Update for the

FHWA ALF Research Activities

Project #1:

High RAP (RAS) + WMA Accelerated Pavement Test

RAP/RAS and WMA

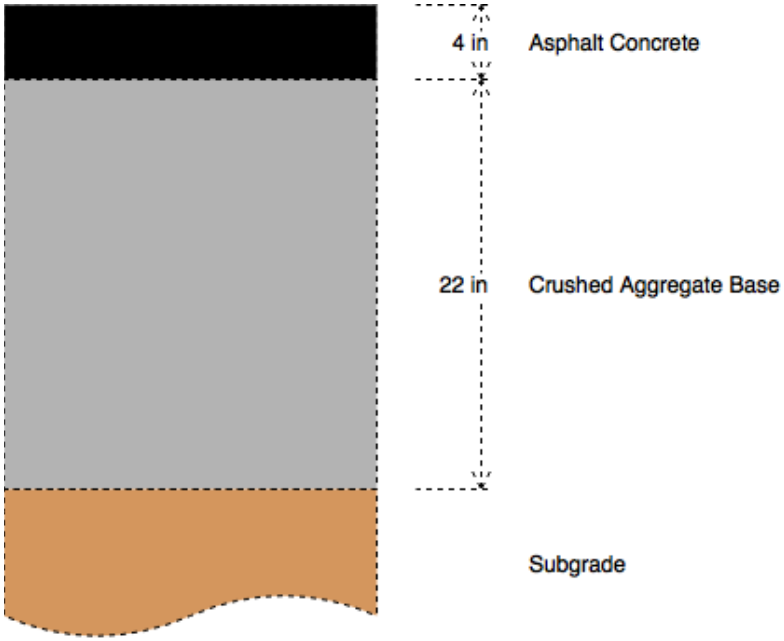
- **Purpose**
  - Advance Use of Recycled Asphalt in Flexible Pavement Infrastructure: Develop and Deploy Framework for Proper Use and Evaluation of Recycled Asphalt in Asphalt Mixtures

- **Objective**
  - Quantify cracking resistance of high RAP/RAS mixtures that considers the use of lower temperature production with warm-mix asphalt (WMA); Investigate limitations and provide recommendations for combining the two technologies

