

Engineered Materials

Details of UW Madison
Work Plans

Related to Modeling

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EPMs – Main Research Themes



- **Use modeling to guide materials' design**
 - Micromechanics and phenomenological
 - Rheology and damage resistance
- **Focus on two main areas**
 - **Asphalt materials for critical applications.**
 - High traffic volume, slow moving, heavy axle loads,
 - extreme climate, and
 - perpetual service life.
 - **Conserving energy and natural resources**
 - Increased use of (RAP) in hot-mix asphalt.
 - emulsions for cold mix asphalt, and
 - warm mix additives

Engineered Materials- 10 Work Plans



Category	Specific Work Element	Consortium Partner- Work Elements				
		WRI	TTI	UWM	UNR	AAT
Modeling	Analytical and Micro-Mechanics Model for Mastics and Mixtures		E1-a E1-b			
	Damage Resistance Modeling of Binders			E1b-1 E1b-2		
	Warm and Cold Mixtures			E1c-1 E1c-2	E1c-2	
	Comparison of Modification Techniques			E2a		
Design Guidance	Use of High Percentage of RAP			E2b	E2b	E2b
	Critically Designed HMA Mixtures				E2c	
	Thermal Cracking Resistant Mixes for Intermountain States			E2d	E2d	
	Design of Fatigue and Rut Resistant Mixtures					E2e

Focus of this Presentation and Relationship to FHWA Focus Areas



<i>FHWA Focus Areas</i>	<i>Asphalt Research Consortium Program - Related Tasks</i>
<ul style="list-style-type: none">Optimize Pavement PerformanceAdvanced Quality Systems	E1b-1 Damage Resistance Characterization
<ul style="list-style-type: none">Environmental Stewardship	E1c-1 Warm Mixes

E1b-1: Rutting Resistance of Asphalt Binders – Modeling Considerations



- Type of Loading
 - Must be consistent with actual traffic loading
- Stress Level
 - Representative of binder stresses realized in the mix.
 - Quantify the effects of accumulated damage – nonlinear behavior.
- Effects of Modification on Performance
 - Polymer / additive effects:
 - Damage Resistance
 - Elastic Recovery

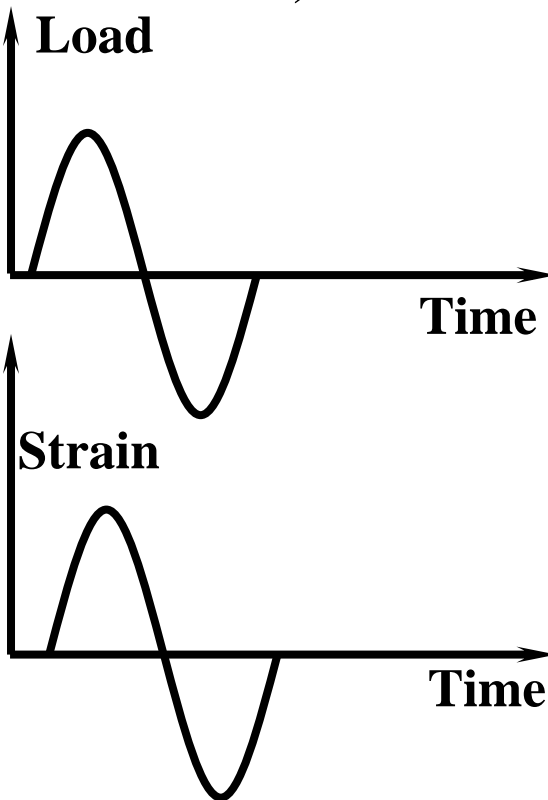
E1b-1: Rutting Resistance of Asphalt Binders – Modeling Considerations



