

# Mixture and Production Parameters Affecting Cracking Performance of Mixtures with RAP and RAS

## Introduction

The laboratory testing can be conducted on mix design (lab produced) and QA/QC (plant produced) stages. To evaluate the performance of asphalt mixtures in the lab, an understanding of differences between the properties and performance measured on specimens fabricated in different ways is required.

- Laboratory mixed, laboratory compacted (LMLC)
- Plant mixed, laboratory compacted (PMLC)
- Plant mixed, plant compacted (PMPC)

While the use of some amount of recycled materials in asphalt mixtures has become routine, contractors and departments of transportation (DOTs) are interested in incorporating higher percentages to realize savings of costs and natural resources. Reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS) are the most common types of materials used for recycling. However, one of the concerns with using higher amounts of RAP or RAS is the increased potential for cracking, as the materials tend to be stiffer and less workable.



The objective of this study is the comparison of characteristics of plant and lab produced mixtures, varied in binder PG grade, nominal maximum aggregate size (NMAS), and recycled materials type and content, and the evaluation of impacts of these factors using experimental testing.

## Mixtures

### Lebanon Plant

- 11 Mixtures (Plant), 8 Mixtures (Lab)
- Binder PG Grade (PG 58-28, PG 52-34)
- Two sources for each binder grade
- NMAS (12.5 and 19 mm)
- Recycled Material (20% RAP, 20% RAP/RAS, 30% RAP)

### Hooksett Plant

- 4 Mixtures (Plant)
- Binder PG Grade (PG 58-28, PG 64-28)
- NMAS (9.5 and 12.5 mm)
- Recycled Material (20% RAP, 23% RAP)

## Testing

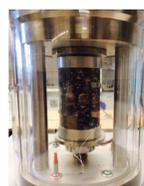
### Binder Testing (by NHDOT)

- Extraction and Recovery
- PG Grading
- 4mm DSR



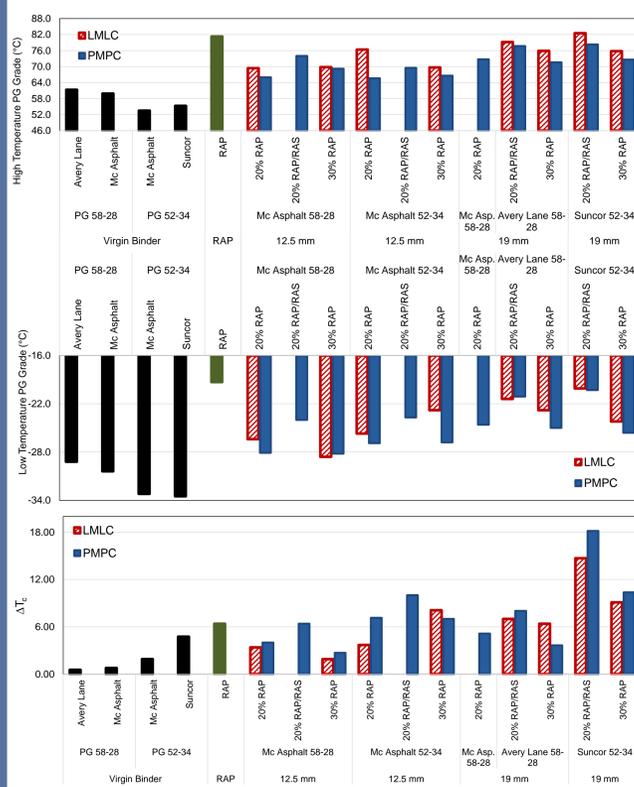
### Mixture Testing (by UNH):

- Complex Modulus (AASHTO TP-62)
  - 3 replicates
  - Different Temperatures and Frequencies
  - Dynamic Modulus and Phase Angle Mastercurves
- SVECD Fatigue Testing (AASHTO TP-107)
  - 4 replicates
  - C-S and  $G^R-N_f$
  - Simplified Viscoelastic Continuum Damage Approach



