Industry Use of the AMPT

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Outline

1. **Tests run on the Asphalt Mixture Performance Tester (AMPT) or similar devices/load frames**

- Dynamic Modulus (E*)
- Flow Number (F_n) / Flow Time
- Direct Tension Cyclic Fatigue
- Overlay Test

2. **How Industry can use the device**

- Specification/Supplier Guidelines Development
- New Product Development

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Apparatus

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Mixture Characterizations using AMPT

Mixture Stiffness

- Dynamic Modulus (E*) - AASHTO TP 79-11 / T 342-11
- Determines the dynamic modulus and flow number for HMA/WMA
- Material input for pavement design

Resistance to Permanent Deformation

- Flow Number (F_n) / Flow Time (also AASHTO TP79-11)

AASHTO TP 79

Dynamic Modulus (E*)

Flow Number (F_n) / Flow Time

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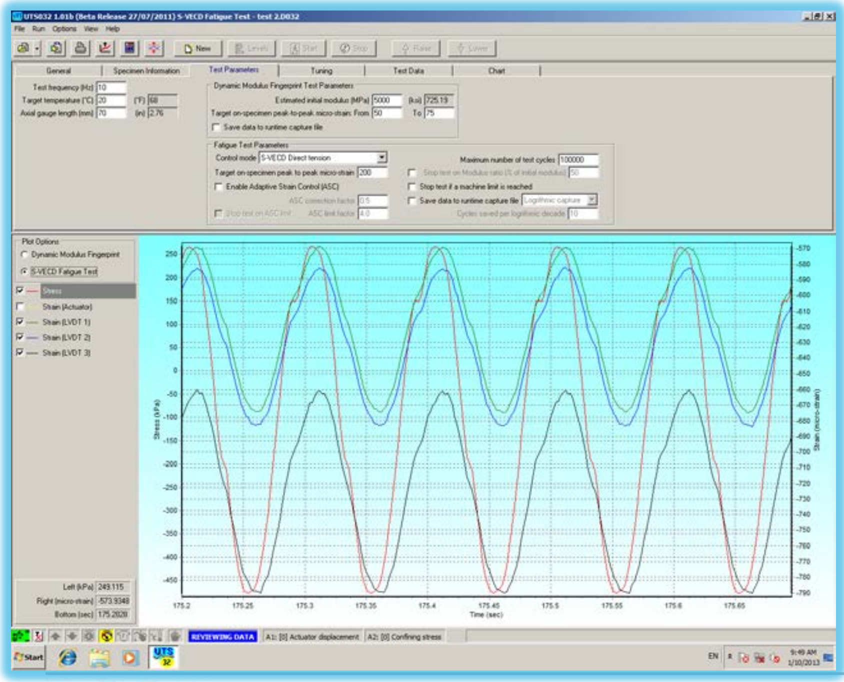
Mixture Characterizations using AMPT

Durability

- Cyclic Fatigue - ***Simplified Continuum Damage Uniaxial Fatigue***
- Proposed AASHTO Method
  - *Standard Method of Test for Determining the Damage Characteristic Curve of Asphalt Concrete from Direct Tension Cyclic Fatigue Tests*

Cyclic Fatigue

Direct Tension Cyclic Fatigue



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Mixture Characterizations using AMPT

Reflective Cracking

- Overlay Test
- Draft ASTM Standard Test Method

Reflective Cracking

Overlay Test

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WMA Chemical Manufacturer's Guidelines/Specification Development

Modeled after existing work

- NCHRP 9-43, Report 691
- Build/expand on Appendix to AASHTO R 35: Special Mixture Design Considerations and Methods for Warm Mix Asphalt (WMA)

Address WMA lab sample prep to replicate field produced mix

WMA Mix Evaluations

- Coating, Compactability, Moisture Sensitivity, Rutting

WMA Chemical Manufacturer’s Guidelines/Specification Development

Expand on Compaction Ratio (Compactability)

- gyrations to 92 percent relative density, CDI/ Locking Point
- CFI / TFI / N@Norm S_g% (0.95)
- $\sum W(N1 – N2) S_g$

Workability Test (Compactability)

- Dongré Workability Test (DWT)
  - Currently run on Pine G2, other compactors should be able to run
  - No special equipment
  - ASTM Draft Test Method