- Type of Loading Reflects Actual Conditions

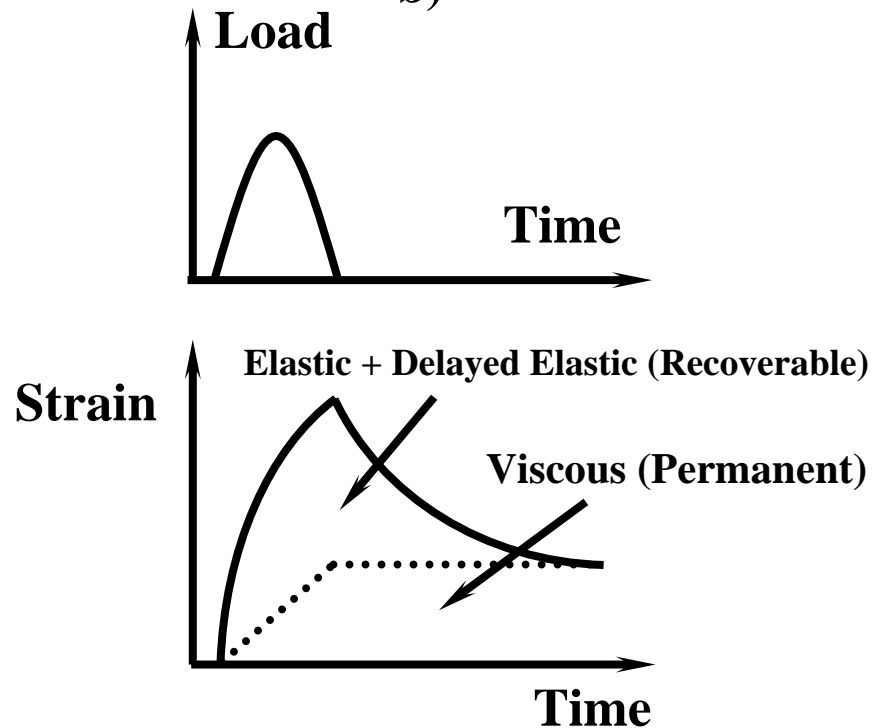
Cyclic

a)

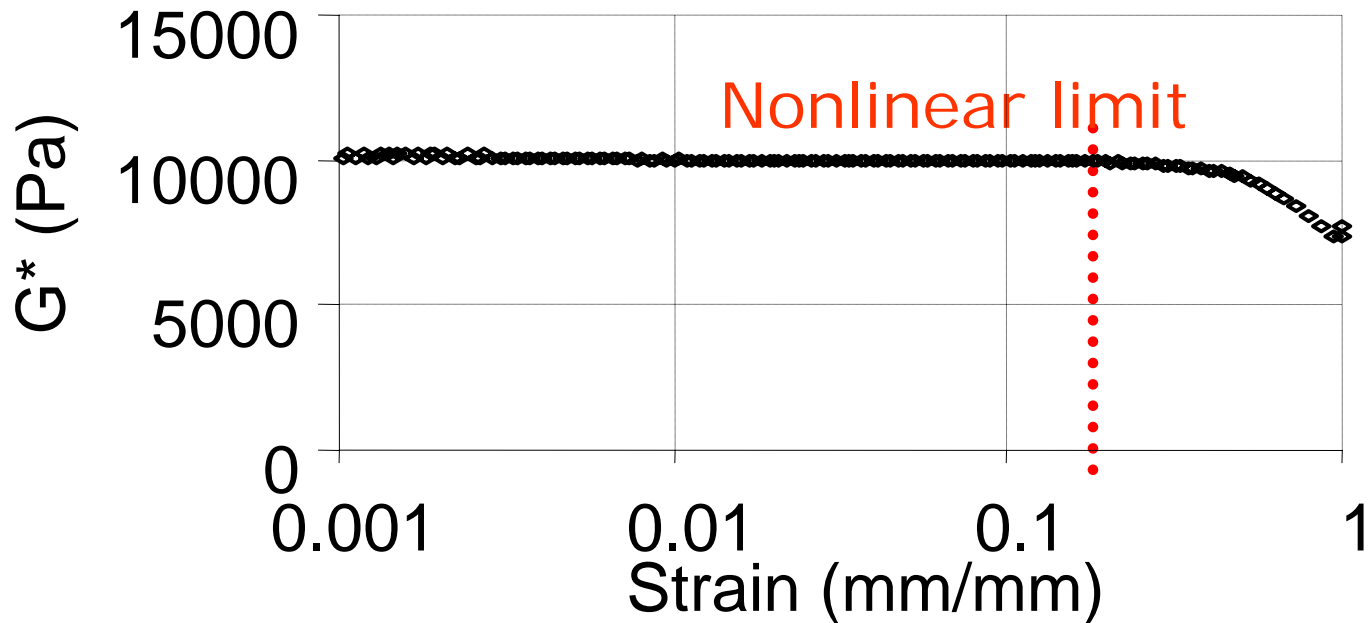


Impulse Load with a Rest Period – Considers Recovery

b)

