

# Performance Characteristics of Thin Lift Overlay Mixtures Containing High RAP Content, RAS, and Warm Mix Asphalt Technology

## *Northeast Pavement Preservation Partnership*



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# ACKNOWLEDGEMENTS

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Mr. Mike Nichols - Aggregate Industries

Mr. Pat Mitchell - Hudson Liquid Asphalt

Mr. Chris Strack - Sonneborn, Inc.

# PROJECT SCOPE - Green Design



Reclaimed Asphalt Pavement

*9.5mm Thin Lift Mixture*



Recycled Asphalt Shingles (RAS)

*Looking at Use of  
Each Material Both  
Individually and  
Collectively*



Warm Mix Asphalt Technology

# **BENEFITS OF GREEN DESIGN FOR THIN LIFT MIXTURES**

- 1. Use of RAP and RAS leads to reduction in the amount of virgin asphalt binder required. Subsequently, mixture costs are reduced.**
- 1. The use of RAS in HMA leads to decreased volumes of asphalt shingles being disposed in landfill sites.**
- 1. WMA technologies lead to more environmentally friendly mixtures since plant and field emissions are reduced.**
- 1. WMA technologies allow for lower production and placement temperatures which can lead to financial savings in fuel costs.**

# PROJECT OBJECTIVES

1. Develop a 9.5mm Superpave thin lift overlay mixture using virgin materials.
1. Develop similar 9.5mm Superpave thin lift overlay mixtures incorporating a high percentage of RAP, RAS, and a WMA technology individually and also collectively.
1. Measure the effect of RAP, RAS, and WMA technology on the dynamic modulus of the mixtures as a measure of stiffness.
1. Measure the reflective cracking resistance of the mixtures using the Texas Overlay tester.

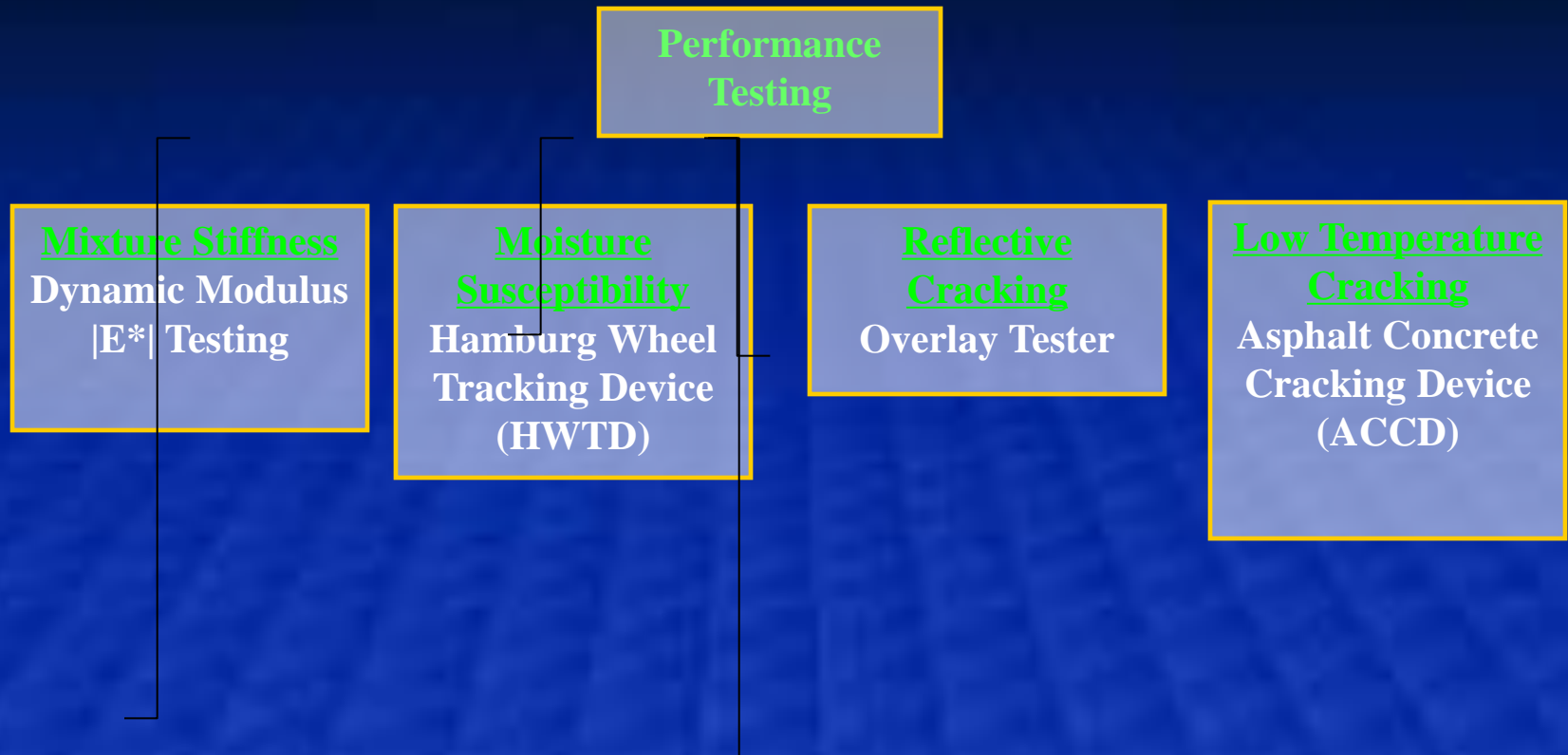
# PROJECT OBJECTIVES

1. Evaluate the low temperature cracking performance of the mixtures using a simple performance test device known as the Asphalt Concrete Cracking Device (ACCD).
1. Measure the moisture susceptibility of the mixtures using the Hamburg Wheel Tracking Device (HWTB).
1. Measure the Performance Grade (PG) of the extracted mixture binder.