The Experiment

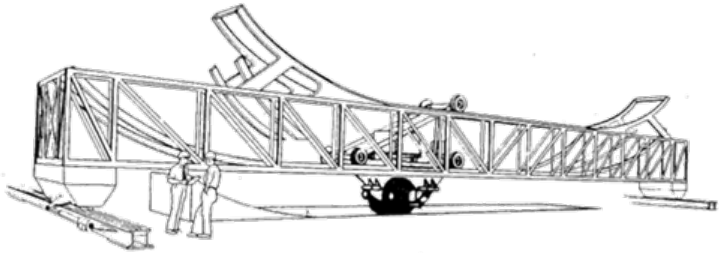
Structure

- 10 Lanes (10 Mixes)
- Build in 2013



Materials

- 2 Binder Grades
- RAP/RAS
- 2 WMA Technologies
- 3 ABR contents



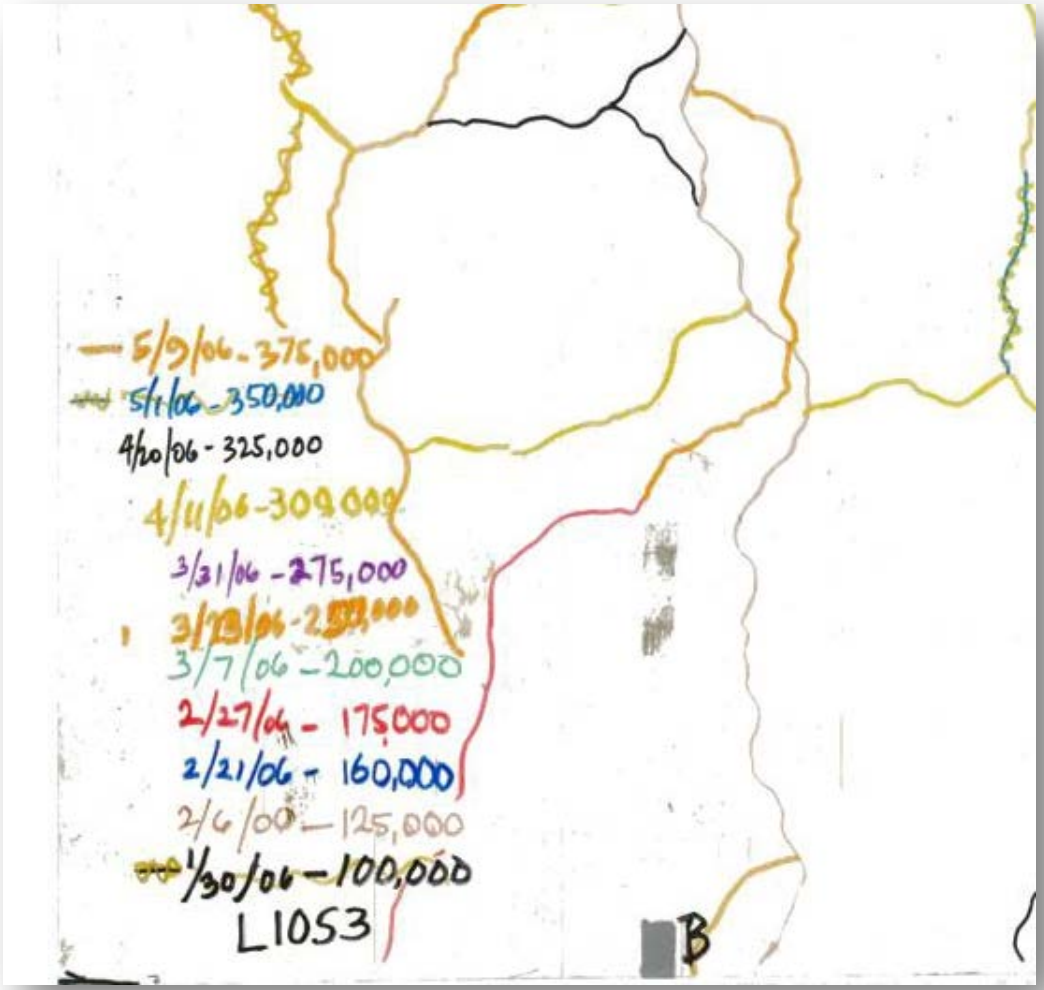
ALF Experimental Design

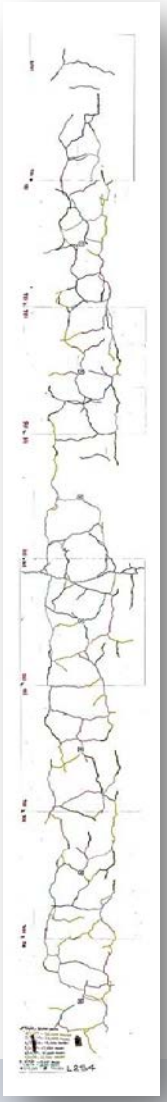
Drum Discharge Temperature / HMA / WMA Warm Mix Technology / Recycle Content	300°F - 320°F		240°F - 270°F	
	-		Foam	Chem.
0%	✔ PG64-22		-	-
20% ABR RAP ≈ 23% by weight	✔ PG64-22		✔ PG64-22	✔ PG64-22
20% ABR RAS ≈ 6% Shingle by weight	✔ PG64-22	✔ PG58-28	-	-
40% ABR RAP ≈ 44% by weight	✔ PG64-22	✔ PG58-28	✔ PG58-28	✔ PG58-28

Loading Conditions

- Tire
  - 425/65R22.5 wide base
  - Tire pressure: 100 psi
- Total load: 14,200 lbf
- Speed = 11 mph (4.9 m/s)
- Isothermal at 20°C (target temperature at AC mid-thickness)