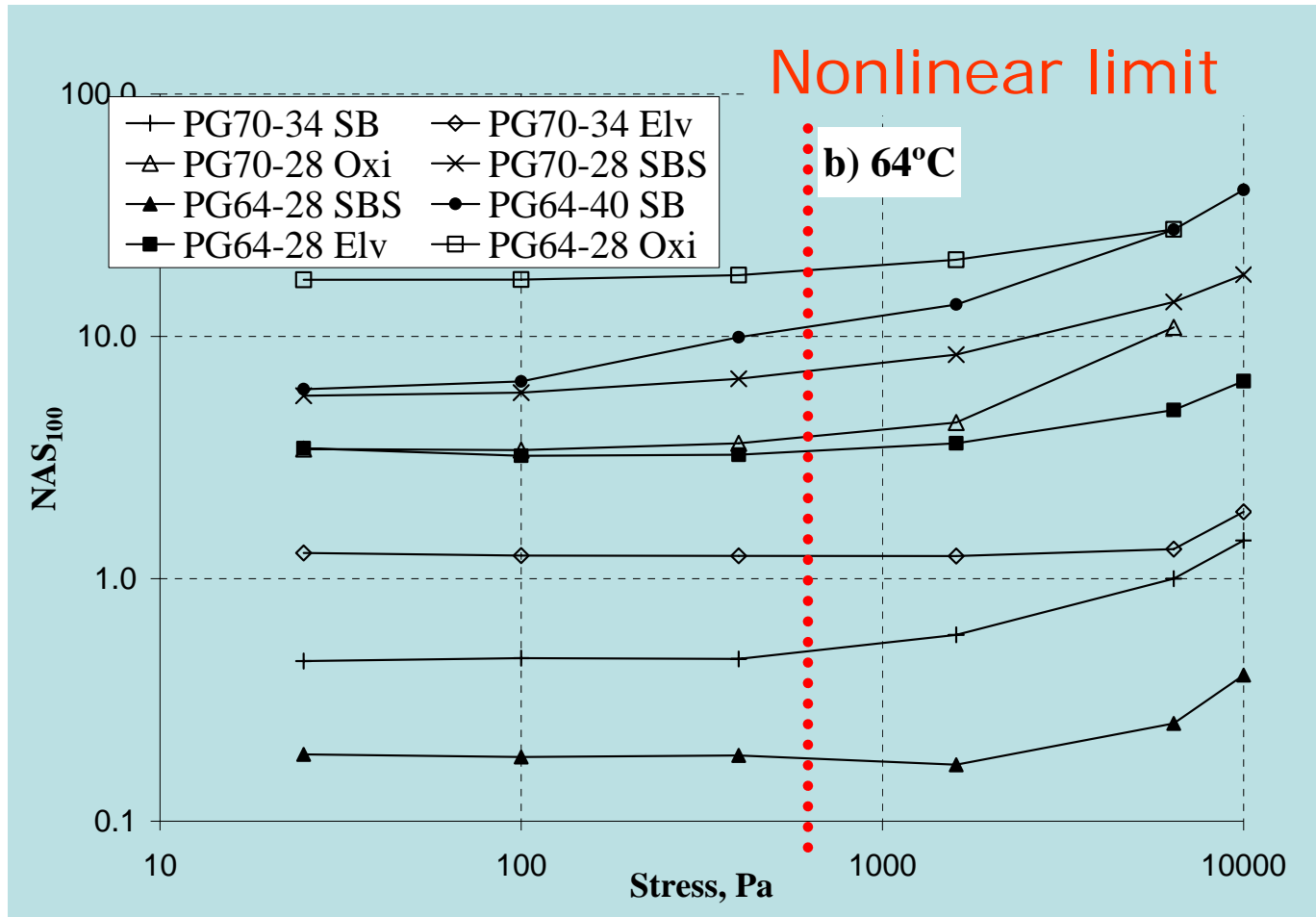


E1b-1: Rutting Resistance of Asphalt Binders – Strain Level



- Strain levels in the binder estimated 0-500 times those realized in the mix.
- Clearly non-linear behavior must be considered