# EXPERIMENTAL PLAN



# EXPERIMENTAL PLAN (CONT'D)





# BINDER

- ➔ A PG52-28 binder used for all mixture designs.
- ➔ Softest grade available that met low temperature requirement of a PGXX-28 typically specified in Massachusetts.
- ➔ Soft binder grade utilized in attempt to offset potential increase in mixture stiffness due to incorporation of RAP and/or RAS.

# WARM MIX ASPHALT TECHNOLOGY

- ➔ Waxed based additive known as SonneWarmix™.
- ➔ SonneWarmix™ added at a dosage rate of 1.0% by weight of total binder (Virgin +RAP + RAS).
- ➔ Mixture incorporating the warm mix technology were fabricated with a 35°F reduction in mixing and compaction temperatures as compared to the mixtures without the technology.

# RAP & RAS

- ➔ RAP was obtained from same contractor that supplied the virgin aggregates.
- ➔ RAS was provided from a shingle recycling facility in Fitchburg, Massachusetts and was pre-consumer material (manufacturer waste).
- ➔ RAP average binder content = 5.95% (AASHTO T308 - Ignition)
- ➔ RAS average binder content = 17.7% (AASHTO T308 - Ignition)

# MIX DESIGN

- ➔ Superpave design methodology
- ➔ Design ESALs = 0.3 to < 3million
- ➔  $N_{\text{design}} = 75$  Gyration
- ➔ RAS content limited to 5% maximum
- ➔ All mixture gradations designed to be similar to the control mixture without RAP and/or RAS.

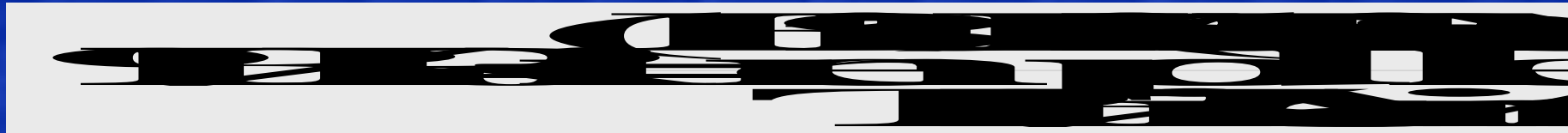


# MIXTURE VOLUMETRICS - w/o WMA Technology


# MIXTURE VOLUMETRICS - with WMA Technology


# PERCENT BINDER REPLACEMENT

- ➔ Estimates how much aged (RAP and/or RAS) binder can potentially be imparted to the mixture.
- ➔ Method assume 100% blending of aged and virgin binder.
- ➔ Method takes into account differences in binder content between different RAP stockpiles.