WMA Chemical Manufacturer's Guidelines/Specification Development

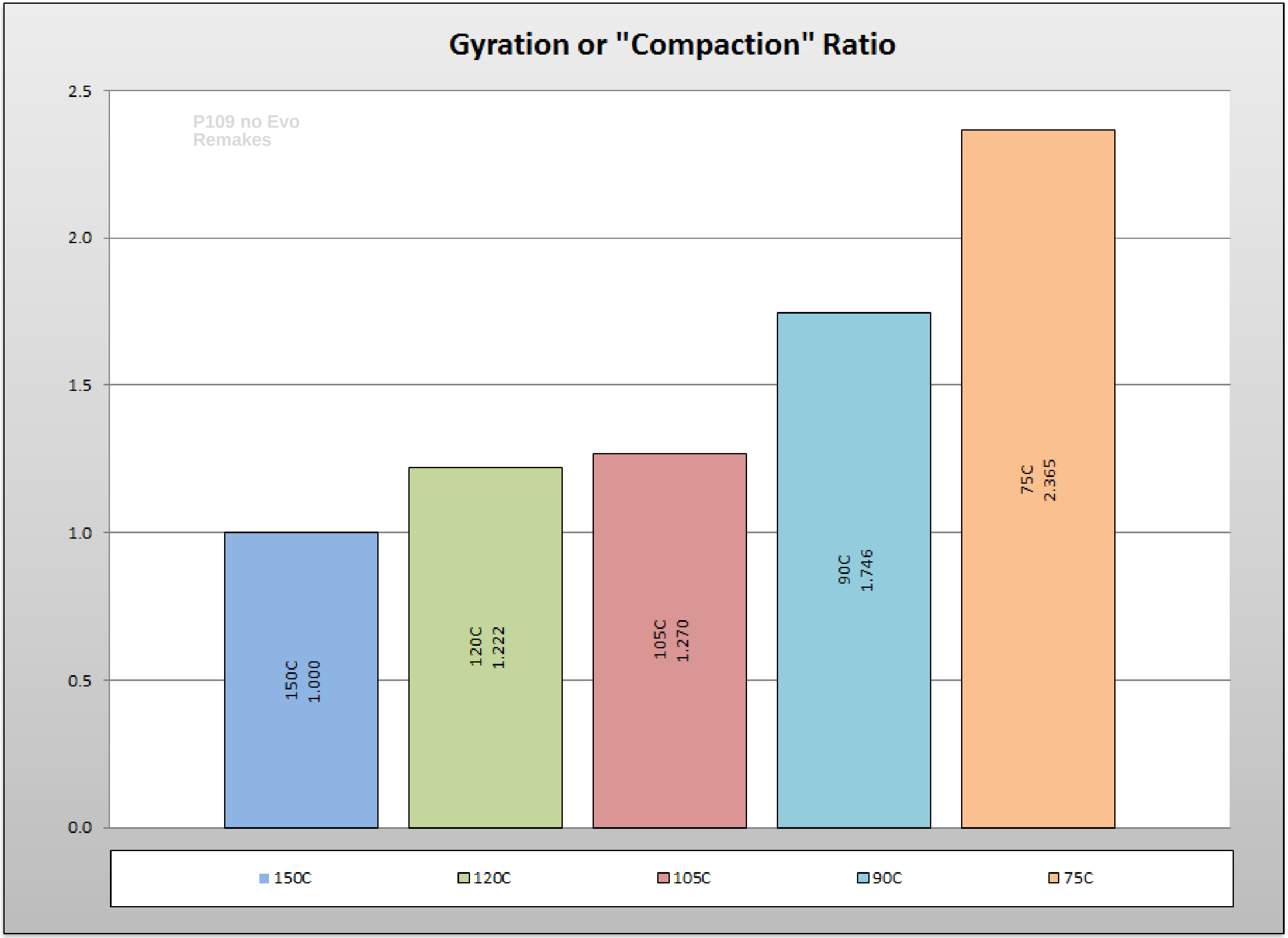
Determine effective dose rate for WMA additive

- Compaction Metric (example)
- DWT (example)