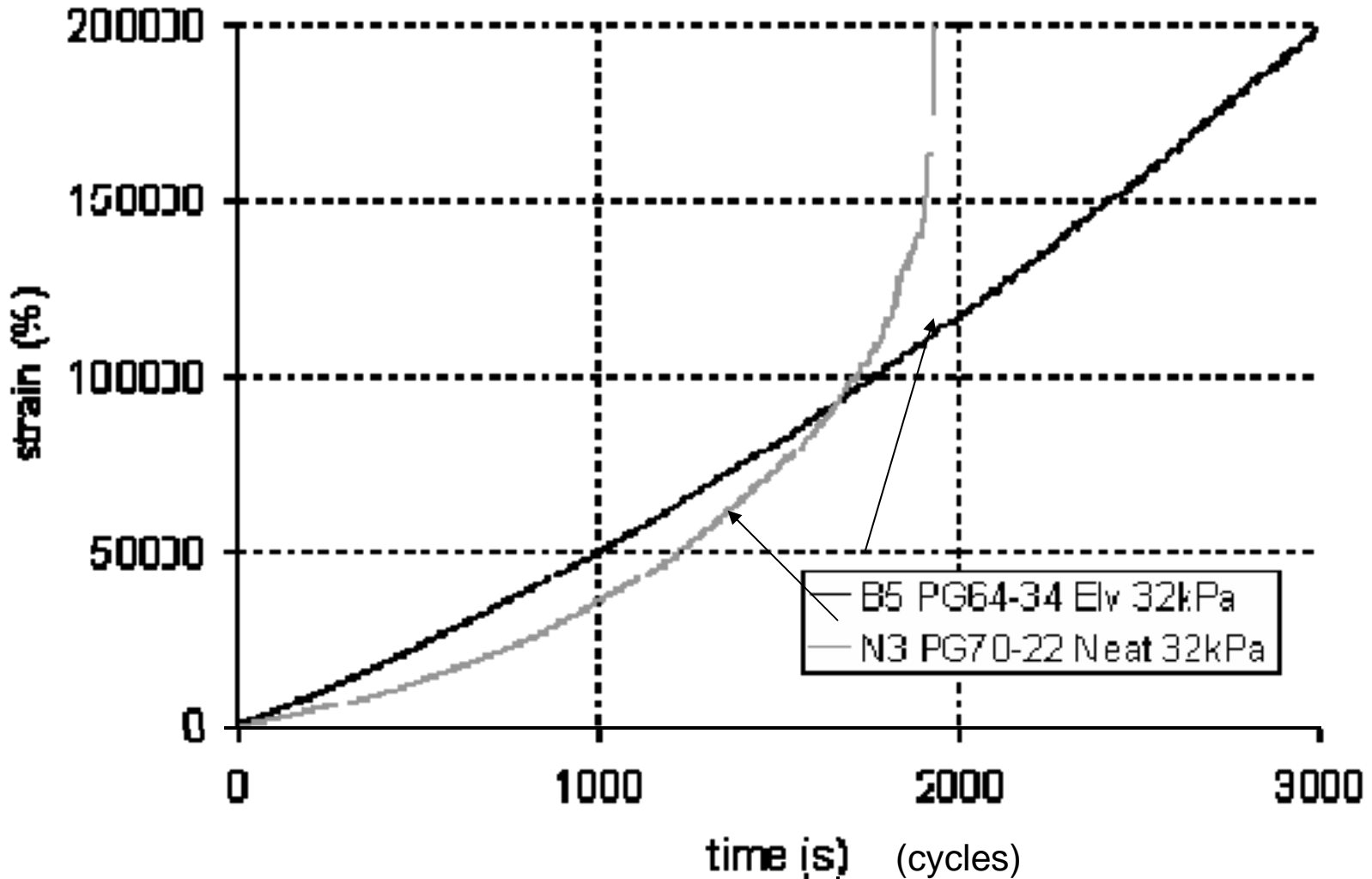
Normalized Accumulated Strain after 100 cycles NAS_{100}