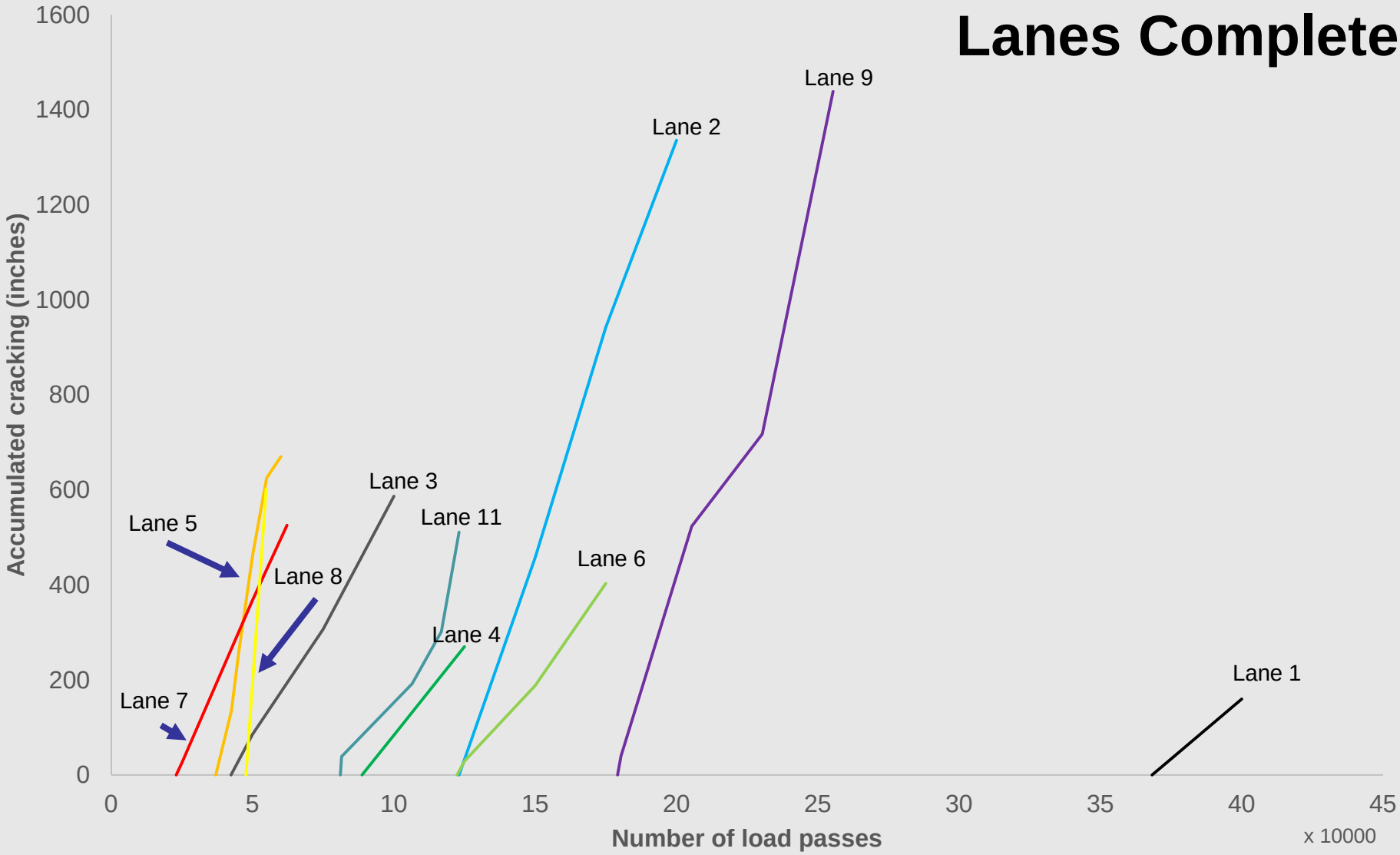
Cracking Measurements





Crack lengths are individually traced with planimeter

Lanes Completed



Crack Data Summary

Lane	Mix	Age when tested (months)	Duration (Days)	Cycles to First Crack (Calculated)	Total Passes	Total Cracking (in)
1	0% ABR Control PG64-22	7	286	368,254	400,000	160
2	40% ABR RAP PG58-28 WMA Foamed	38	79	123,035	200,000	1,336
3	20% ABR RAS PG64-22	14	28	42,399	100,000	587
4	20% ABR RAP PG64-22 WMA Evotherm	16	71	88,740	125,000	271
5	40% ABR RAP PG64-22	11	98	36,946	60,000	670
6	20% ABR RAP PG64-22	24	81	122,363	175,000	403
7	20% ABR RAS PG58-22	18	43	23,005	62,200	526
8	40% ABR RAP PG58-22 WMA Evotherm	31	47	47,679	54,844	602
9	20% ABR RAP PG64-22 WMA Foamed	2	163	179,167	255,397	1,439
11	40% ABR RAP PG58-28	3	147	81,044	123,052	512

Mixture Field Sample Testing

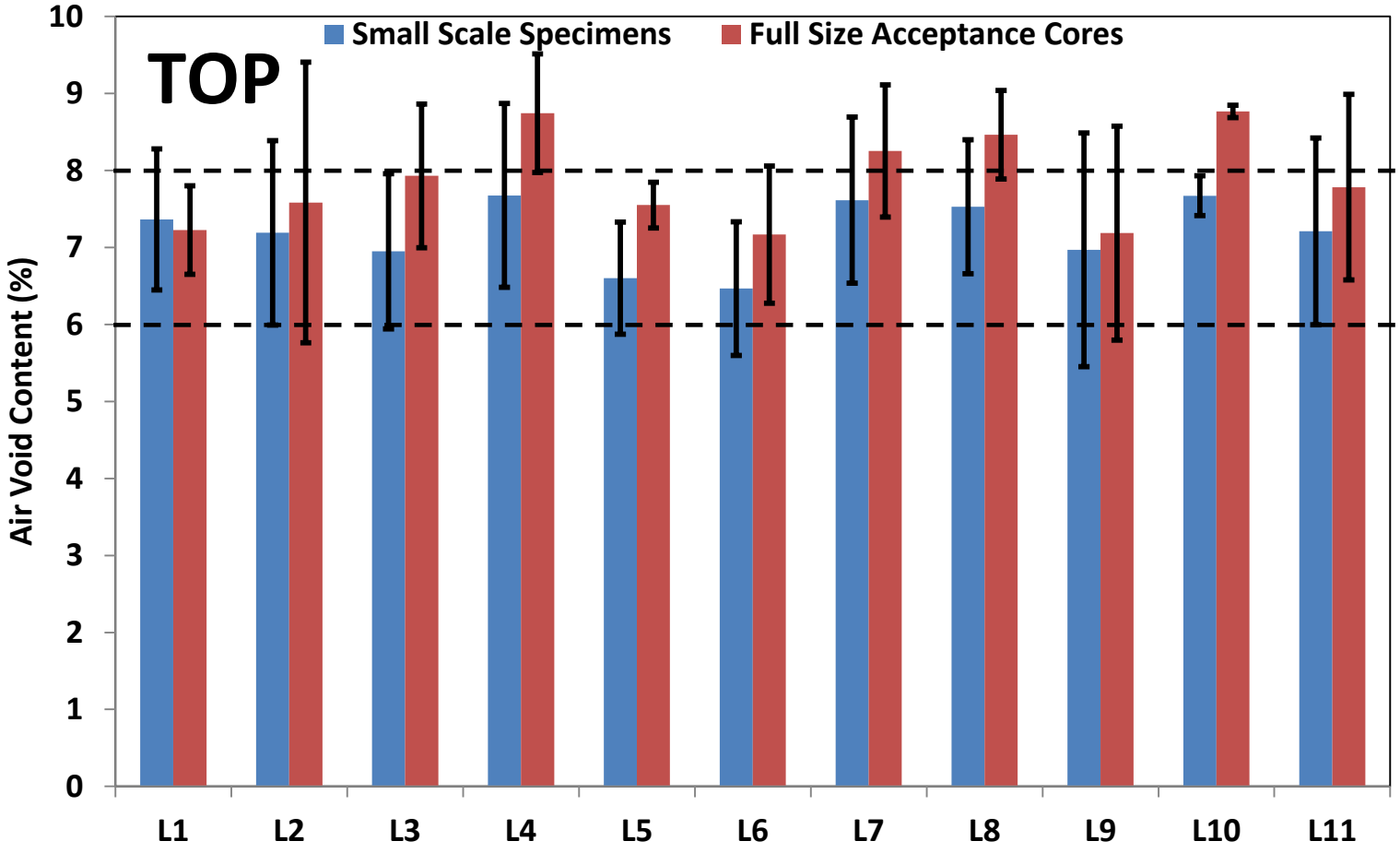
Reduced Size (38mmx110mm)

