Proposed Small Specimen Geometry Specifications

Specimen Fabrication, AMPT Dynamic Modulus, and AMPT Cyclic Fatigue

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Presented to the Asphalt Mixture ETG

Ames, IA

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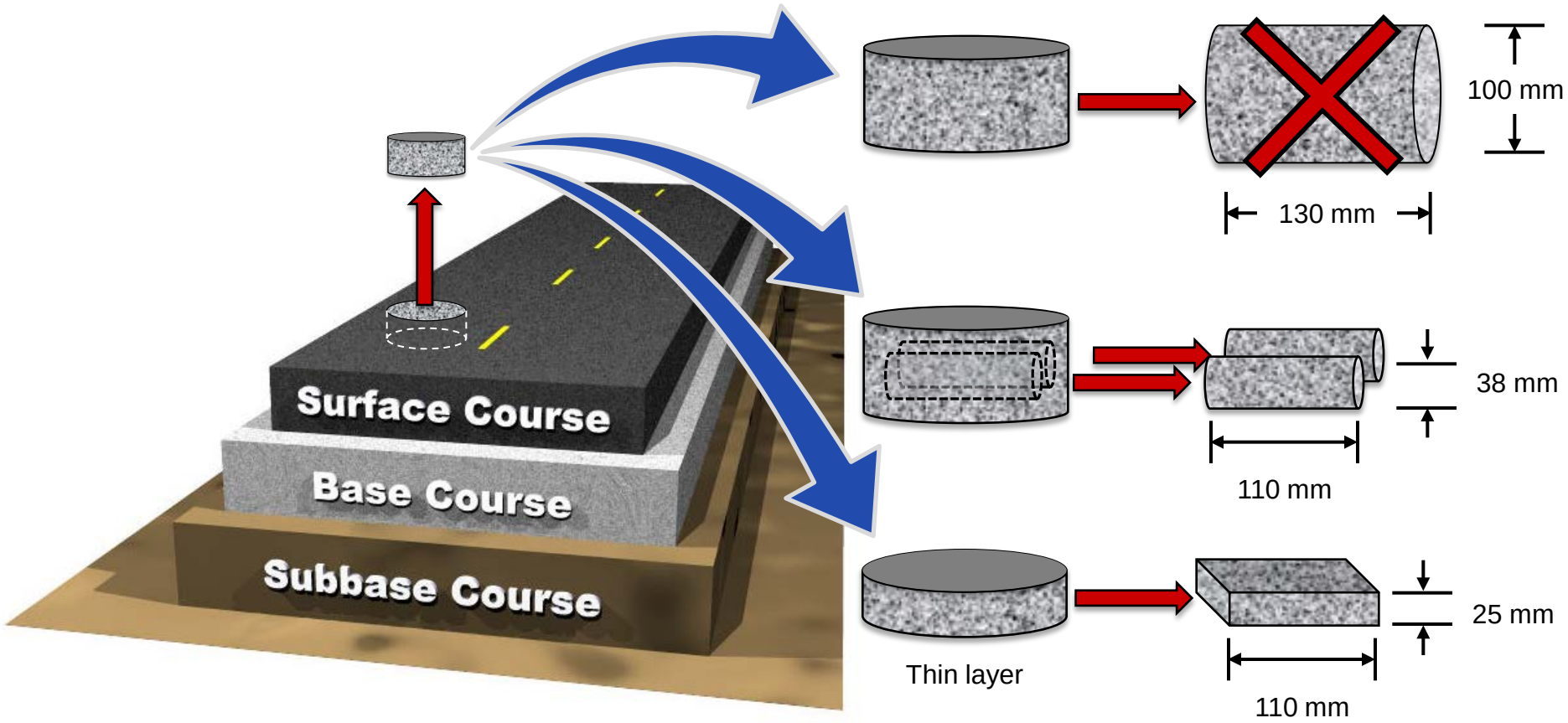
Outline

