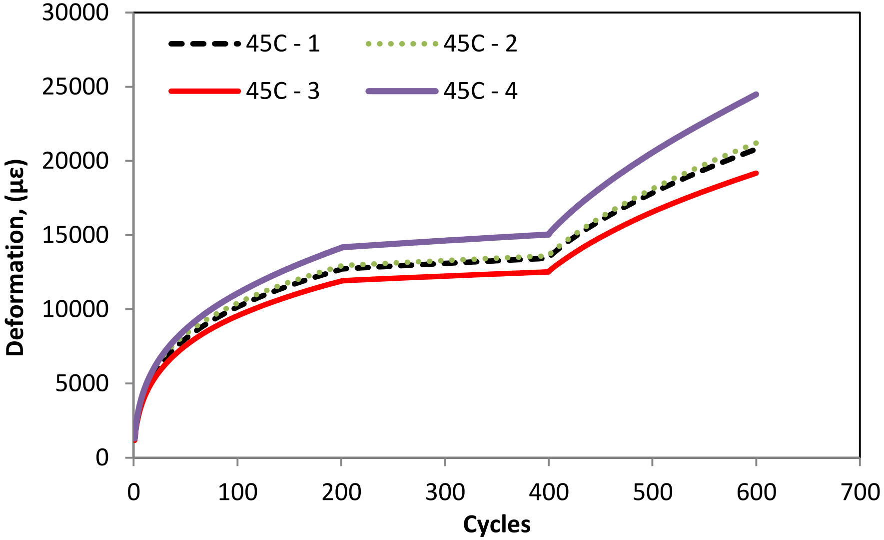
Stress Sweep Rutting Test

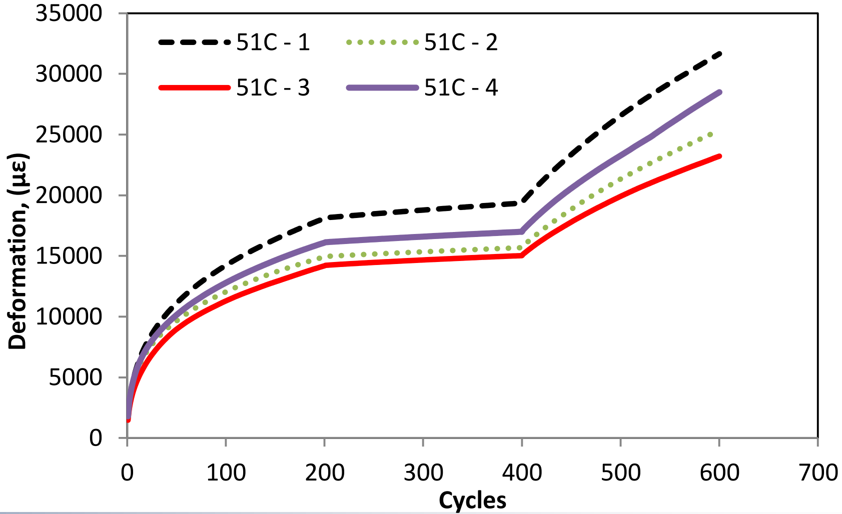
- **One loose mix (PG 64E-34)**
- **Three air voids**
  - 5%, 7% and 9%
- **Three temperatures**
  - 20°C, 51°C, 45°C
- **Two geometry**
  - 38mm x 110mm
  - 100mm x 150mm