- **Dynamic Modulus**
- **Fatigue (AASHTO TP 107)**
- **Monotonic Direct Tension**

All testing done on AMPT




Air Void Content of Field Cores



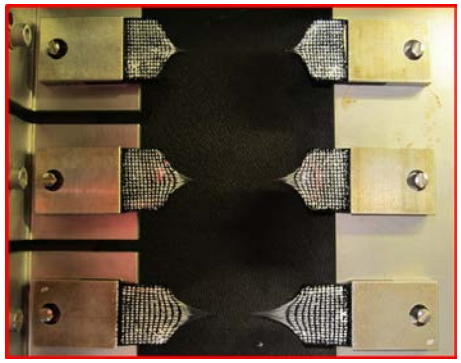
Need to take construction variation into account analyzing performance testing data

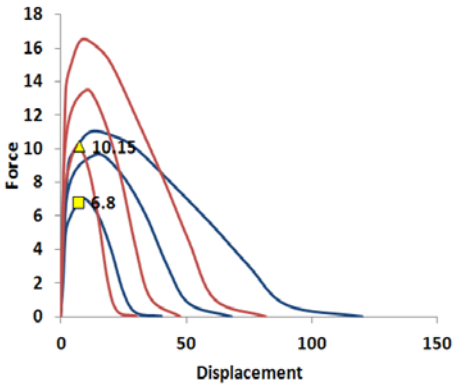
Field Core Sampling and Testing

	2013	2014	2015	2016
				
	t = 0m Top Bottom	t = 12m Top Bottom	t = 24m Top Bottom	t = 36m Top Bottom
Cores Taken	✓	✓	✓	✓
Testing Done	✓	✓	✓	*Undergoing*
Binder Extraction & Testing	✓	✓	✓	*Will do*
Data Analysis	✓	✓	*Undergoing*	*Will do*