- Introduction
- Experimental Plan
- Results
- Proposed Specifications

Introduction

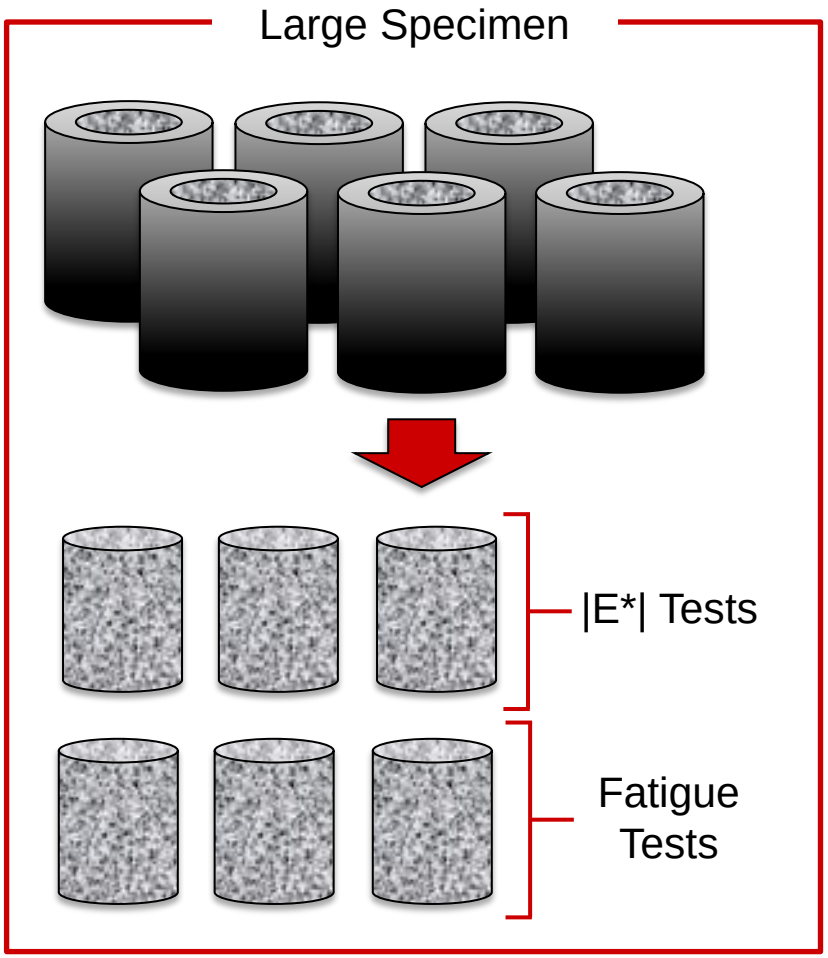
Small Specimen Geometries

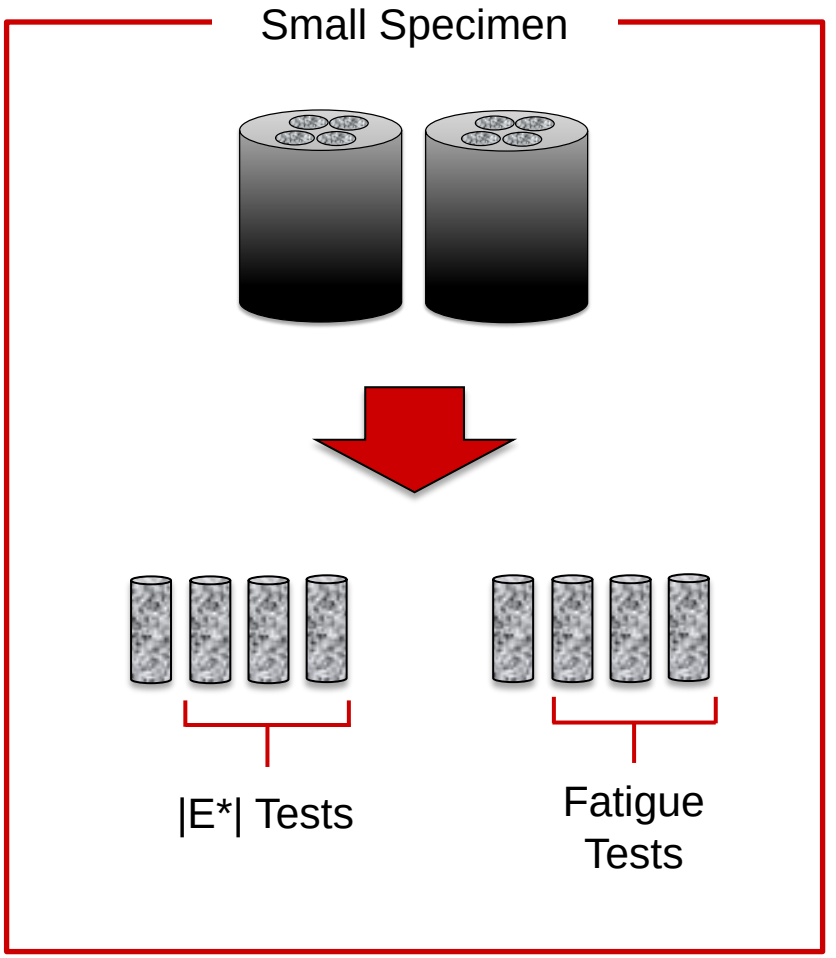
- Proposed to enable field core testing (Kutay et al. 2009, Park and Kim 2013, Li and Gibson 2013, and Bowers et al. 2015)



Introduction
Small Specimen Geometries

- Improve the efficiency of laboratory specimen fabrication





Introduction

NCHRP IDEA Project Objectives

- Evaluate the effects of specimen geometry on dynamic modulus and direct tension fatigue tests using mixtures with various NMAS values.
- Optimize the laboratory fabrication of small specimens extracted from gyratory-compacted specimens.

Experimental Plan

Materials

- Plant-produced loose mixtures

Mixture Type	NMAS (mm)	Asphalt Binder	RAP Content (%)
RSF9.5A	9.5	PG 64-22	30
RS9.5D	9.5	PG 76-22	20
SM12.5A	12.5	PG 64-22	30
RI19.0B	19.0	PG 64-22	20
RI19.0B(2)	19.0	PG 64-22	34
RB25.0B	25.0	PG 64-22	30

Experimental Plan

Test Methods

- Dynamic Modulus

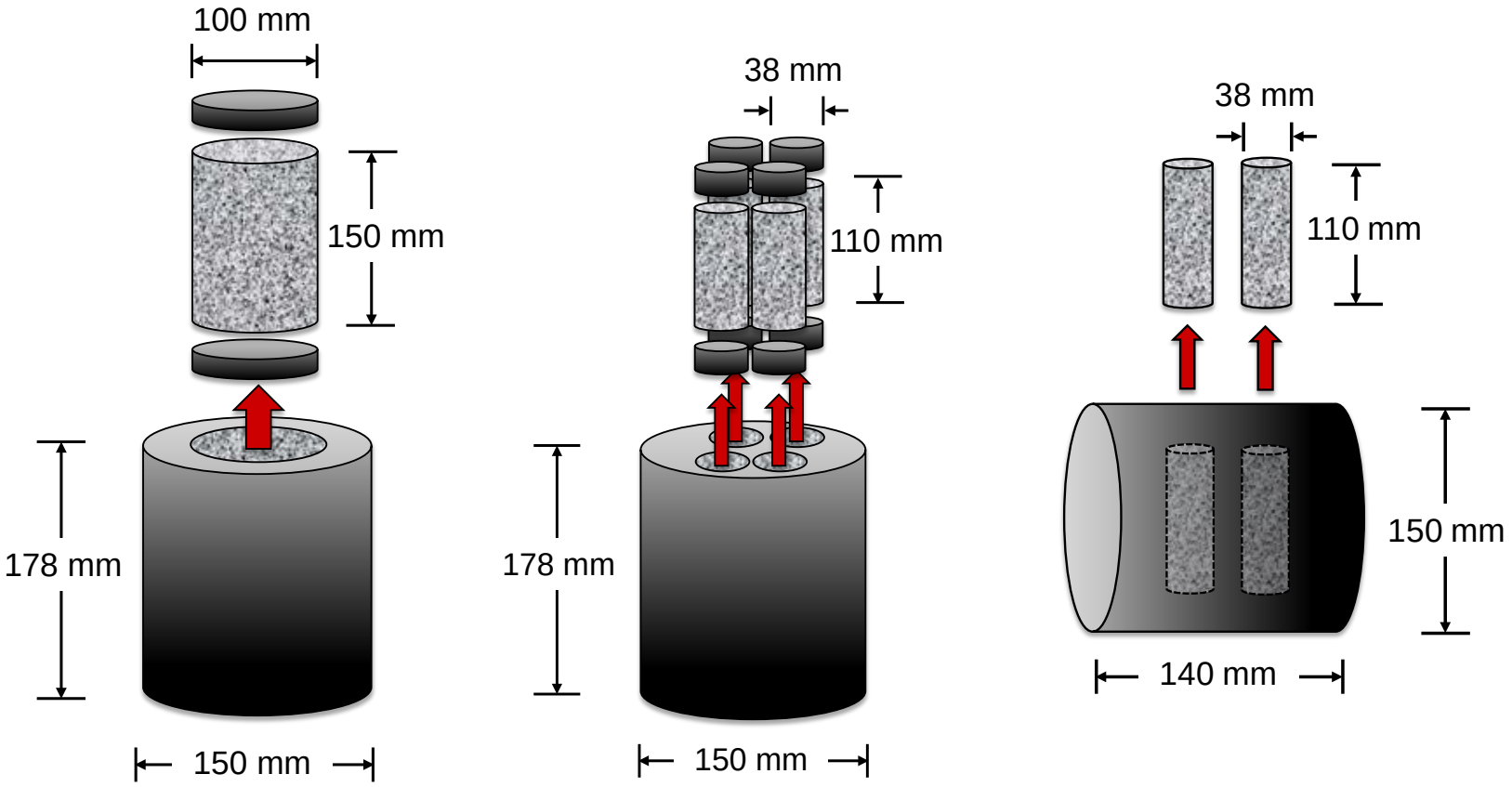
	Large Specimen	Small Specimen
Test Temperatures	4, 20, 40, and (54)°C	
Test Frequencies	25, 10, 5, 1, 0.5, and 0.1 Hz	