SSR Testing Results

- Repeatability
  - 38mm + 5% Va

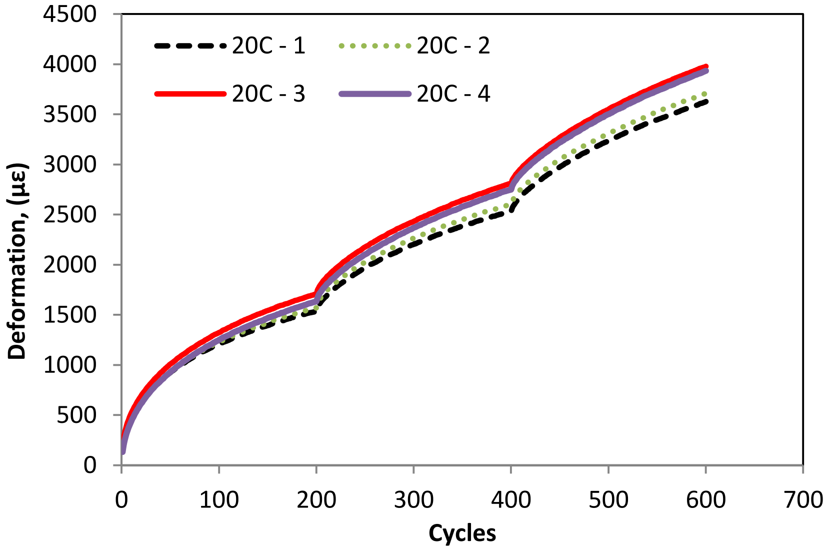


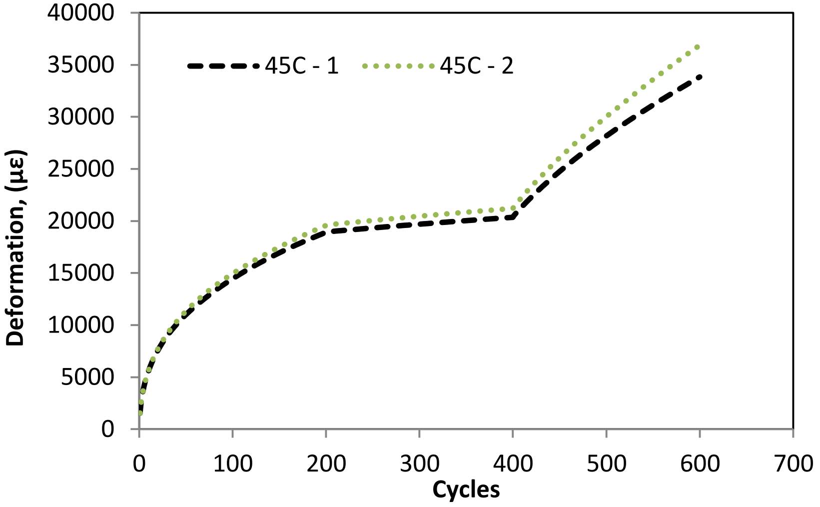


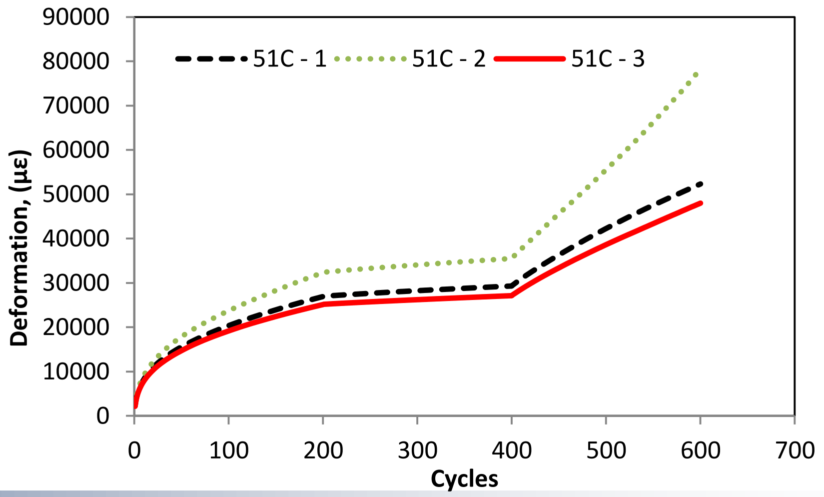


SSR Testing Results