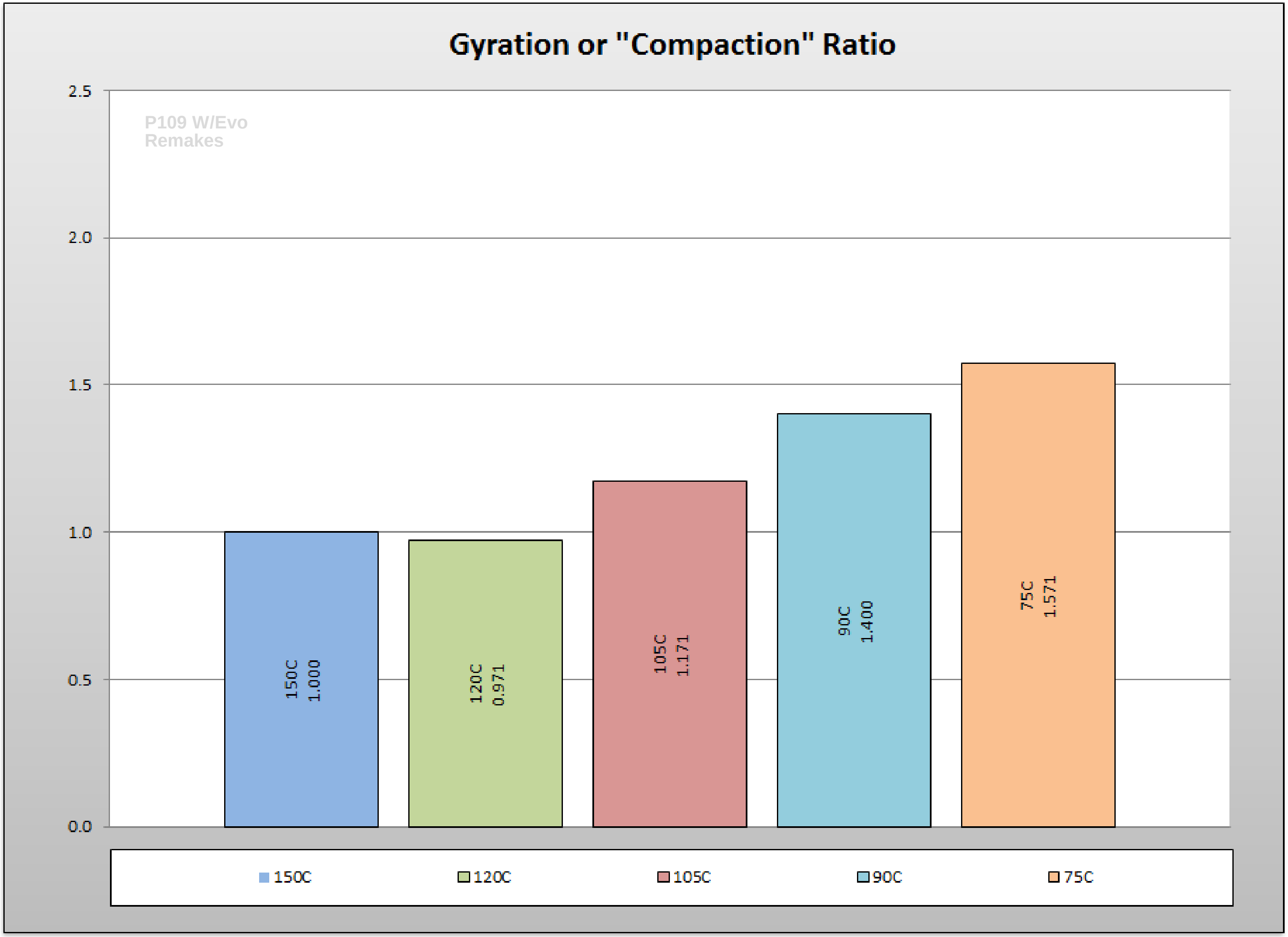
Evaluation of HMA & WMA using AMPT

- Dynamic Modulus, E*
- Flow Number, F_n
- Direct Tension Cyclic Fatigue
- Overlay Test