- Cyclic Fatigue

	Large Specimen	Small Specimen
Test Temperature	18°C	
Test Frequency	10 Hz	
Epoxy Curing Time	16 hours	1 hour

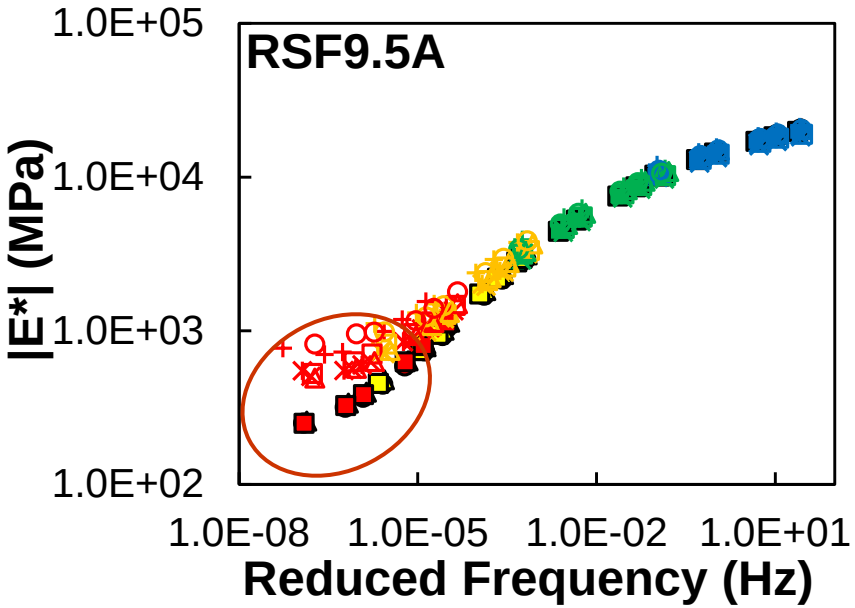
Experimental Efforts

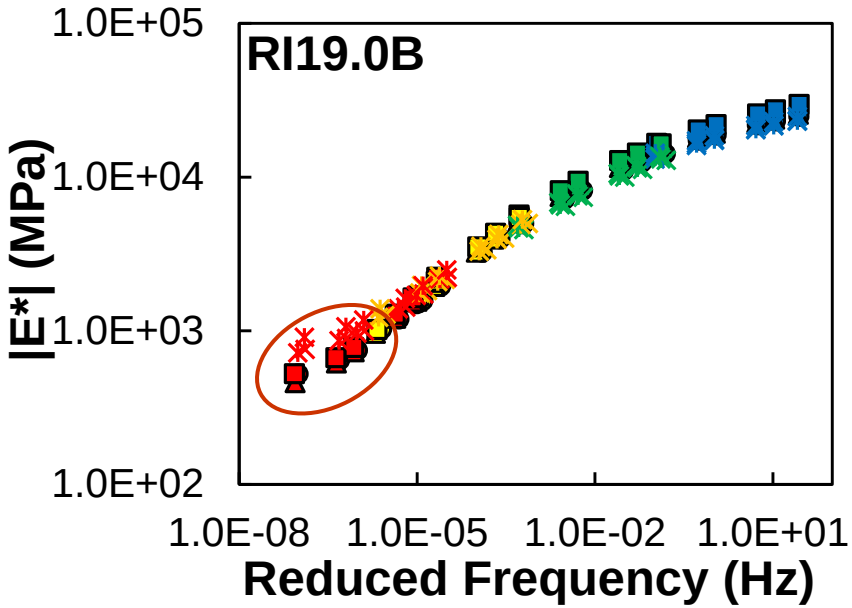
Specimen Fabrication



Results

Specimen Geometry Effects





Solid: large specimen
Line: small cylindrical specimen
Empty: small prismatic specimen

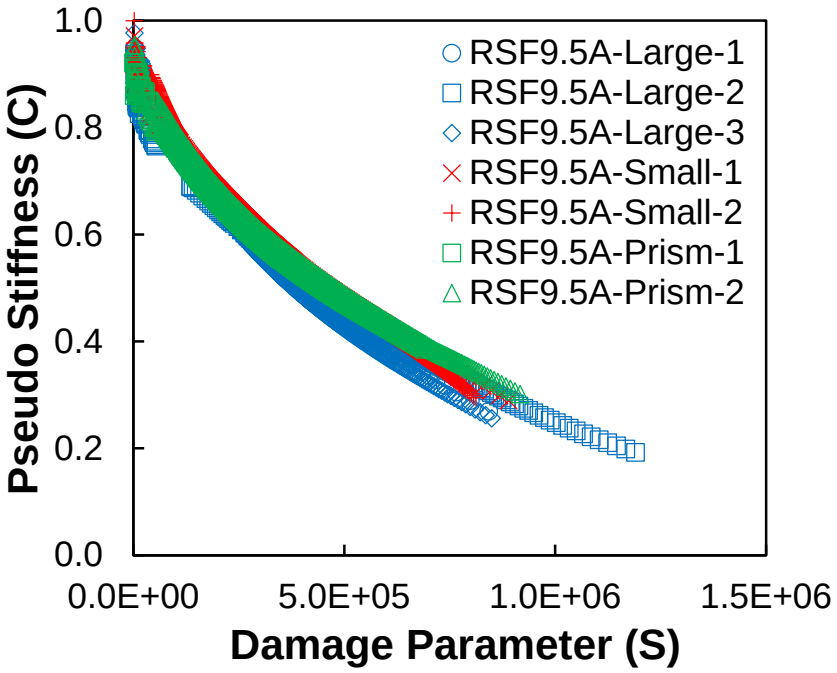
Blue: 4°C test temperature
Green: 20°C test temperature