- Repeatability
  - 38mm + 9% Va

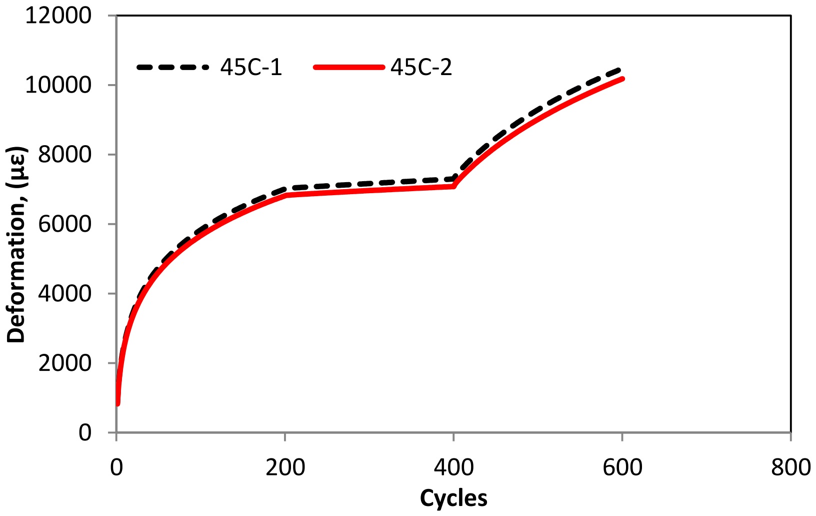


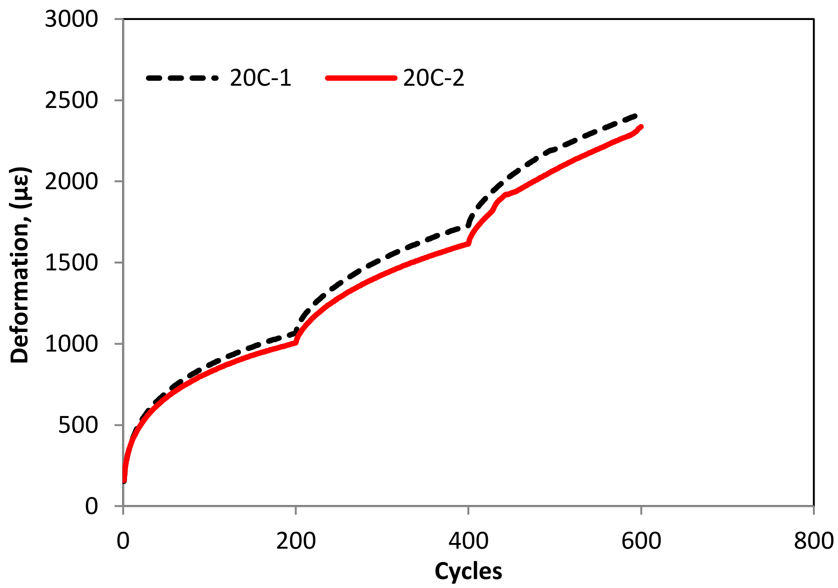


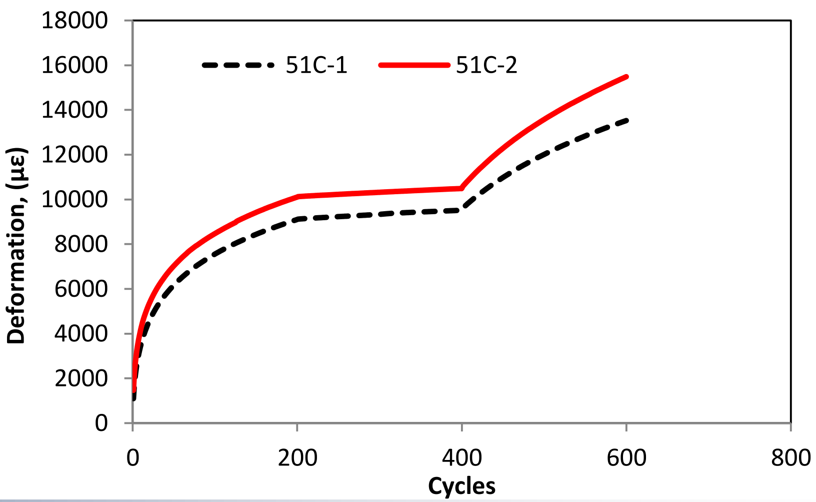


SSR Testing Results