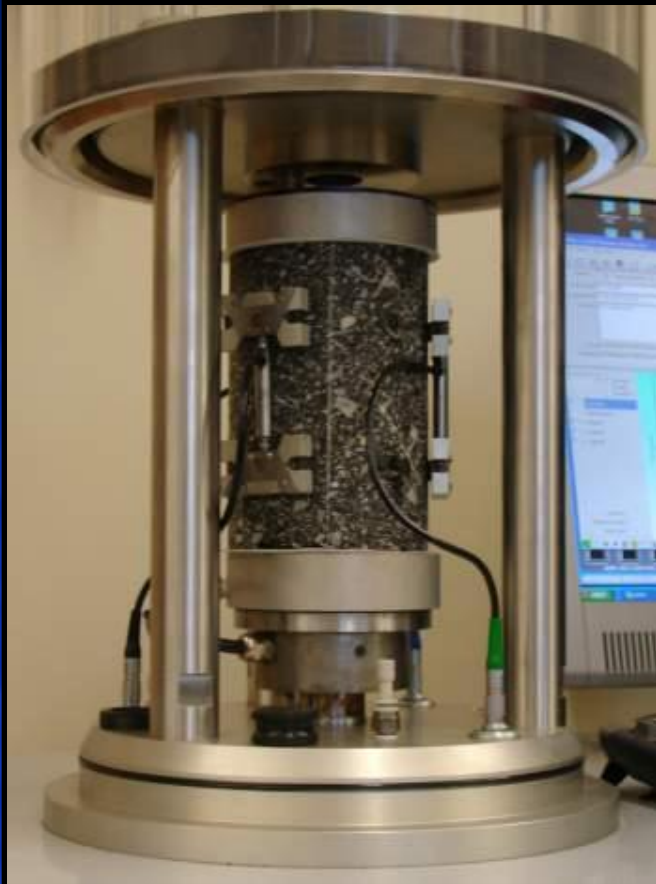








# MIXTURE STIFFNESS – Dynamic Modulus

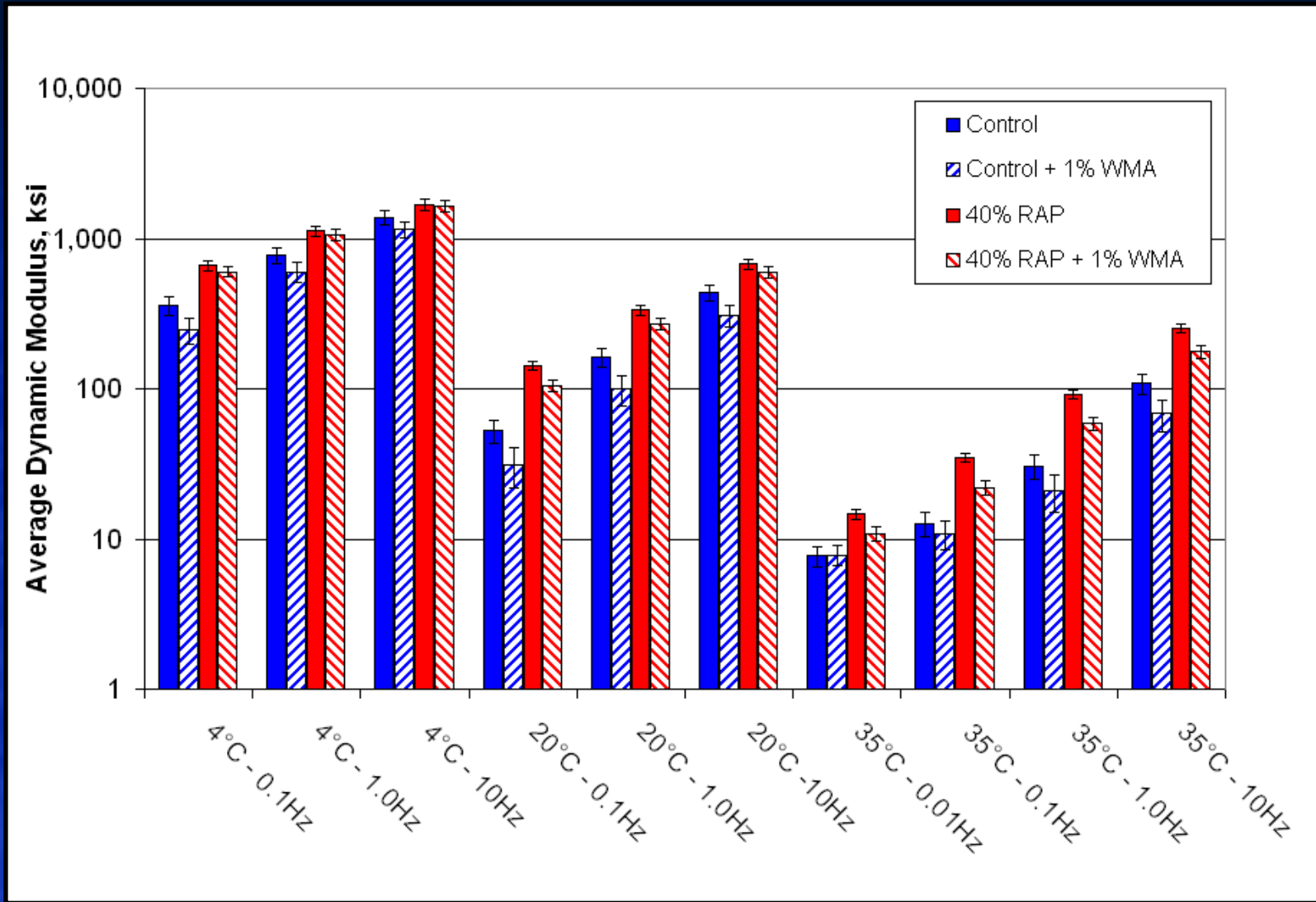


Conducted to determine changes in mixture stiffness due to incorporation of RAP, RAS and/or the WMA Technology.