Yellow: 40°C test temperature
Red: 54°C test temperature

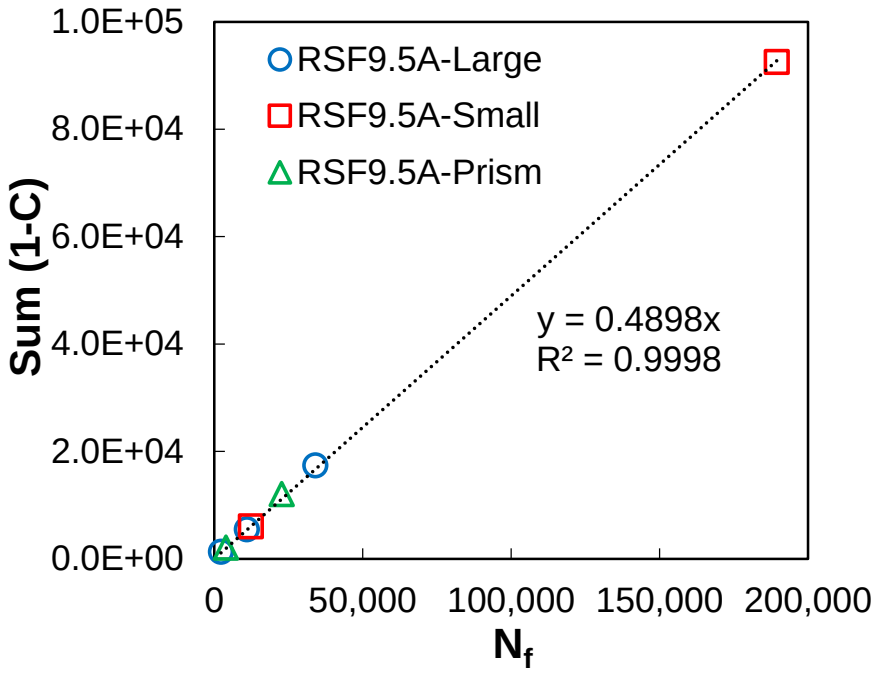
Results

Specimen Geometry Effects - RSF9.5A

Damage Characteristic Curves



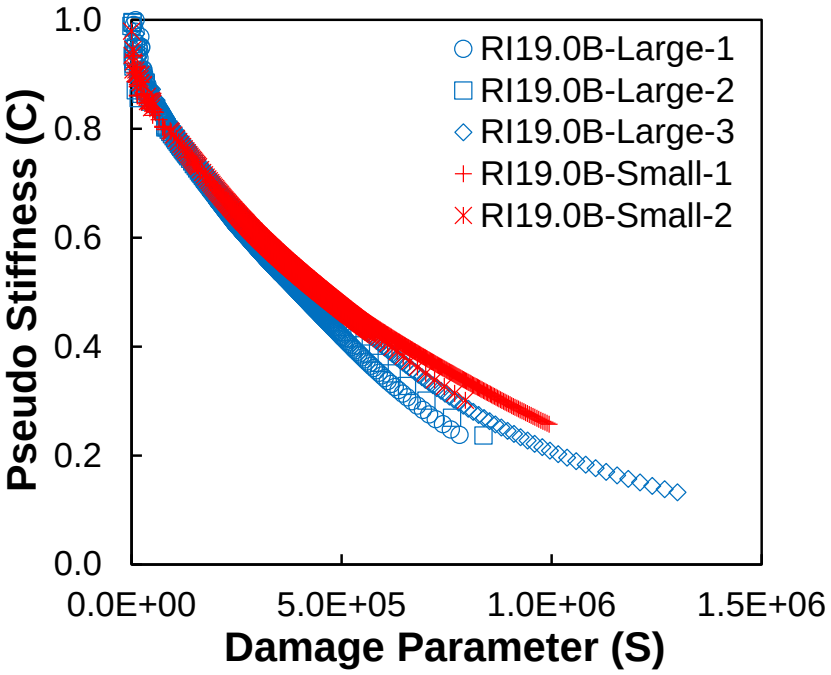
Failure Criterion



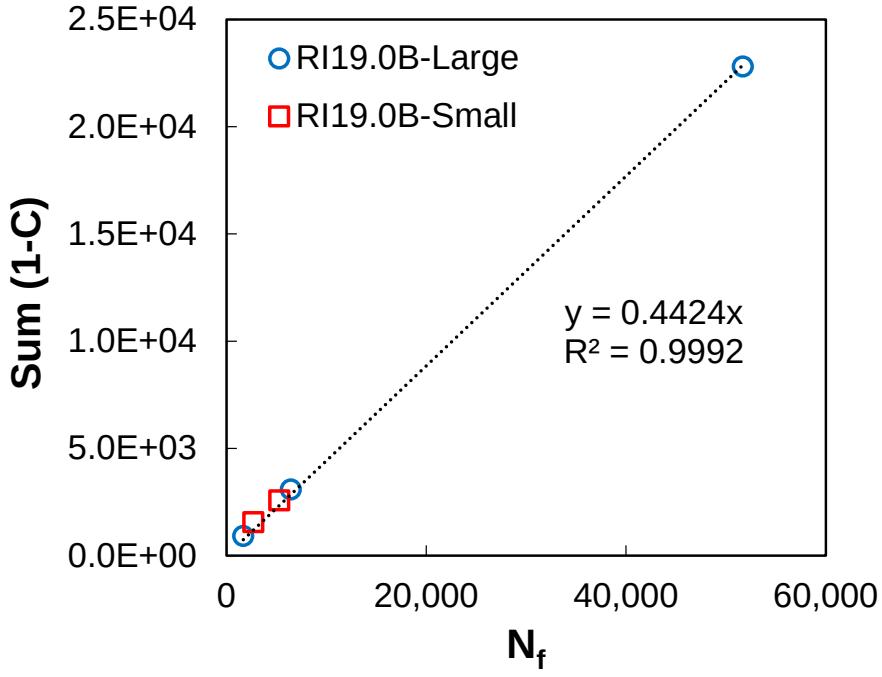
Results

Specimen Geometry Effects - RI19.0B

Damage Characteristic Curves

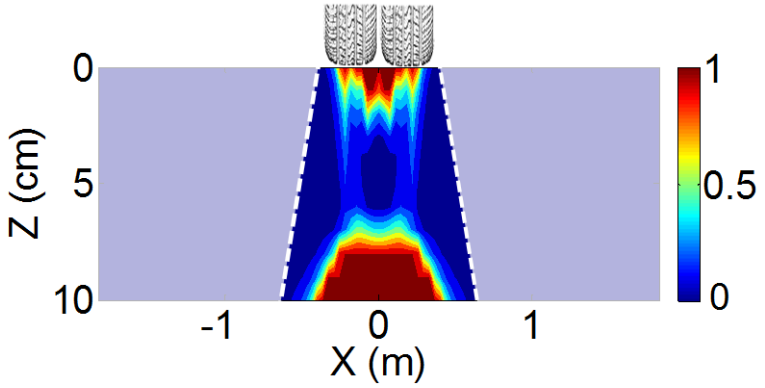


Failure Criterion



Results