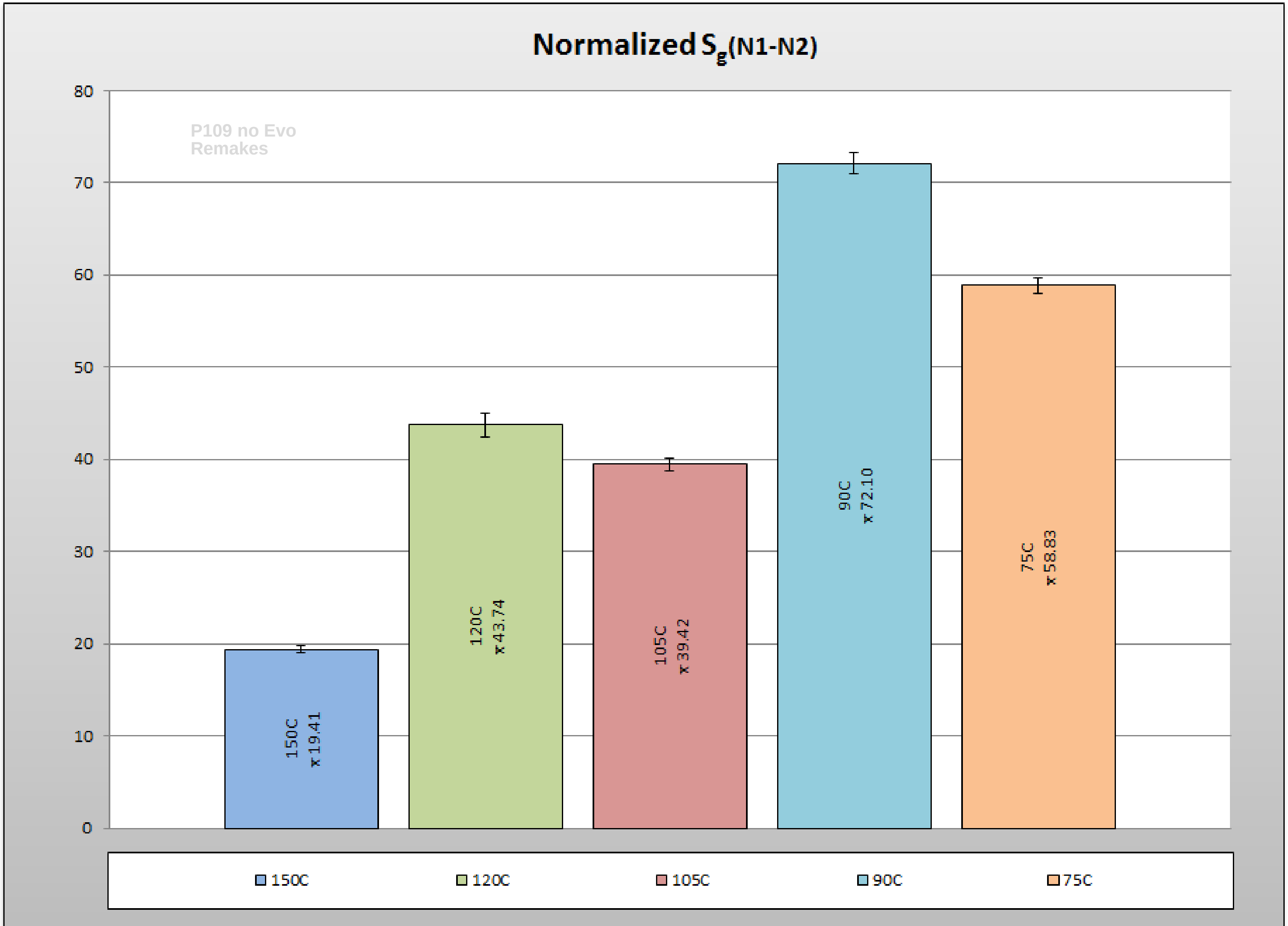
Example HMA Mix Compaction Ratio



Example WMA Mix Compaction Ratio



Example HMA Mix - Norm Sg(N1-N2)



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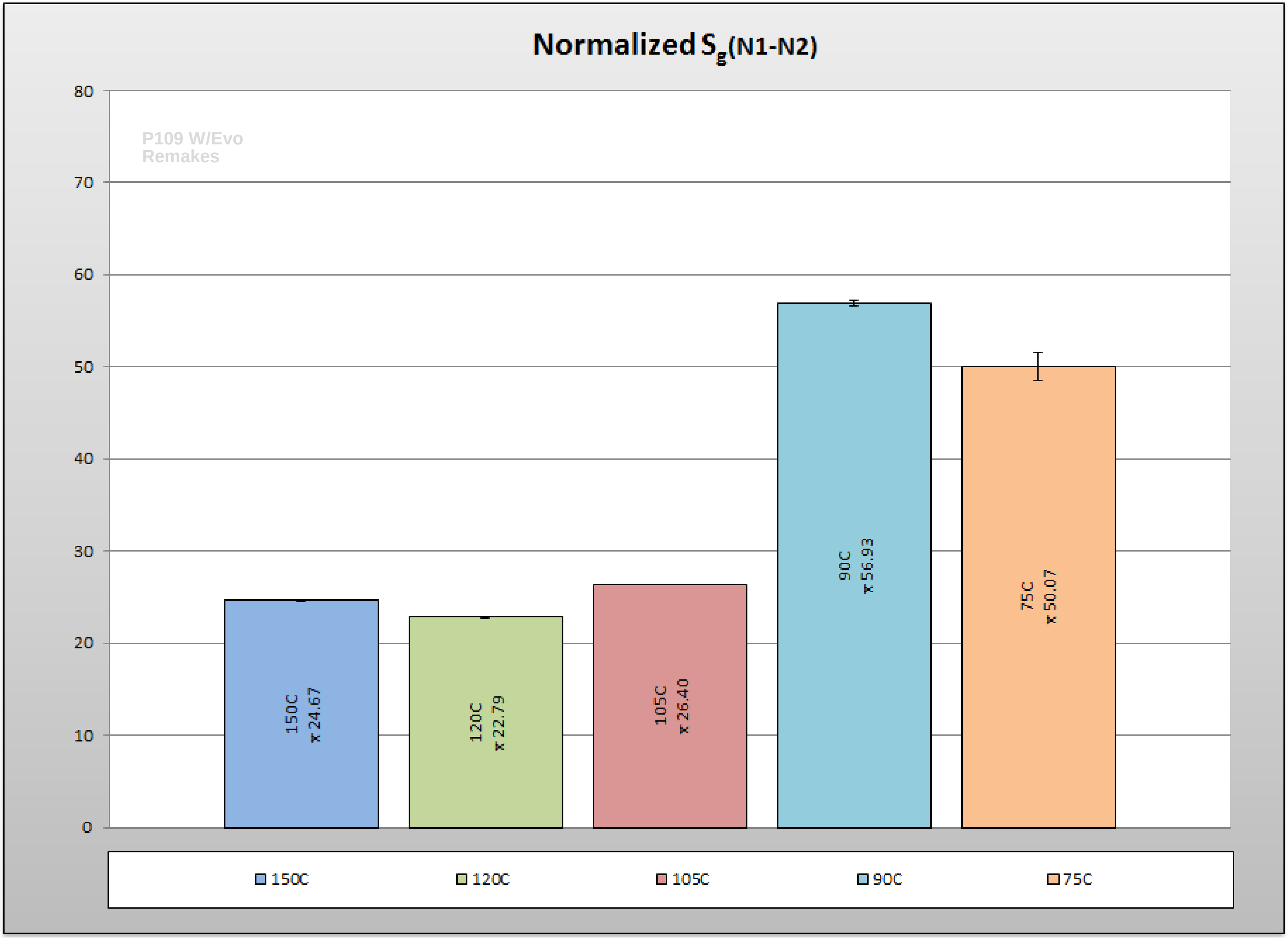