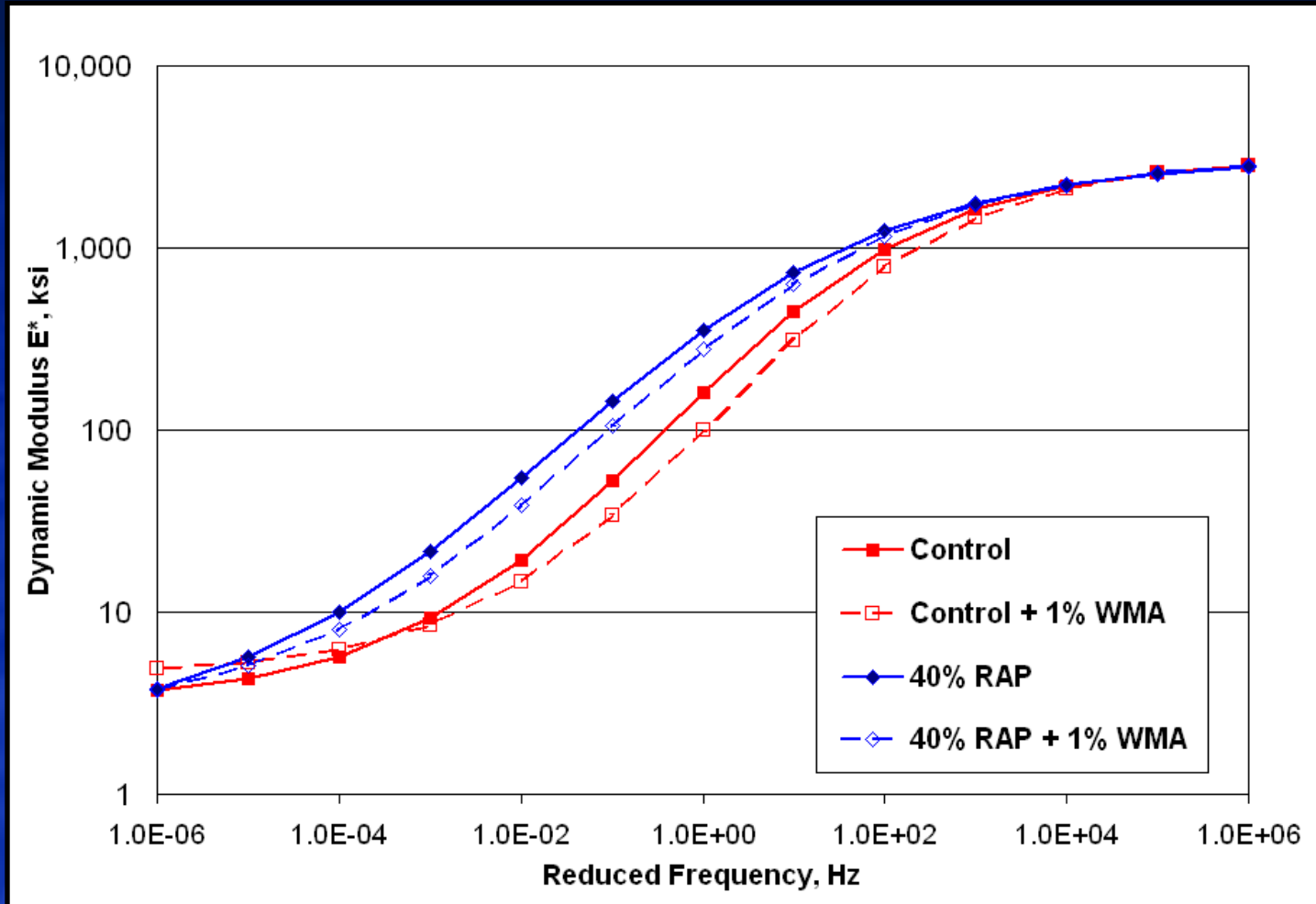
Temperature	Frequency
4°C	10 Hz, 1Hz, 0.1Hz
20°C	10 Hz, 1Hz, 0.1Hz
35°C	10 Hz, 1Hz, 0.1Hz, 0.01Hz

Asphalt Mixture Performance Tester (AMPT)