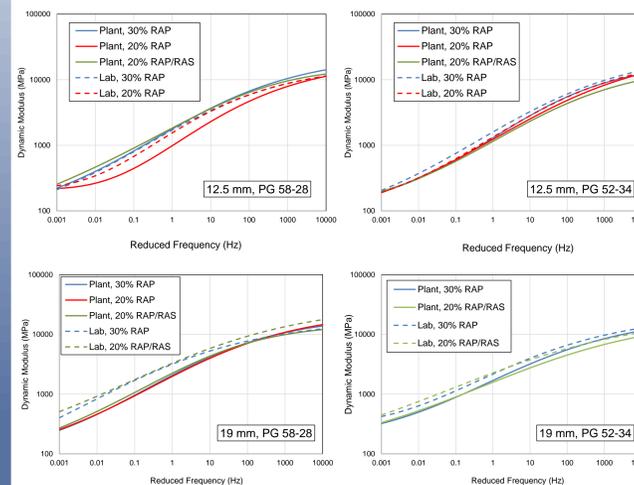
## Results

### Binder Results

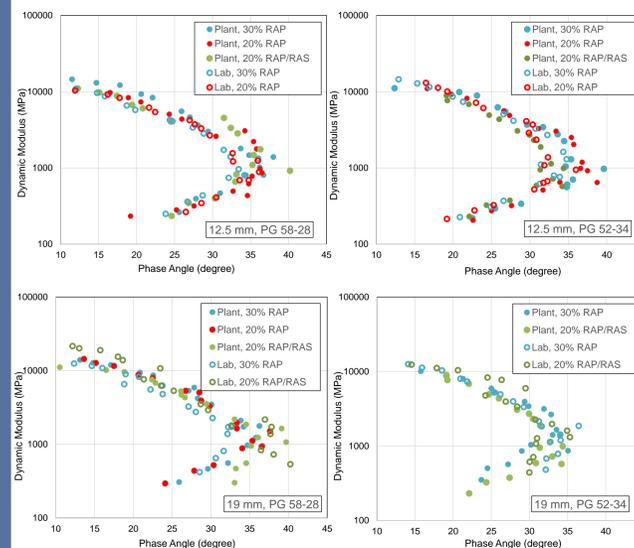


## Mixture Results

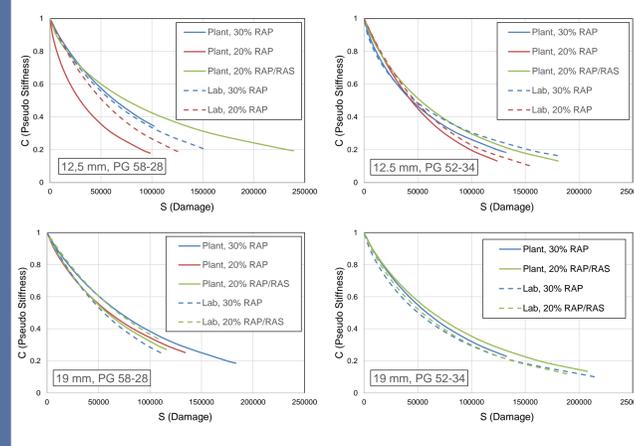
### Dynamic Modulus Mastercurves



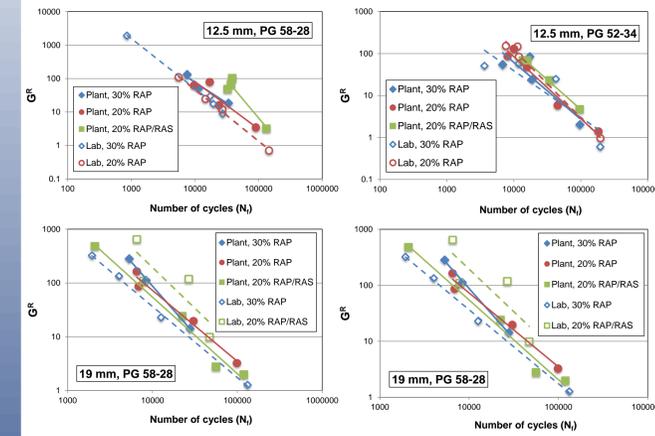
### Black Space Diagrams



### Damage Characteristic Curves



## Fatigue Failure Criterion



## Conclusions

### Binder Results

- Recovered binders of lab produced mixtures have warmer high and low PG temperature → stiffer binders
- Lab produced mixtures are more m-controlled than plant produced mixes → more susceptible to cracking.
- The binders extracted from the 19 mm mixtures have warmer temperatures than those extracted from 12.5 mm mixtures.
- Generally,  $\Delta T_{cr}$  of the mixtures containing RAS are larger than those for the mixtures with RAP only.

### Dynamic Modulus

- Dynamic Modulus of lab produced mixtures are higher than plant produced mixtures.
- Inclusion of higher RAP increases dynamic modulus, while incorporating RAS does not follow a consistent trend.

### Fatigue Cracking

- The difference between C-S curves for lab produced mixtures is less than those for plant produced ones.
- Integrity (C-S) of mixtures is dependent on NMAS (12.5 mm: Lab > Plant, 19 mm: Plant > Lab)
- Using a softer binder does not necessarily improve the fatigue performance.
- Mixtures with lower NMAS resist better against fatigue.

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