- Repeatability
  - 100mm + 5% Va

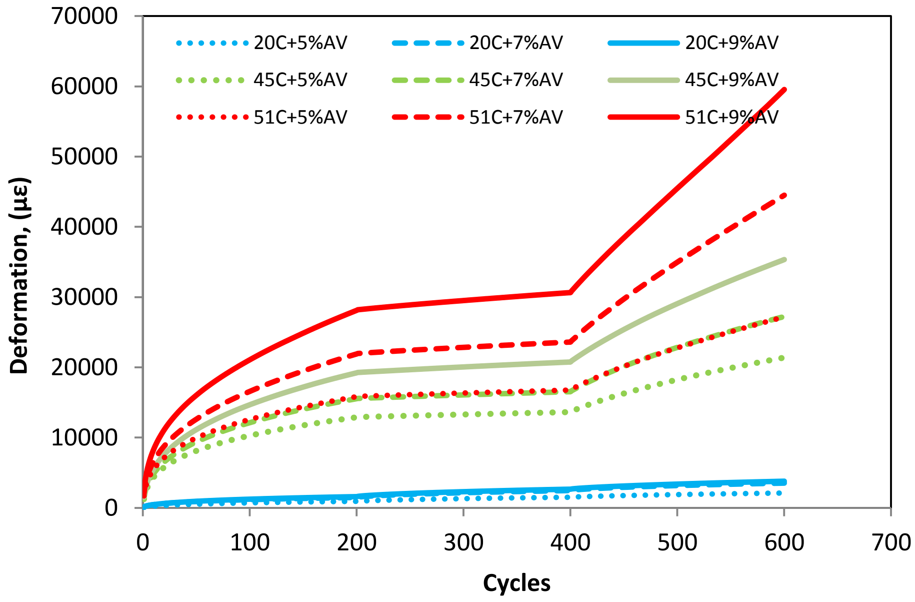




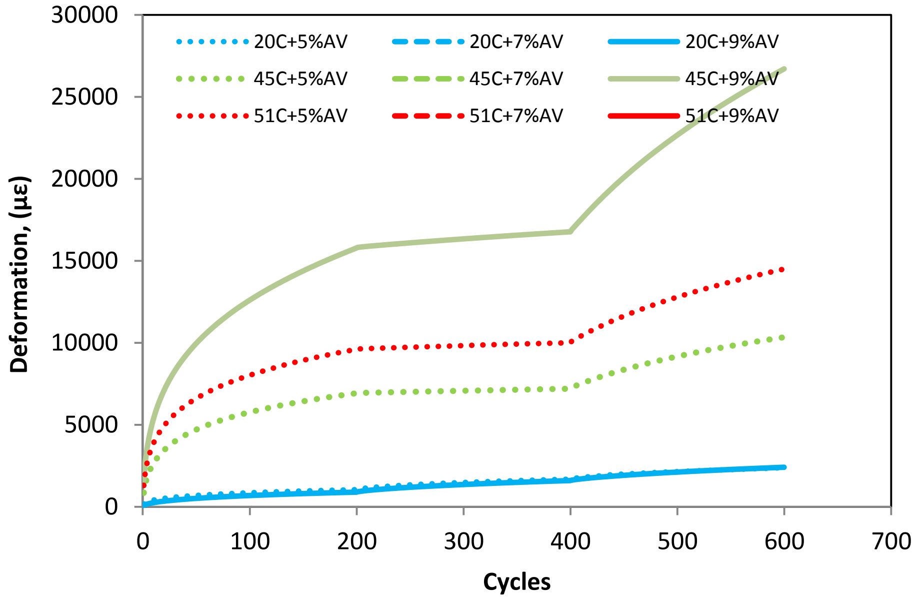


SSR Testing Results

- Effect of air voids
  - 38mm vs. 100mm