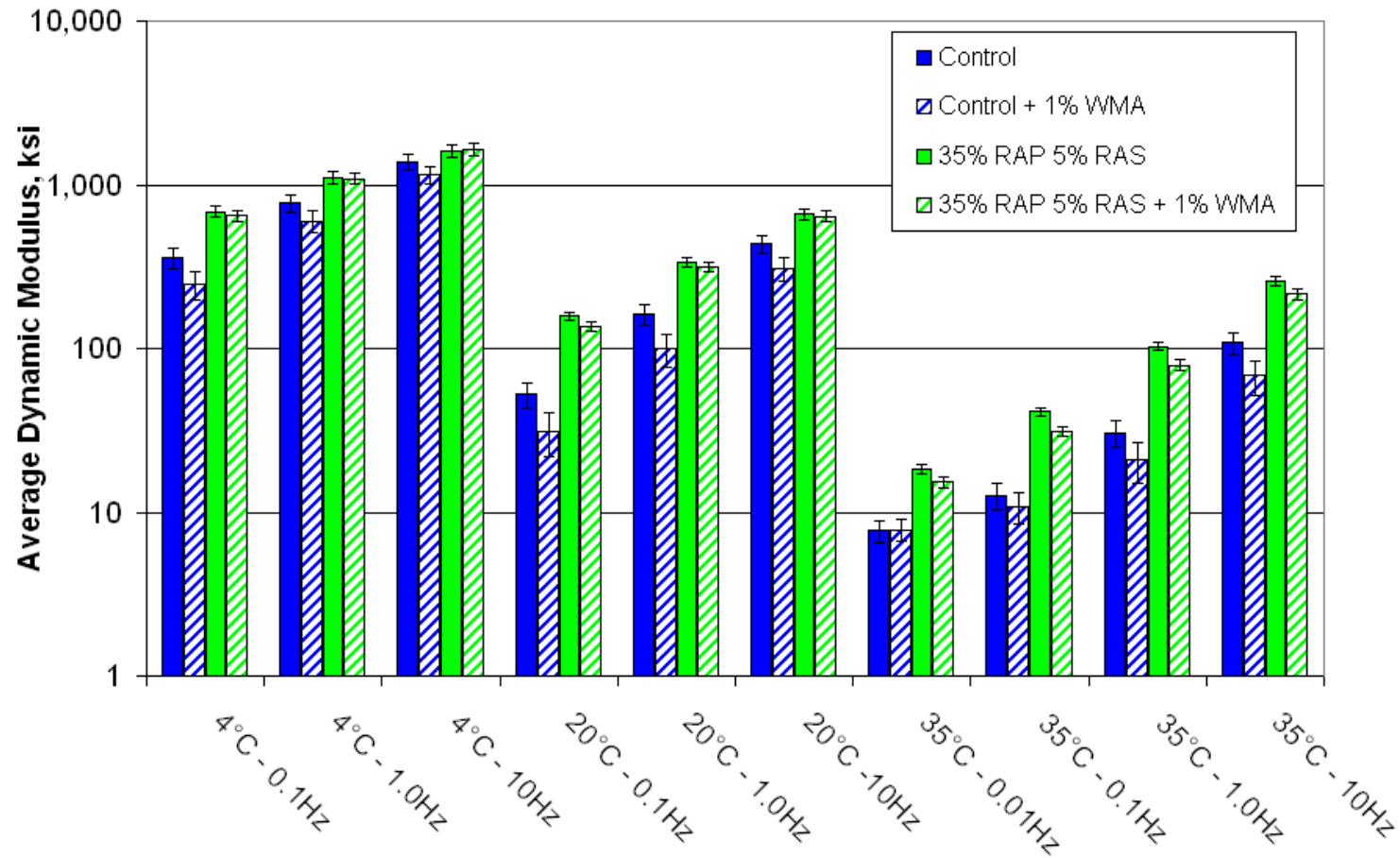
# |E\*| DATA - Control & 40% RAP



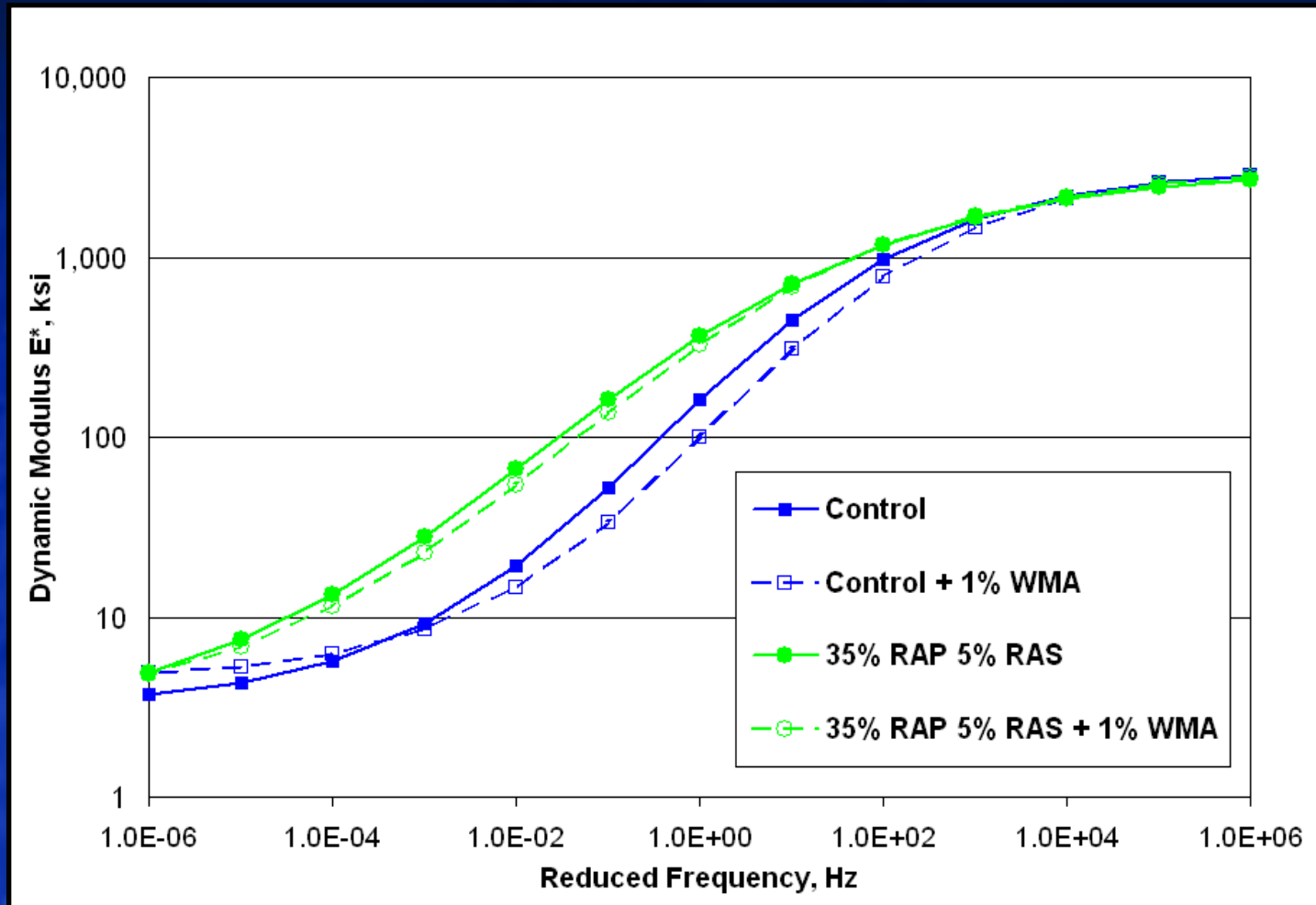