FlexPAVE Pavement Performance Prediction

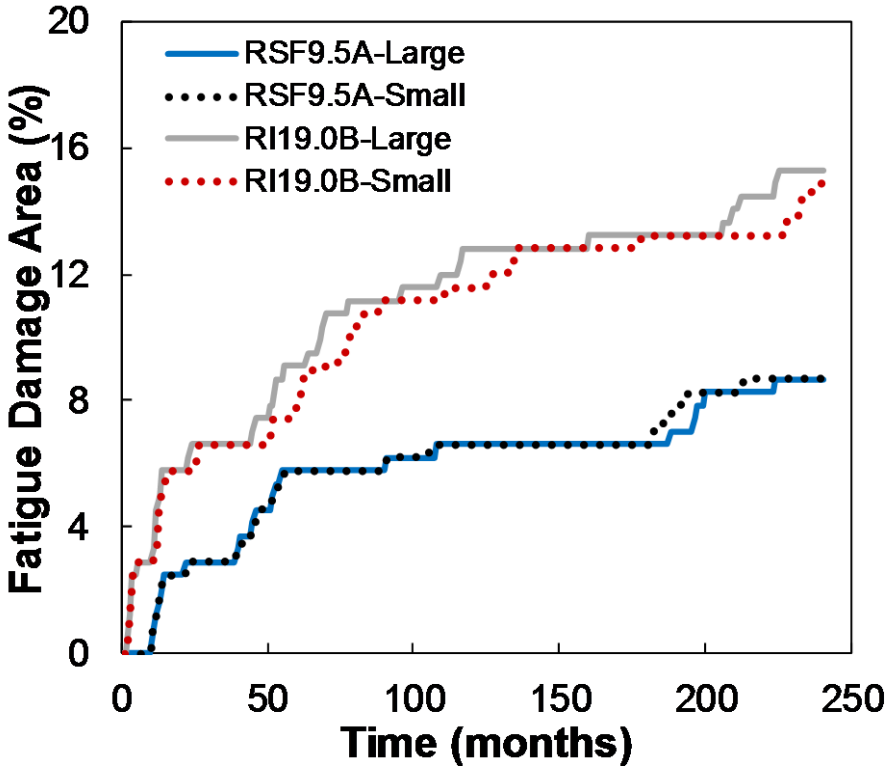


$$Fatigue\ Damage\ Area = \frac{\sum D_i \times Area_i}{Total\ Area} \times 100 \qquad (D_i = 1)$$

where

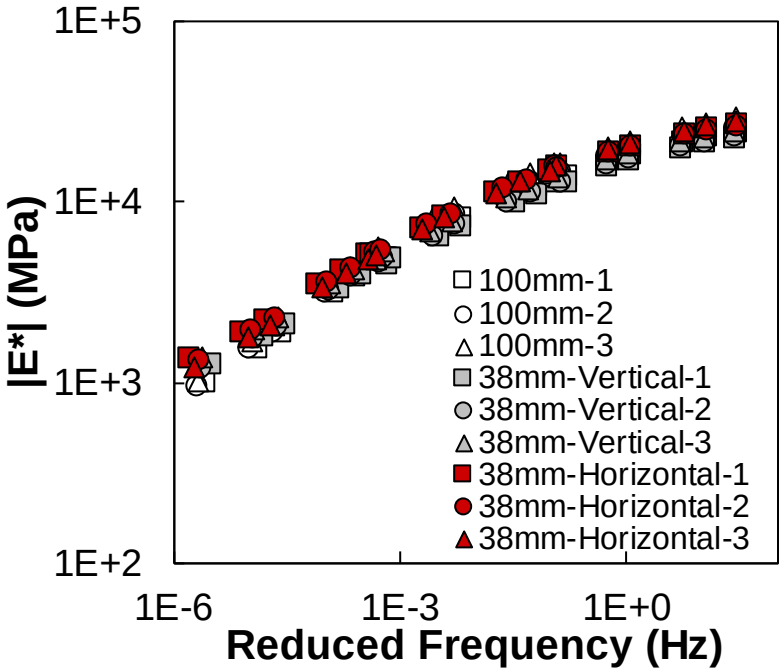
$$D_i = \frac{n_i}{N_{fi}} \ (Fatigue\ Damage\ at\ the\ element\ i,\ 0 \le D_i \le 1)$$

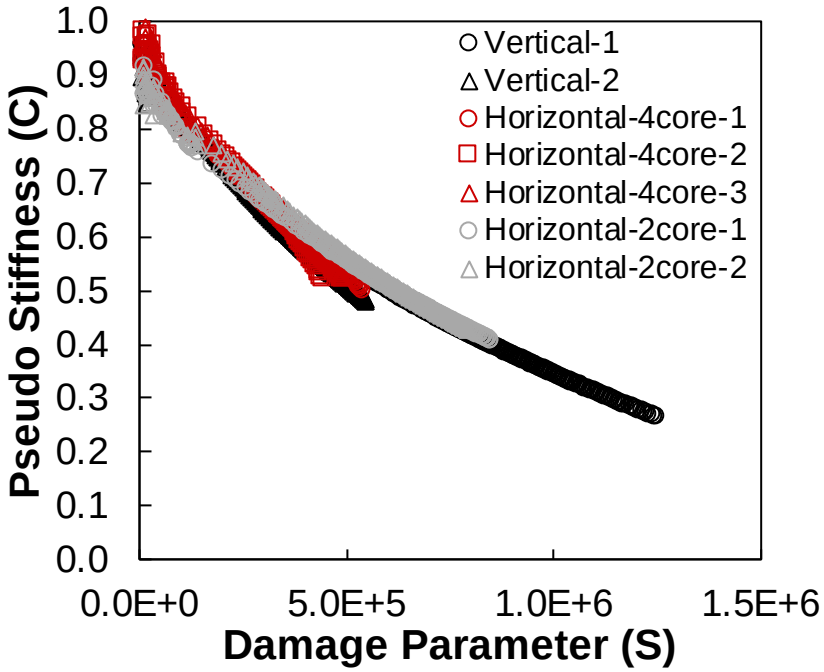
$$Total\ Area = total\ area\ of\ the\ trapezoidal\ area$$