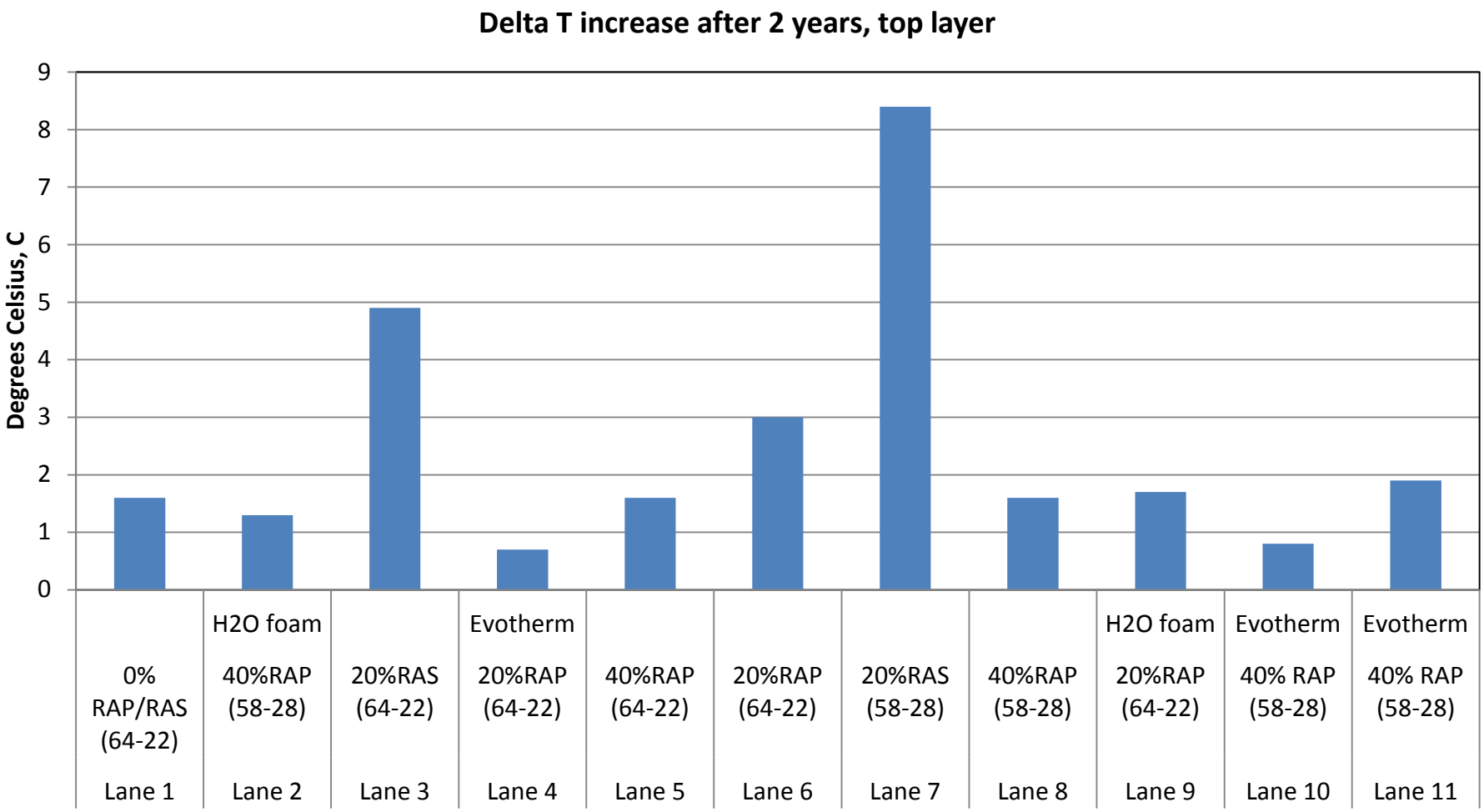
Extracted Binder Testing

- DSR Fatigue: Linear Amplitude Sweep (LAST)
- BBR $\Delta T_{critical}$: $PG_{(S)tiffness} - PG_{(m)\text{-}creep}$
- Double Notched Tension: Cracking Strain Tolerance





ΔT INCREASE


Delta T increase after 2 years, top layer
Degrees Celsius, C
9
8
7
6
5
4
3
2
1
0
0% RAP/RAS (64-22)
Lane 1
H2O foam
40%RAP (58-28)
Lane 2
20%RAS (64-22)
Lane 3
Evotherm
20%RAP (64-22)
Lane 4
40%RAP (64-22)
Lane 5
20%RAP (64-22)
Lane 6
20%RAS (58-28)
Lane 7
40%RAP (58-28)
Lane 8
H2O foam
20%RAP (64-22)
Lane 9
Evotherm
40% RAP (58-28)
Lane 10
Evotherm
40% RAP (58-28)
Lane 11

Next Steps

- Second run at aged conditions
  - Lanes 3, 4, 5 and 8
- Data analysis
  - Data library
  - Data processing
  - Investigations
- Post-mortem evaluations
- Reporting and Documentation

Project #2:

Effect of In-Place Density and Aggregate Base Geosynthetic Reinforcement on the Asphalt Pavement Durability

AC Field Density and CAB Geosynthetic Reinforcement

- **Premise**
  - Compaction of asphalt concrete (AC) mixtures is critical to achieving optimal pavement performance.
  - Quality and strength of the substructure (base and subgrade) have great influence of pavement performance.

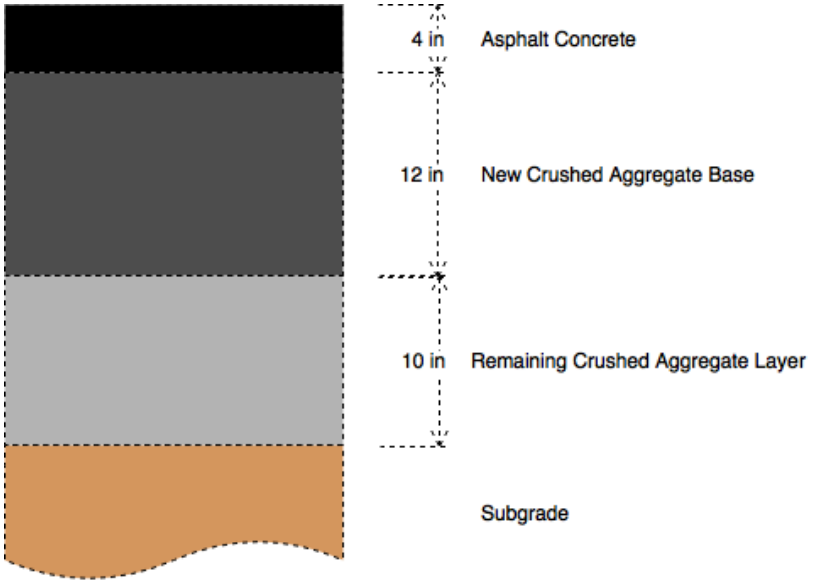
- **Objectives**
  - Investigation of Asphalt Concrete Compaction and Its Impact on Performance of Pavements Built with and without Geosynthetic Base Reinforcement