# MASTER CURVE - Control & 40% RAP



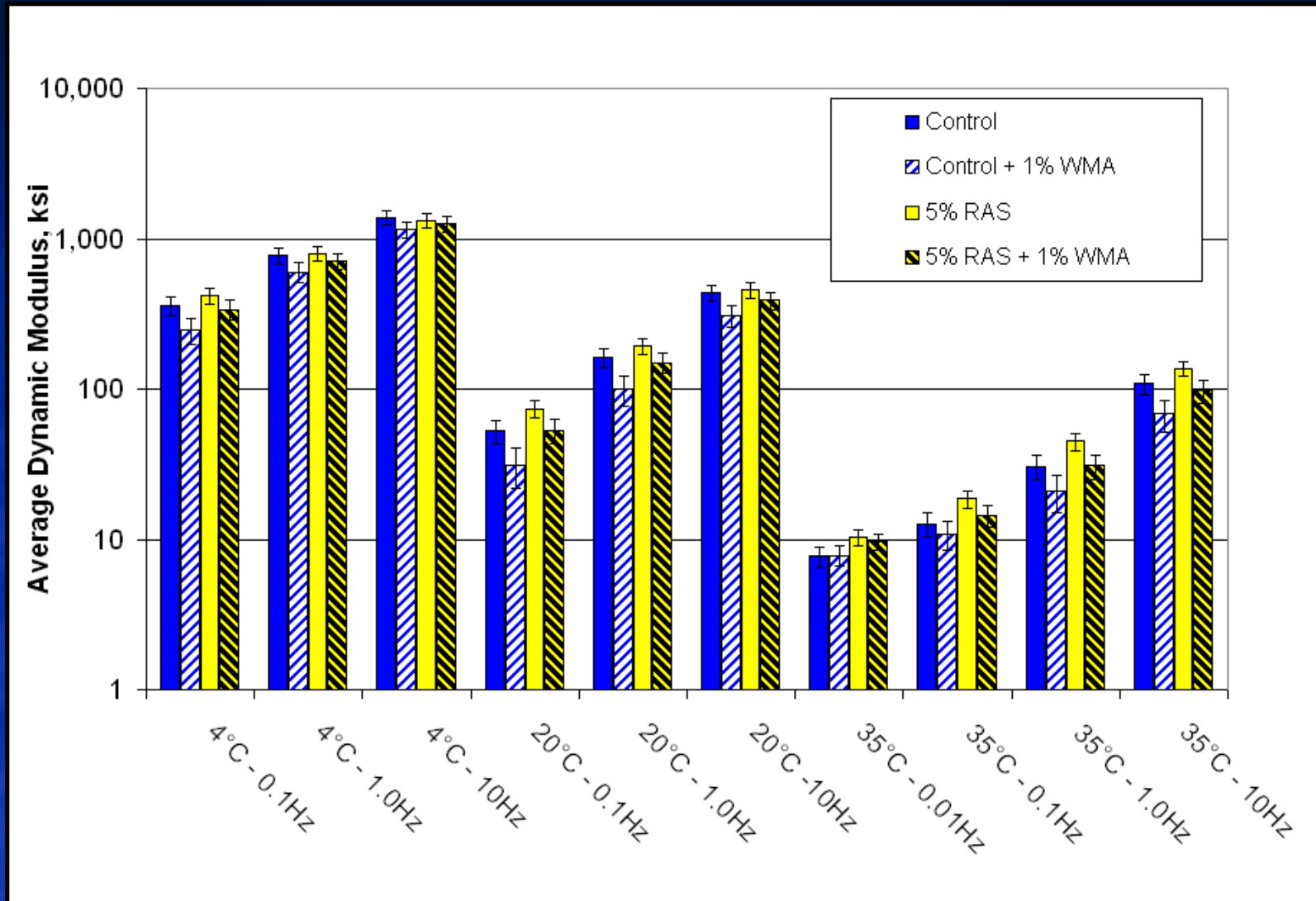
# |E\*| DATA - Control & 35% RAP + 5% RAS