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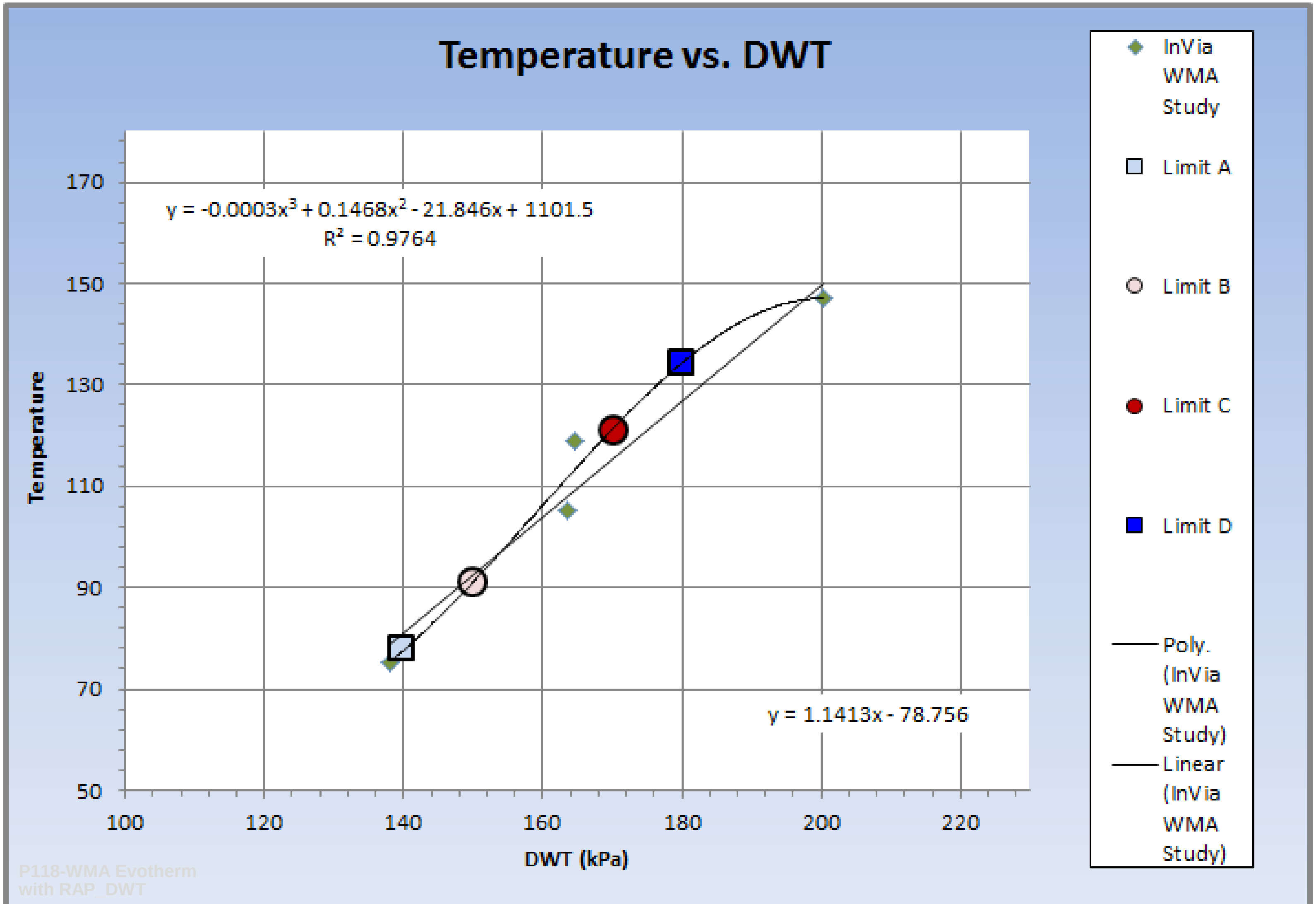
Example WMA Mix DWT workability