The Experiment

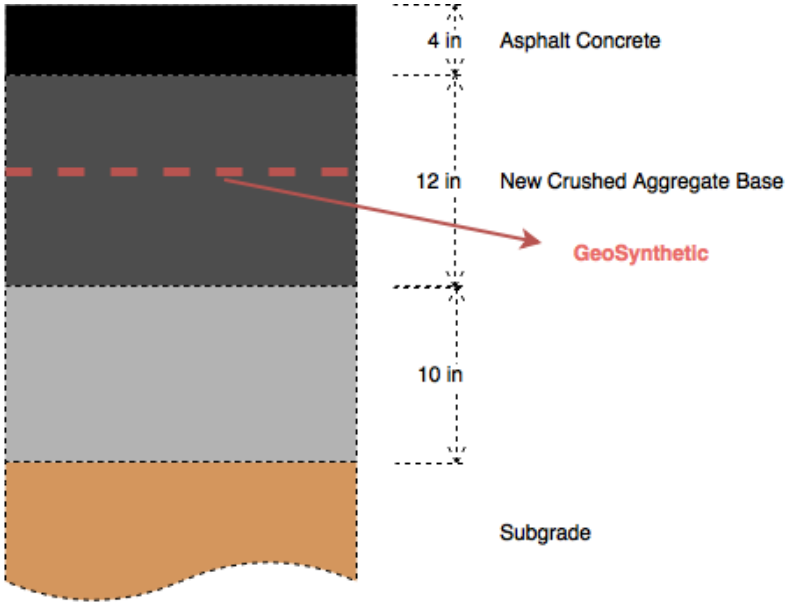
- One AC mixture
- Four Lanes (4 different AC compaction levels)
  - High (>92% compaction)
  - Medium (90-92%)
  - Low (< 90%)
- Two structures per lane
  - Unreinforced
  - Reinforced with a Standard BS-1200
- Performance measures
  - Cracking
  - Rutting