# MASTER CURVE - Control & 35% RAP + 5% RAS

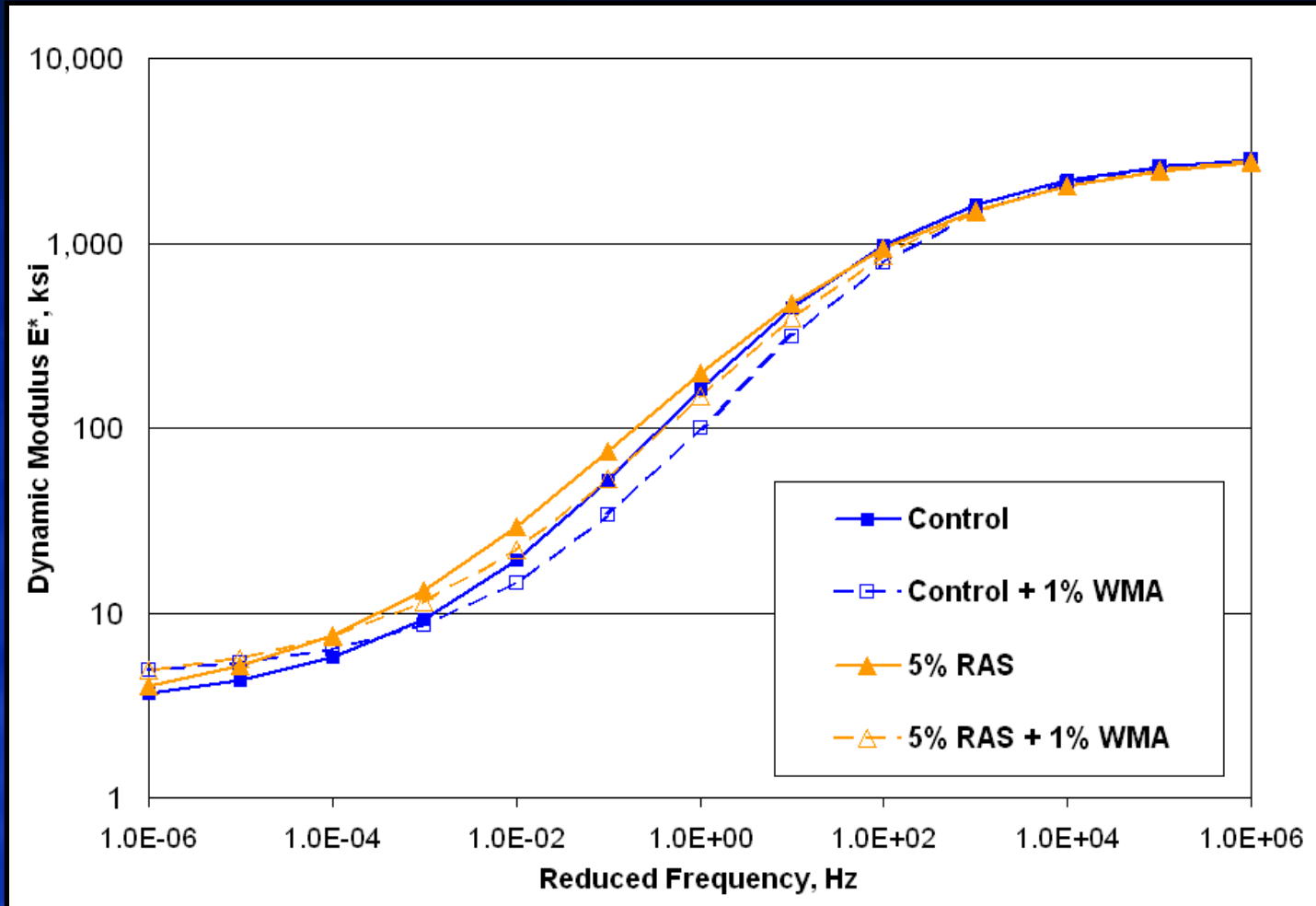


# |E\*| DATA - Control & 5% RAS





# MASTER CURVE - Control & 5% RAS



# REFLECTIVE CRACKING - Overlay Test



- Test Temperature = 15°C (59°F)
- Test Termination at 1,200 cycles or 93% Load reduction
- Testing in accordance with Tex-248-F

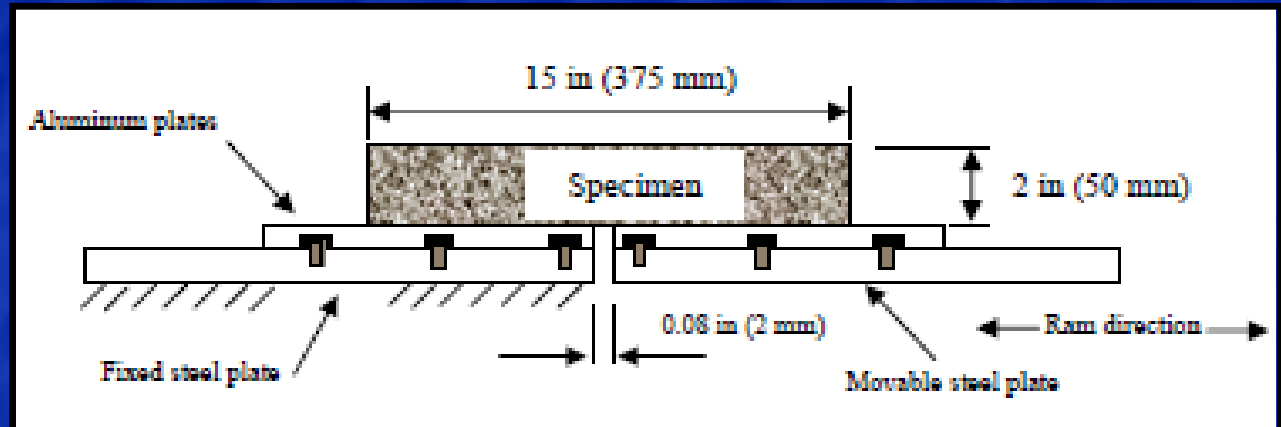


Diagram from: Zhou and Scullion "Overlay Tester: A Rapid Performance Related Crack Resistance Test" Report No. FHWA/TX-05/0-4467-2 (2005).

# OVERLAY TEST - Results


# LOW TEMPERATURE CRACKING -

## Asphalt Concrete Cracking Device (ACCD)

- Utilized to evaluate impact of RAP and/or RAS on low temperature cracking resistance of mixture

- Operates on principal of accumulation thermal stress until failure (crack)