WMA Chemical Manufacturer's Guidelines/Specification Development

Mixture aging

- As per RRD 370, *Guidelines for Project Selection and Materials Sampling, Conditioning, and Testing in WMA Research Studies*

PMFC -> DWT, Compaction Metrics

PMLC -> TSR, HWT, MiST, E*, F_n, OT, Direct Tension Cyclic Fatigue

- PMFC Aging conditions
  - Compacted within 1 to 8 hours of production
- PMLC Aging conditions
  - **TSR, HWT, MiST** - 2hrs @ WMA Compaction Temp + 16 Hr at 60C (140F) +2 Hr Compaction Temp
  - **E*, F_n, OT, Cyclic Fatigue** - Long Term Aging (AASHTO R30) 5 days at 85C (185F) + 2 Hr at Compaction Temp

WMA Chemical Manufacturer's Guidelines/Specification Development

Evaluate E*, Fn, OT, Direct Tension Cyclic Fatigue

Current Status –

- Collected mix on 11 projects / 18 mixtures
- Running E*, F_n, OT, Direct Tension Cyclic Fatigue

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New Product Development

EvoFlex™ Recycling Additive

- Product Purpose
  - Binder Grade Modification
  - Improve RAP/RAS Blending
  - Improved Workability
  - Improved Coating

How is AMPT being used?

- Evaluate Binder, RAP, and RAS components during design to determine appropriate EvoFlex™ dose rate

Dynamic Modulus E*

- Compare measured mix E* to Binder/Mix E* predicted via the Hirsch Model

Determine Blended Binder Grade

- Binder G*-> Run Hirsch Model -> Predict Mixture E*

New Product Development

Comparisons - Allow product development to move forward

- How much to use?
- How to add material to mix in lab?

Commercialization activities

- How to use material in the mix design
- Demonstrate how materials perform
  - Mixture Stiffness and Rutting
  - Durability
  - Reflective Cracking

New Product Development

Testing Outline

- Dynamic Modulus Master Curve Testing on Plant Produced Mixture (AASHTO TP 79-11)
- Extraction and Recovery of Binders from Plant Produced Mixtures (AASHTO T 164 and ASTM D 5404)
- Partial Master Curve Testing of the As-Recovered Binder (AASHTO T 315)
- Compare Measured E* (from AMPT) with Predicted E* (Hirsch Model) *F_n run for information only*
- Grading of the Recovered Binders (AASHTO R29)