Pavement Structure

No Reinforcement



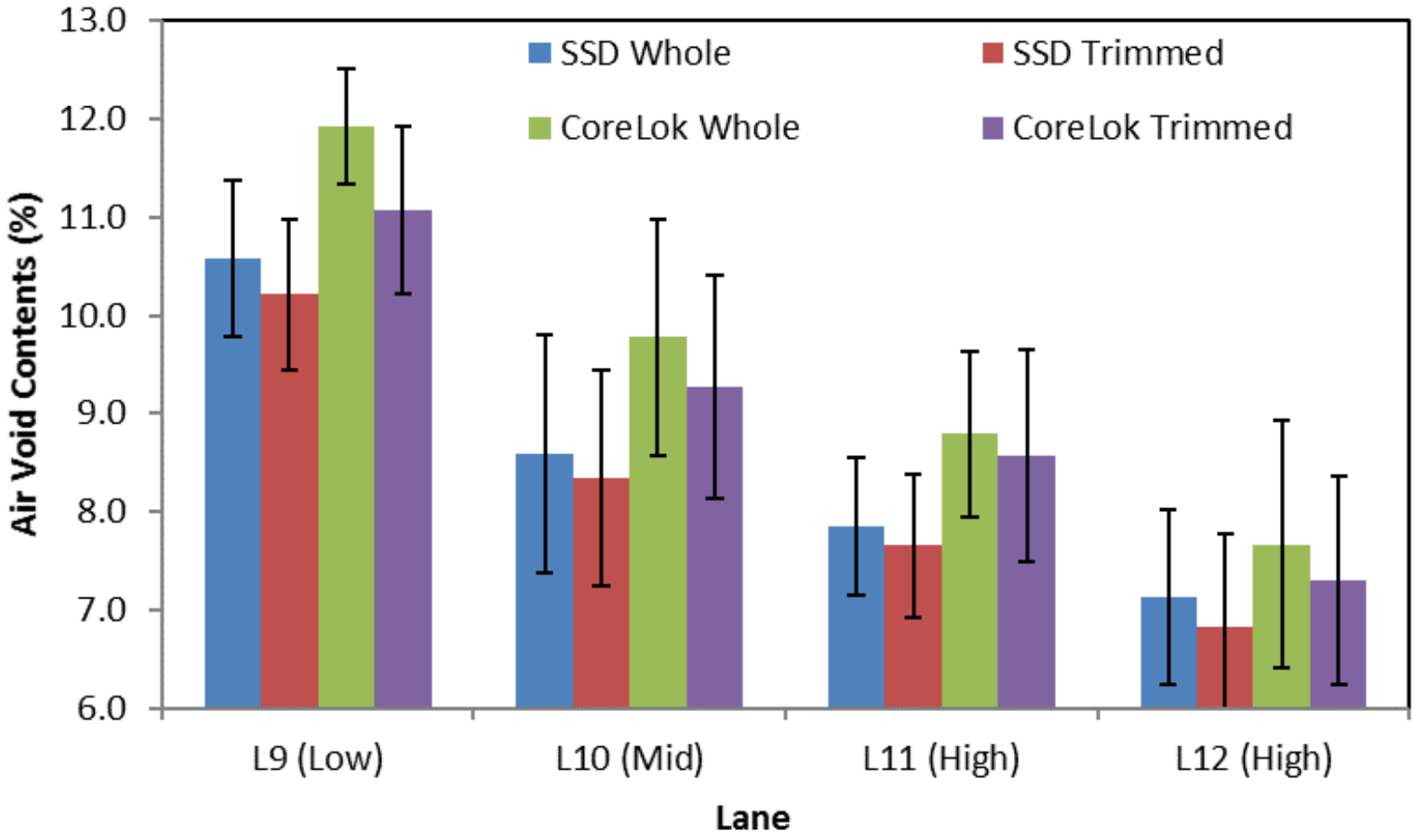
With Reinforcement



Air voids of field cores

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

Air voids of field cores (cont'd)



Proposed Testing

- 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
  - All lanes will be tested at least twice for fatigue cracking:
    - One at one unreinforced base site, and
    - One at one geosynthetic reinforced base site
  - Effects of aging
    - Two lanes will have one extra fatigue test at aged conditions

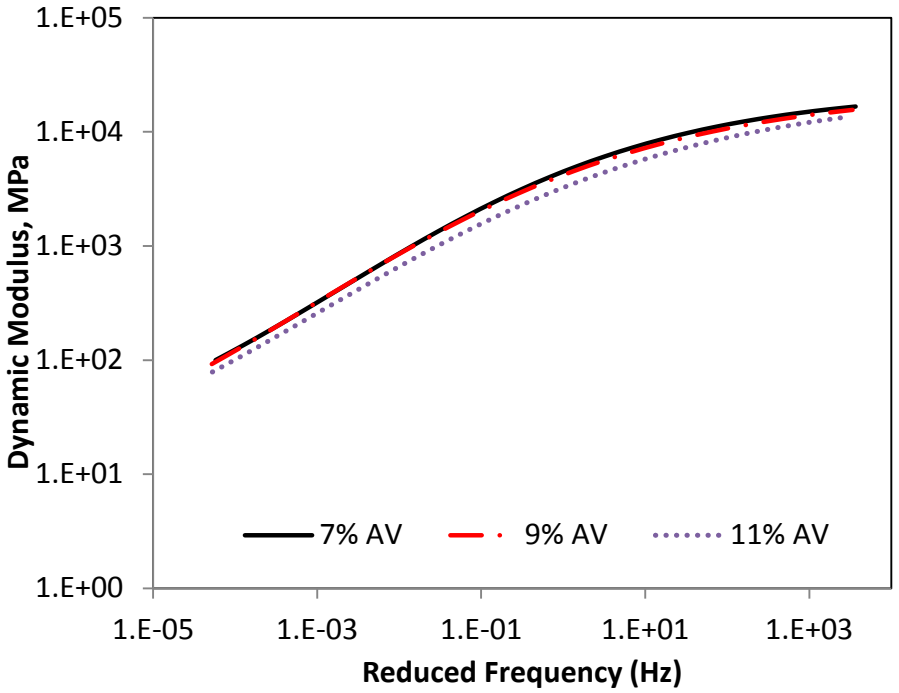
Current Status

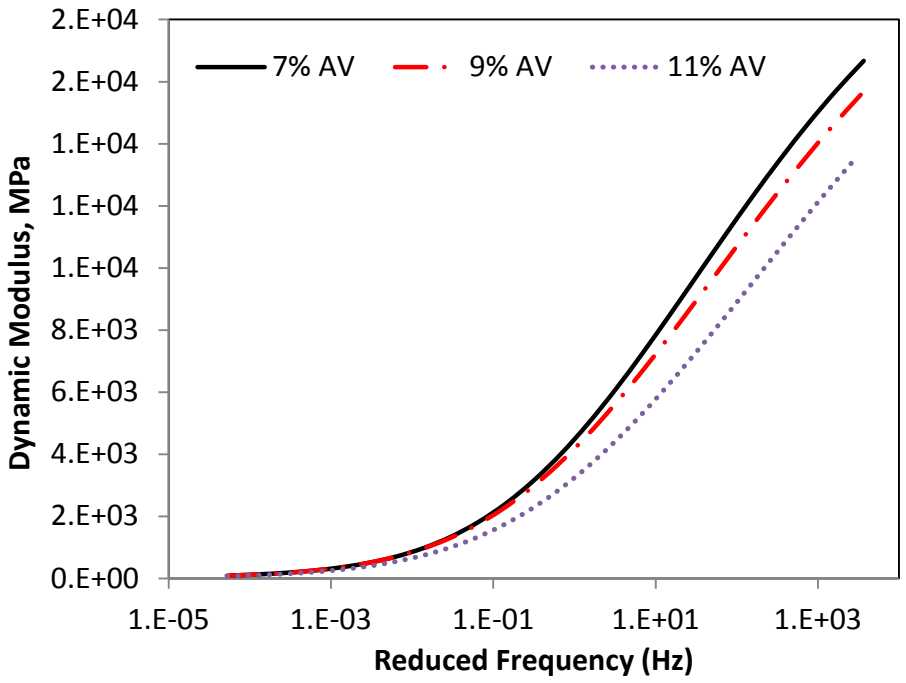
- Construction completed October 2016
- Fatigue testing (Phase 1)
  - May and June/2017
  - Winter/2017 through Spring/2018
- Rutting testing
  - Late Summer through Early Winter/2017
- Fatigue testing (Phase 2)
  - Late Winter/2018 through Early Summer/2018
- Fatigue testing (Phase 3)
  - Fall/2018 through Spring/2019