- Cooling rate of 10°C/hr



# ACCD - Results


# MOISTURE SUSCEPTIBILITY - Hamburg Wheel Tracking Device (HWTd)

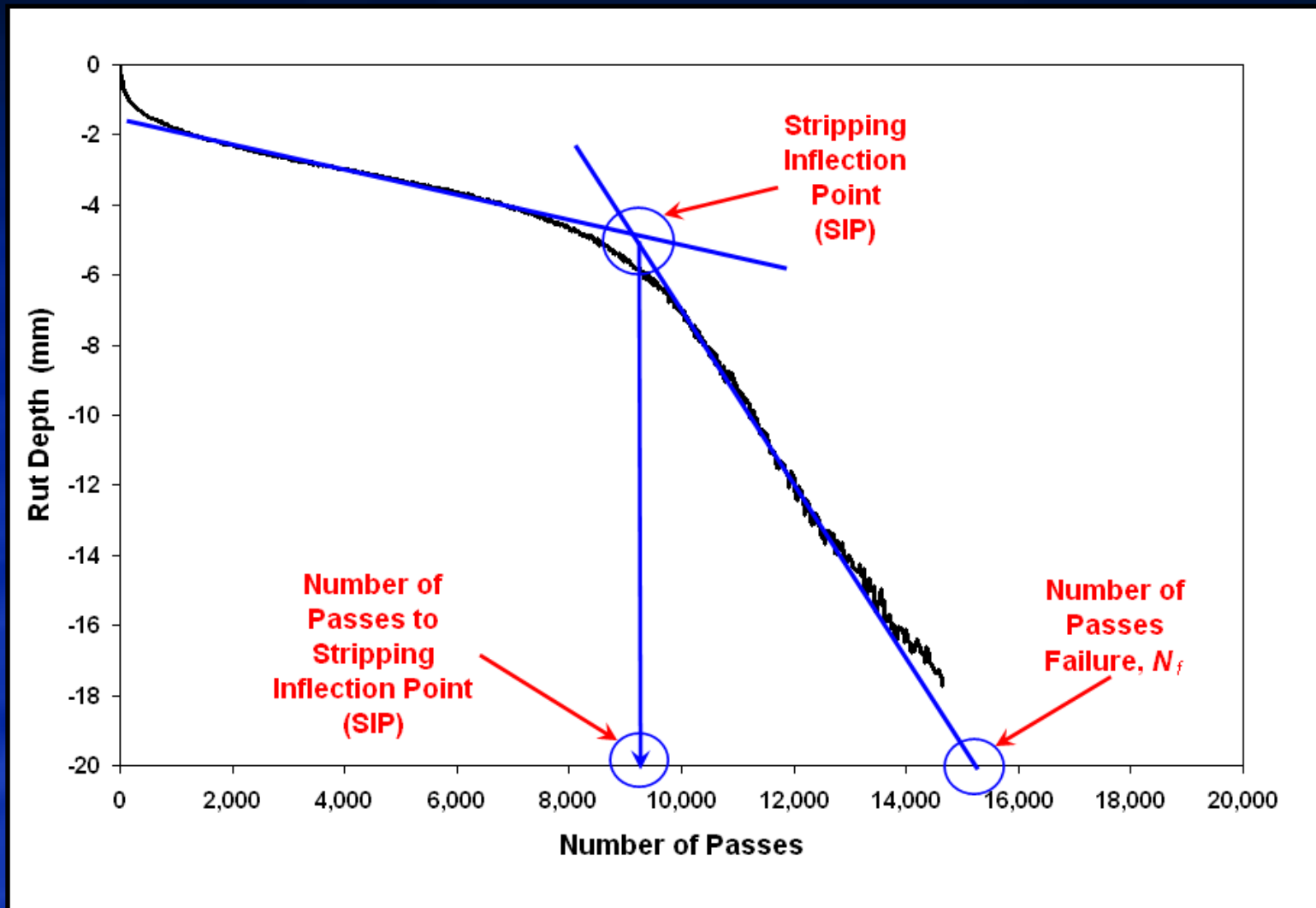


- HWTd testing conducted in accordance with AASHTO T324

- Water temperature of 40°C (104°F) during testing
- Test duration of 20,000 cycles



# STRIPPING INFLECTION POINT (SIP)



# HWTD - Results




# EXTRACTED BINDER GRADING

- ➡ Binder was extracted from each mixture to determine influence of RAP, RAS and /or WMA Technology on the resultant grade of the binder in the mixture.
- ➡ Binder from each mixture extracted in accordance with AASHTO T164.
- ➡ Extracted mixture recovered in accordance with AASHTO T170 (Abson method).

# EXTRACTED BINDER GRADING - Results


# CONCLUSIONS

- ➔ Superpave 9.5mm mixtures designed with high RAP content, RAS, and a wax-based WMA technology can meet the Superpave gradation and volumetric requirements.
- ➔ Dynamic modulus testing indicated that the incorporation of high RAP content and/or RAS caused an increase in the stiffness of the mixtures.
- ➔ Mixtures incorporating the WMA technology showed generally lower dynamic modulus values than the mixture without the technology.

# CONCLUSIONS

- ➔ Reflective cracking results obtained from the Overlay Test indicated that mixtures incorporating the RAP and/or RAS had reduced reflective cracking resistance as compared to the control.
- ➔ Low temperature cracking resistance test results indicated that the addition of RAP, RAS and/or WMA technology did not have a negative impact on the low temperature performance of the mixtures as compared to the control.

# CONCLUSIONS

- ➔ Moisture susceptibility results indicated, for the majority, that the mixtures incorporating RAP and/or RAS had improved moisture susceptibility relative to the control mixtures.

# PHASE II - Ongoing

- ➔ Determine the effect of different polymer modified binders on the performance of thin lift overlay mixtures with RAP, RAS, and WMA.
- ➔ Beam fatigue and cyclic direct tension compression tests will be used as a tool to determine why the mixture with RAP did not perform as well in the Overlay Tester.

**THANK YOU!**