Results

Effect of Coring Direction - RI19.0B

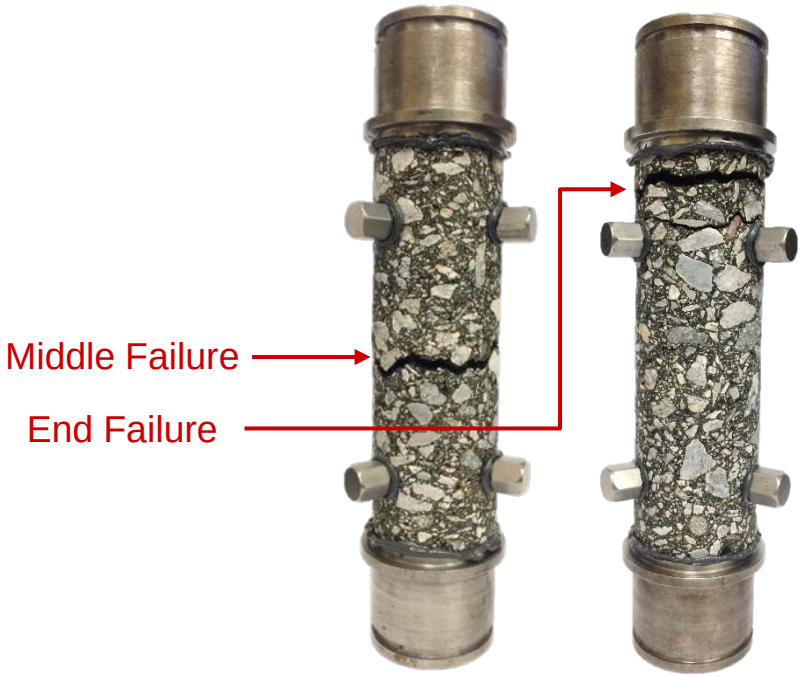




Results

Effect of Coring Direction

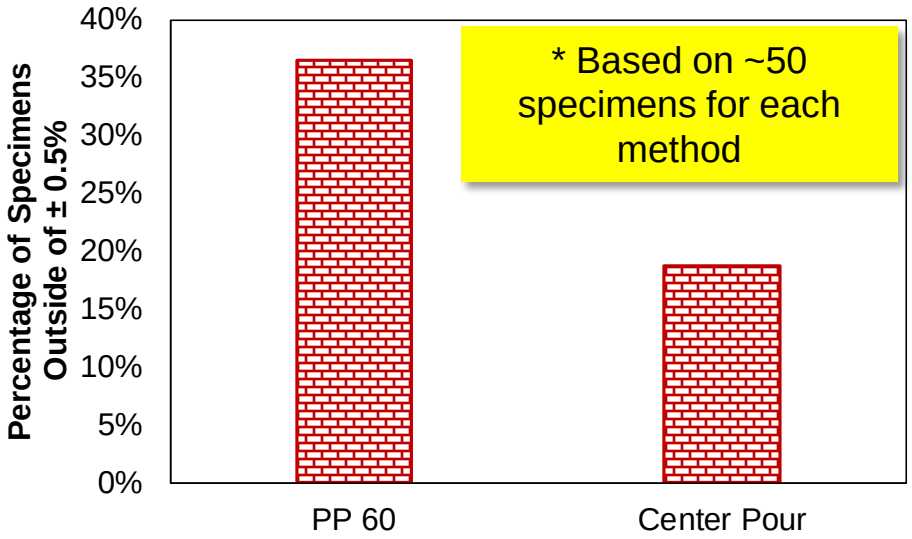
- All of the horizontally-extracted specimens subjected to fatigue testing experienced end failure
  - Vertical coring preferred!



Results

Air Void Variability

- Charging the center of the gyratory compaction mold reduces air void variability
- Produced three gyratory-compacted samples for each mixture evaluated
  - Extracted four small specimens from inner 100-mm diameter
  - All of the specimens were tested regardless of air void content
    - ✓ All air void contents within the range of ± 0.7% of the average