Laboratory Performance Testing

- Dynamic Modulus
- Fatigue (AASHTO TP 107)
- Monotonic Direct Tension
- Flow Number + Stress Sweep Rutting
- All testing done on AMPT

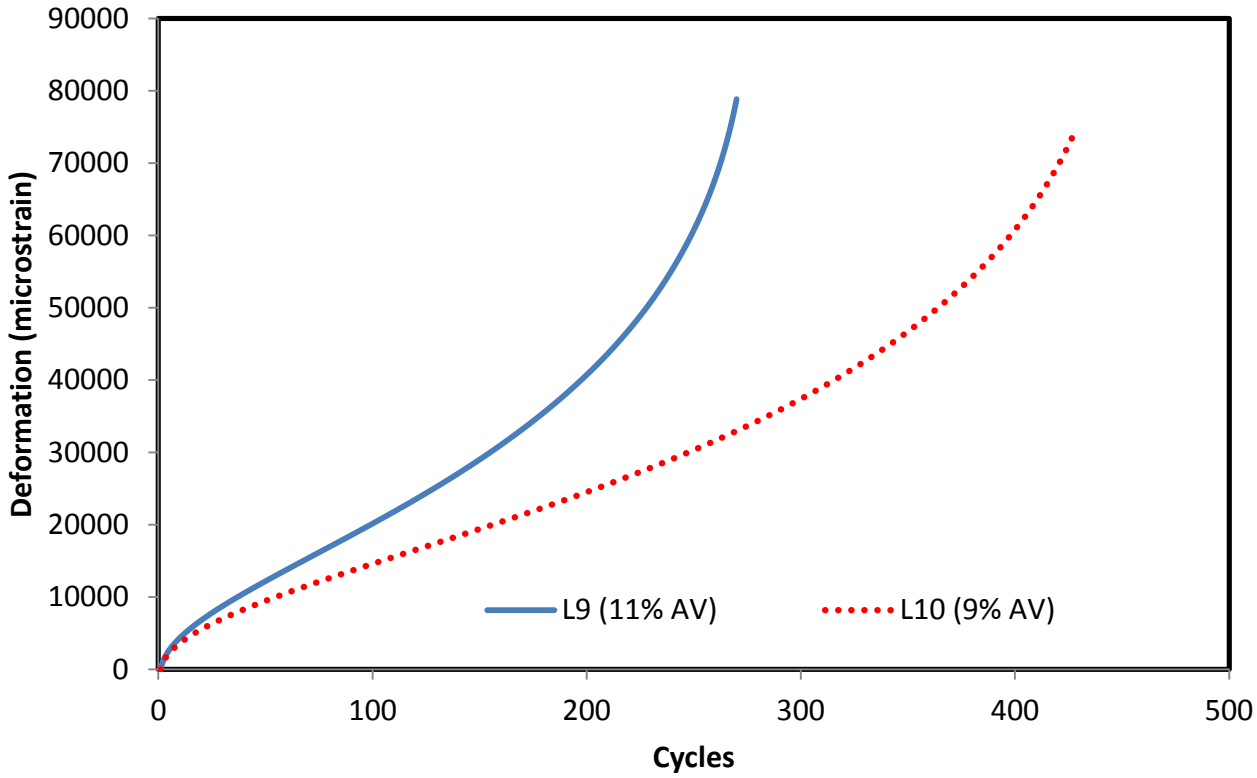
Loose Mix Dynamic Modulus Testing





Dynamic modulus increases with compaction level

Loose Mix Flow Number Testing



Tested at 50°C, unconfined

Proposed Testing (Cont'd)

- Rutting
  - Terminal state: 0.5 inches of total rut
  - Loading temperature:
    - Two proposed approaches for discussion:
      - Fixed temperature at 45°C
      - Variable temperature:
        - » 25K passes at 40°C
        - » 25K passes at 50°C
        - » Repeat until terminal state is reached
  - All lanes will have at least one rutting test at one reinforced base site
  - Two lanes will be tested twice:
    - Impact of base reinforcement on performance
    - Impact of aging on performance

Team

- **Jack Youtcheff**
  - **Pavement Testing Facility**
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    - **Mario Tinio**
    - **Karl Staaf**
    - **Tim and Michael**
  - **Mix and Binder Labs**
    - **Sean Li**
    - **Adrian Andriescu**
    - **Susan Needham**
    - **Scott Parobeck**
    - **Frank Davis**

Questions/Comments?

- **Contact Information**

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