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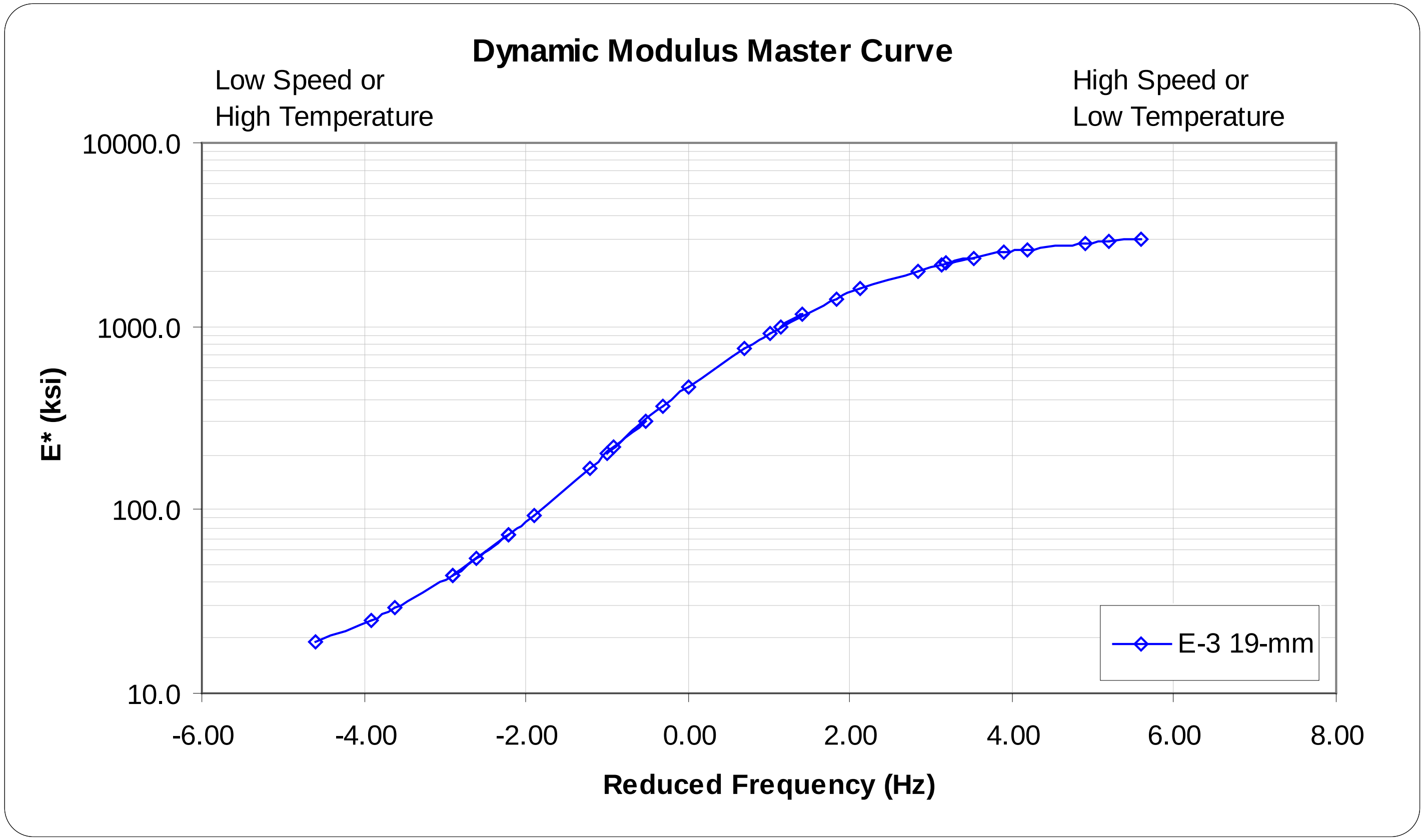
Mix E* Measured Master Curve
AASHTO TP 79-11

Mixture	Air Voids	VMA	VFA
PG 58-28	5.1	14.5	64.8



New Product Development

Hirsch Model

$E^*=f$ (VMA, VFA, and G^*_{binder})

$$E^* = P_c\left[4{,}200{,}000\left(1-\frac{VMA}{100}\right)+3|G^*|_{binder}\left(\frac{VFA\times VMA}{10{,}000}\right)\right]+(1-P_c)\left[\frac{1-\frac{VMA}{100}}{4{,}200{,}000}+\frac{VMA}{3\times VFA\times|G^*_{binder}|}\right]^{-1}$$

$$P_c=\frac{\left(20+\frac{VFA\times 3|G^*|_{binder}}{VMA}\right)^{0.58}}{650+\left(\frac{VFA\times 3|G^*|_{binder}}{VMA}\right)^{0.58}}$$

Christensen, D.W., Pellinen, T., and Bonaquist, R.F., "**Hirsch Model for Estimating the Modulus of Asphalt Concrete**," *Proceedings of the Association of Asphalt Paving Technologists*, Vol. 72, 2003, pp 97-121

Binder Extraction and Recovery AASHTO T 164 & ASTM D 5404

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Binder Testing AASHTO R29-08