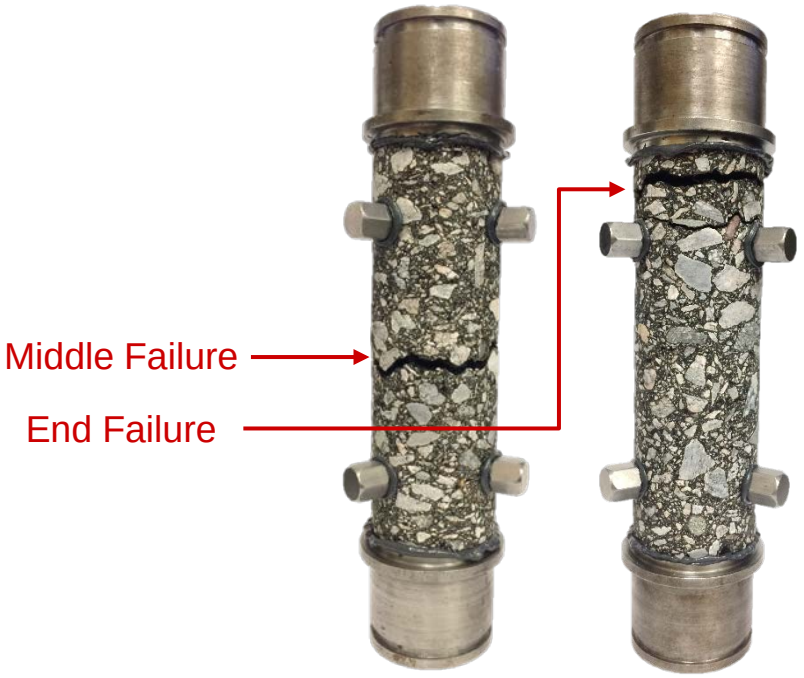


Results

Statistics on the Middle Failure using Vertical Coring

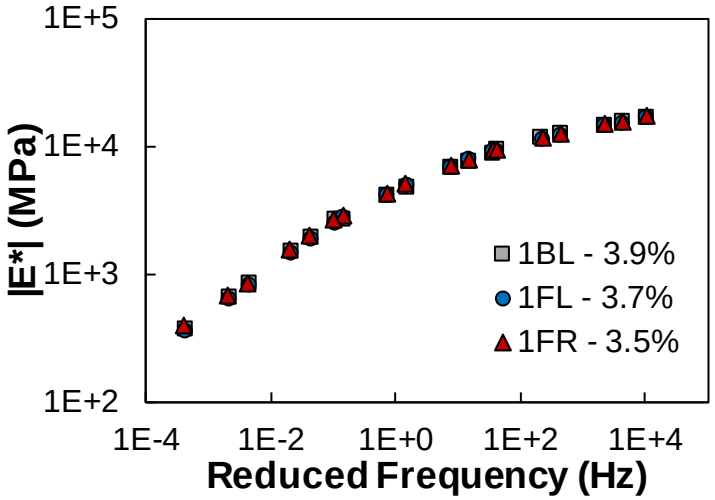
- Fabricated two gyratory specimens for each mixture
- Extracted four cores from a gyratory specimen
- Tested all eight specimens for each mixture

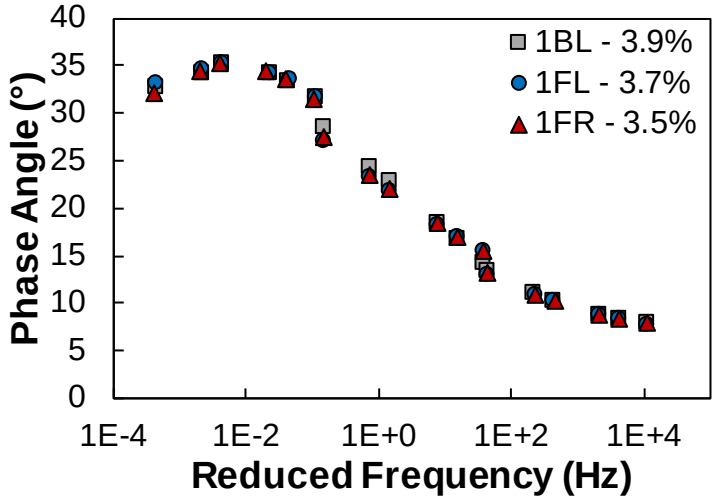
Mixture	End failures/ Number of Tests
RS9.5D	0/8
SM12.5A	1/8
RI19.0B	2/8
RB25.0B	0/8