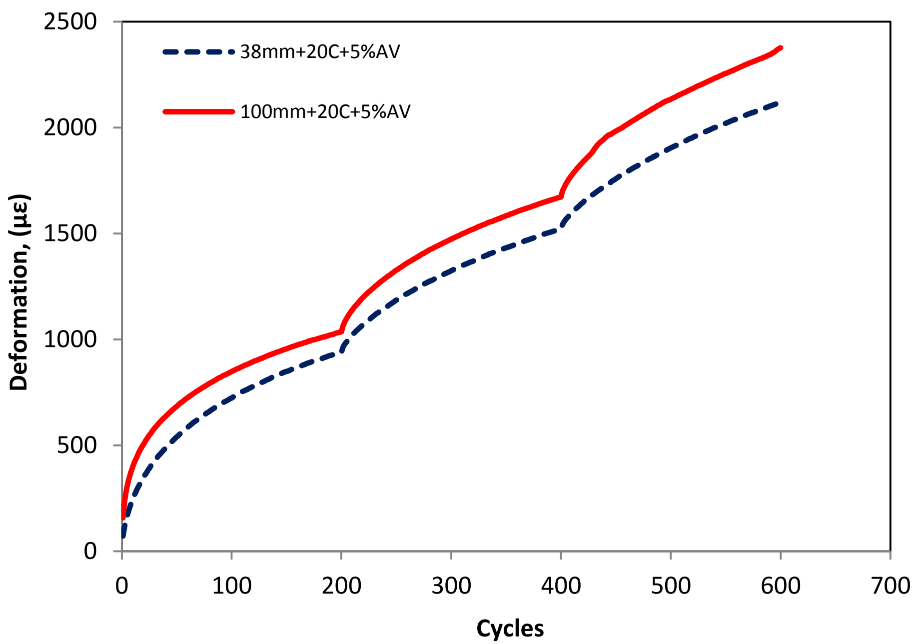
Small specimen



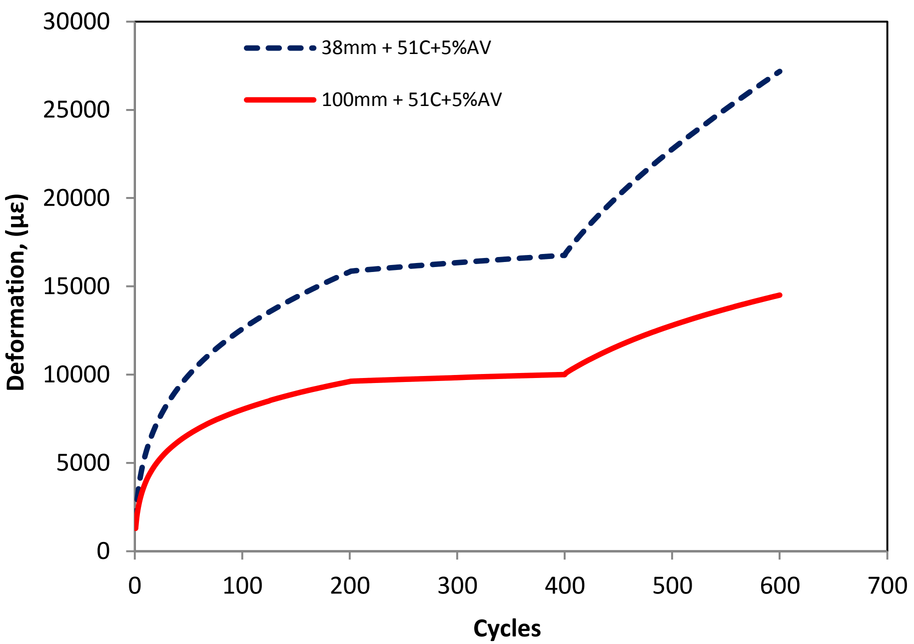
Full size specimen

SSR Testing Results

- **Effect of geometry**
  - 38mm vs. 100mm