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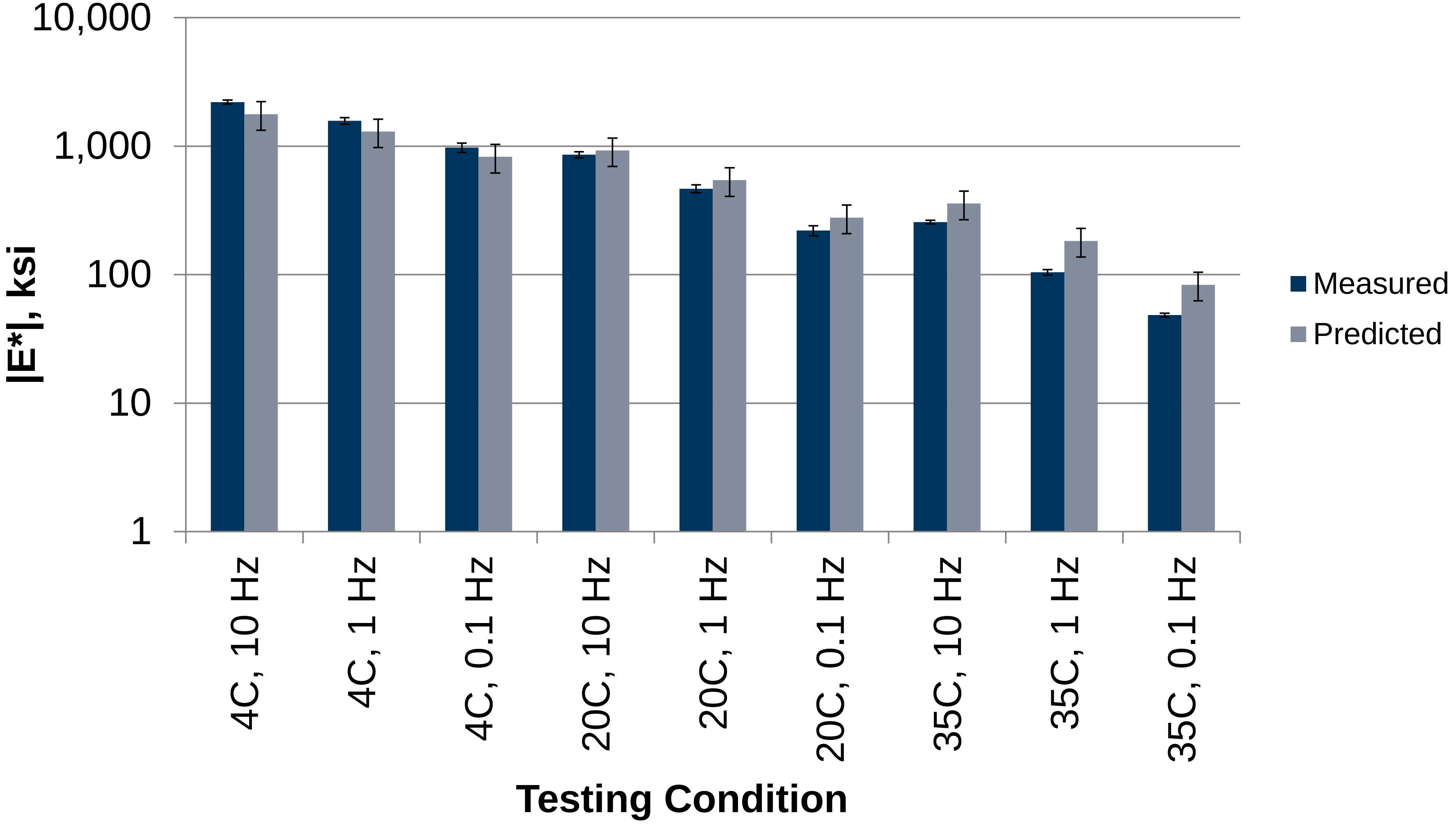
Compare Mix E* (Measured) to Binder E* (Predicted)



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Binder Grading (AASHTO M320)

Condition	Test	Temperature °C	PG 58-28 E-3 19-mm
As Recovered	G*/sinδ, kPa AASHTO T 315	58	12.0
		64	5.45
		70	2.52
		76	1.21
Pressure Aging Vessel Residue	G*sinδ, kPa AASHTO T 315	16	6695
		19	4840
		22	3330
	Creep Stiffness, MPa AASHTO T 313	-18	204
		-12	112
	m-value	-18	0.306
		-12	0.343
Continuous Grade, °C	High	N/A	71.1
	Intermediate		18.7
	Low		-29.0
Grade	AASHTO M 320	N/A	70-28

Summary

AMPT Mechanical Testing

- **Specification/Supplier Guidelines Development**
  - Dynamic Modulus Data Can be Used to Evaluate Chemical WMA
  - Allows Supplier to understand WMA effects on mixture mechanical tests
  - Mixture mechanical tests used to develop Supplier point of view on how best to use WMA
  - Mechanical mixture test data can be related to field performance
  - Predicted field performance can make it easier to agencies to adopt new products for regular use in construction

- **New Product Development – EvoFlex™**
  - Mix E* used to evaluate RAP & RAS mixtures with EvoFlex™
  - Test is sensitive to binder stiffness

Acknowledgements

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Thunderhead Testing

Questions?