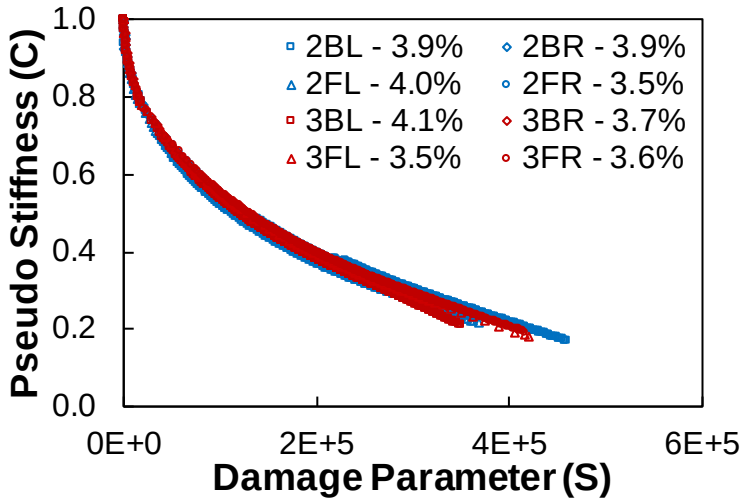


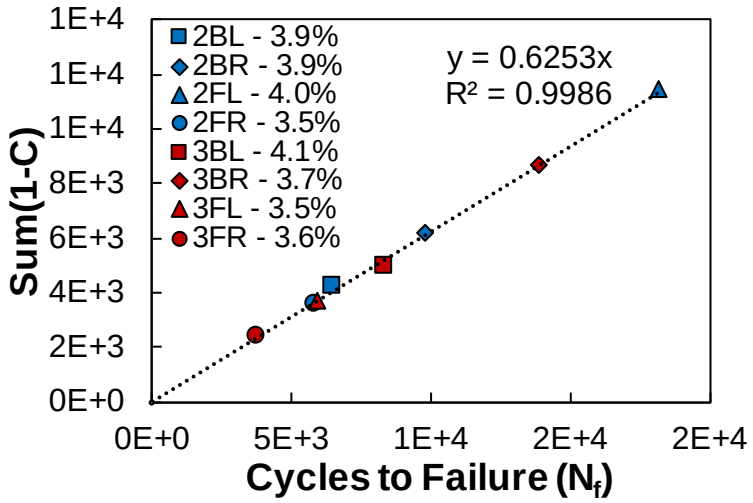
Results

Specimen-to-Specimen Variability – RS9.5D



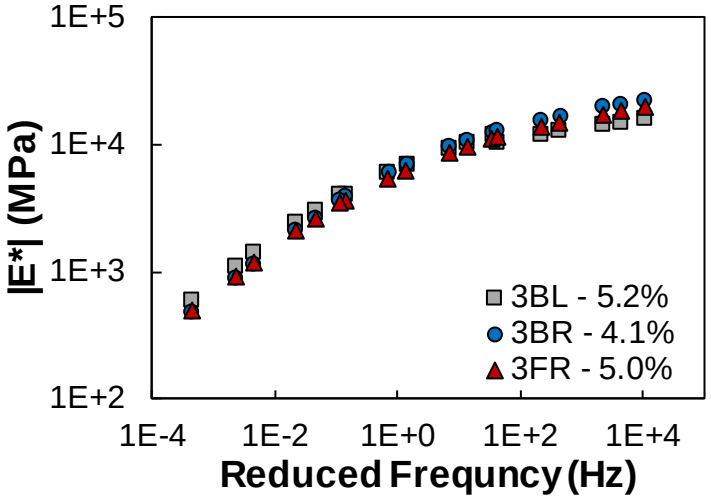


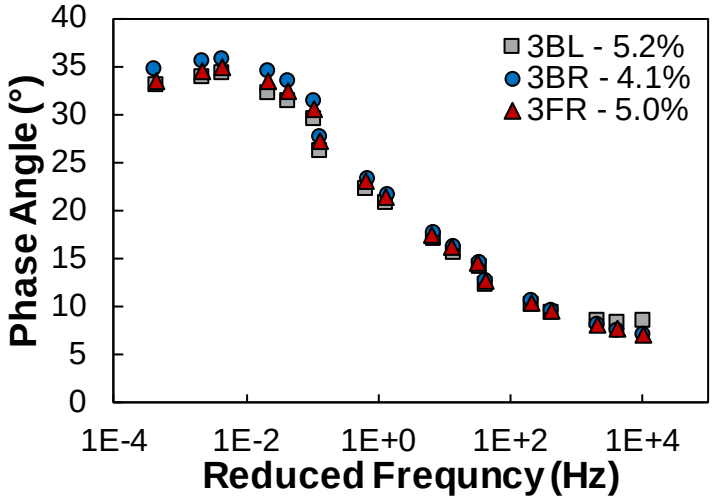


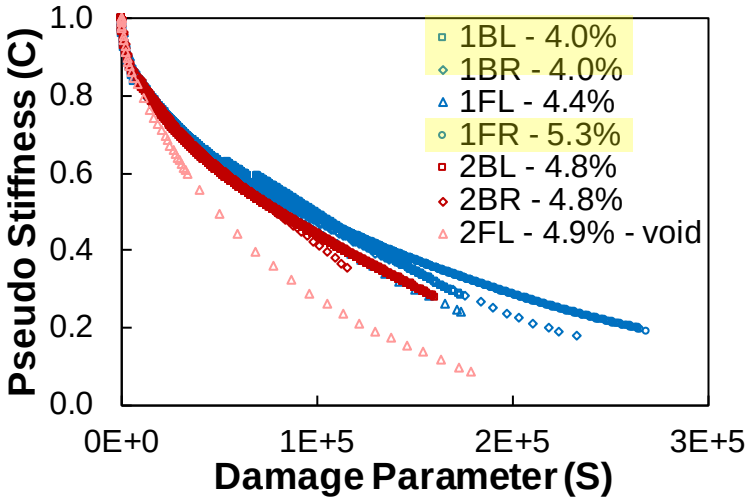


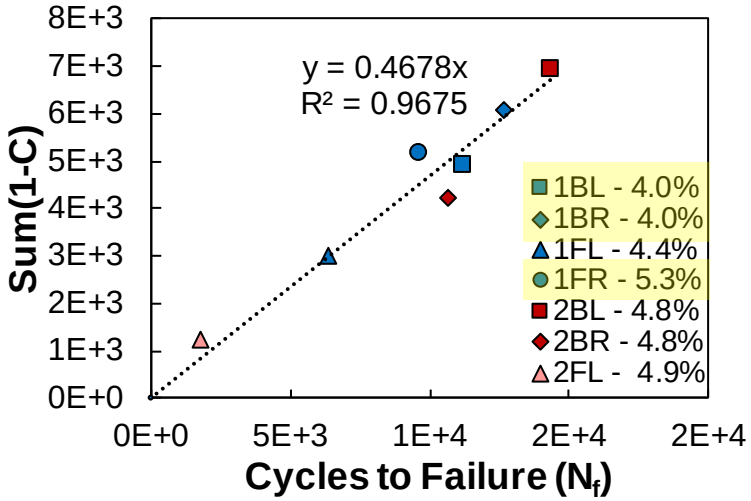
Results

Specimen-to-Specimen Variability – RB25.0B









Results

Summary

- Small specimen testing provides equivalent dynamic modulus test results to large specimen testing at low and intermediate temperatures.
  - Do not recommend testing at 54°C
- Small specimen testing provides equivalent cyclic fatigue test results to large specimen testing
- Anisotropy in gyratory-compacted samples does not affect dynamic modulus or cyclic fatigue test results.
- Horizontal coring in laboratory specimen fabrication should be avoided because it leads to end failure in cyclic fatigue tests.
- The recommended procedure for laboratory fabrication of small specimens is the vertical coring of four specimens from the inner 100-mm diameter of gyratory-compacted samples.

Proposed Specifications
Overview

- Three specifications
  - Fabrication
    - ✓ Follows AASHTO PP60
    - ✓ Covers laboratory specimen fabrication and extraction of small specimens from field cores
  - AMPT Dynamic Modulus Testing
    - ✓ Follows AASHTO TP79
  - AMPT Cyclic Fatigue Testing
    - ✓ Follows AASHTO TP107

Proposed Specifications

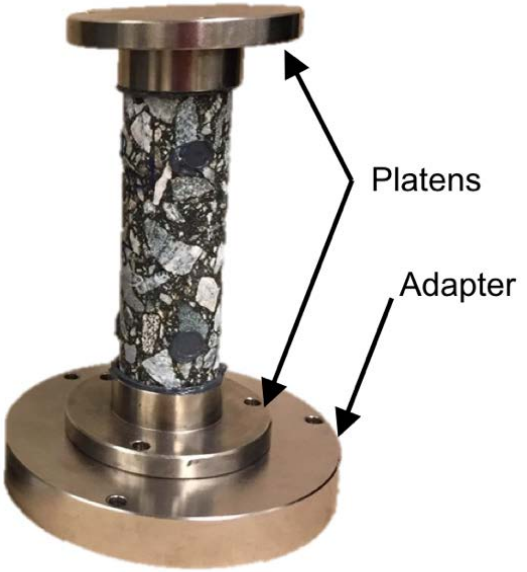
Key Differences from Large Specimen Specs & Questions

- Fabrication
  - Prepare 180-mm tall SGC sample
    - ✓ Charge the center of the mold in two lifts, rod each lift
    - ✓ **Question:** Does anyone have suggestions for facilitating charging the center of the mold?
  - Extract four specimens from inner 100-mm diameter of SGC sample
  - Extract two specimens per lift from 6-in field core

Proposed Specifications

Key Differences from Large Specimen Specs & Questions

- AMPT Dynamic Modulus
  - Select test temperatures using AASHTO PP61
    - ✓ 3 temperatures
  - Apply 50 to 75 peak-to-peak on-specimen microstrain
- AMPT Cyclic Fatigue
  - 5 min epoxy
  - Use adapters to attach specimen to AMPT
  - Apply reduced seating load of 10 N
  - **Question:** For fatigue testing, would it be better to require the testing of three or four specimens?
- Both
  - Increase air void tolerance to ± 0.7%, to be refined upon Ruggedness Testing
  - **Question:** Agree or adopt ± 0.5% from large specimen testing?



Thank you!

- Questions?