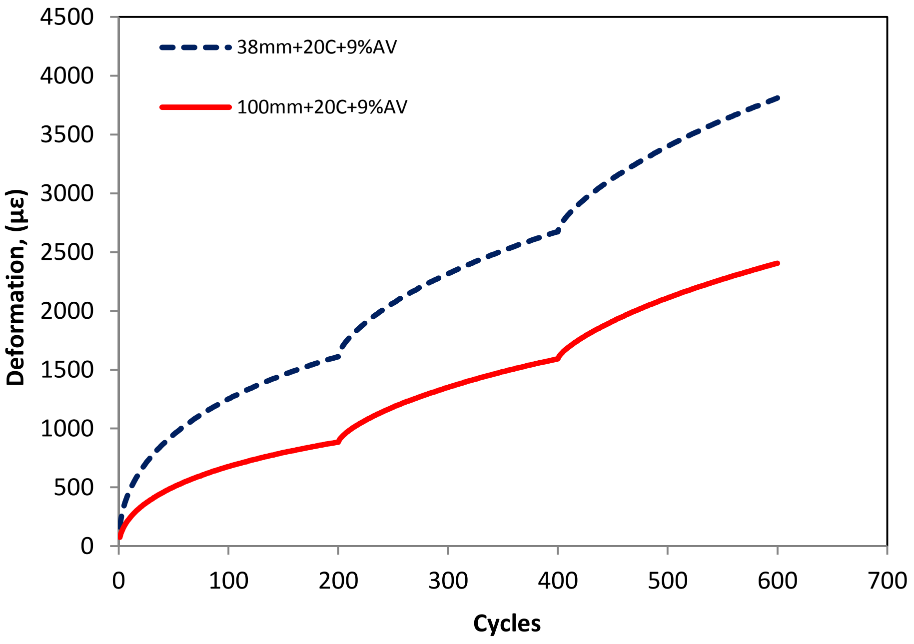
20C+5%Va



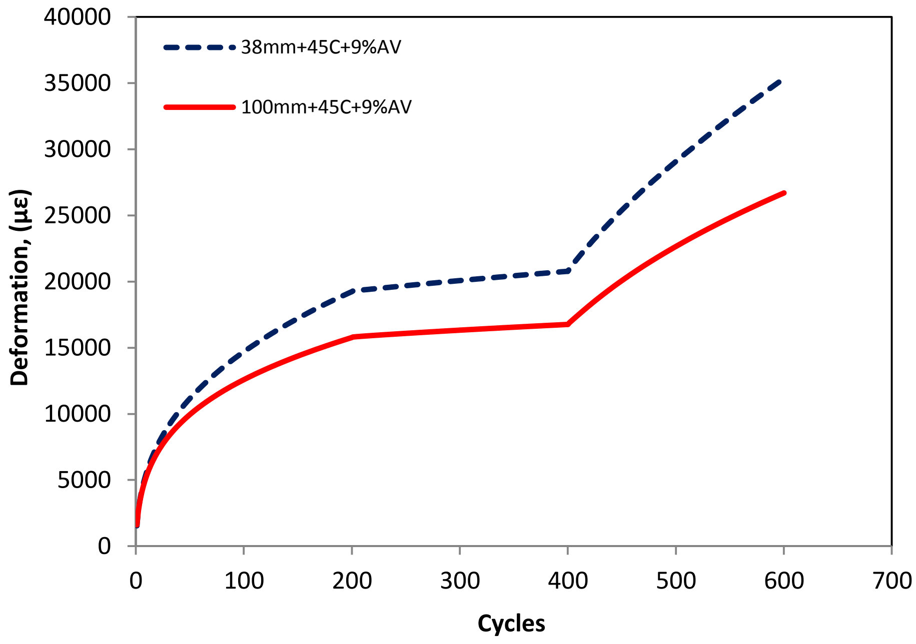
51C+5%Va

SSR Testing Results

- Effect of geometry
  - 38mm vs. 100mm



20C+9%Va



45C+9%Va

Thank You!

+

Questions?