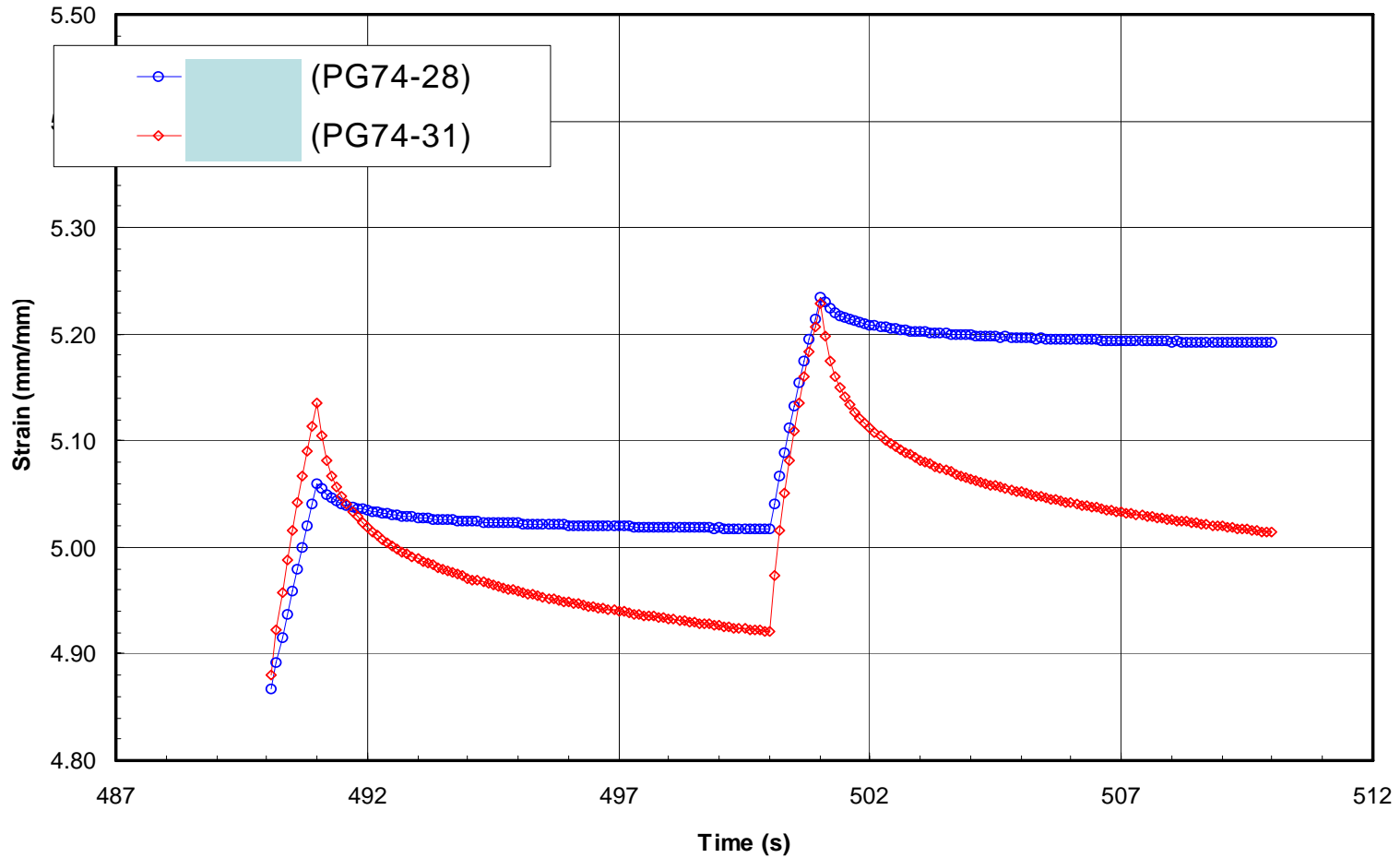
Effect of Accumulated Loading Time Repeated Creep Testing



Delgadillo & Bahia – 2007 Unpublished data



E1b-1: Rutting Resistance of Asphalt Binders – Effects of Polymers - Recovery



E1b-1: Rutting Resistance of Asphalt Binders – Hypothesis



- **Hypothesis**

- Binder needs to be **characterized at different stresses and loading times** in order to accurately predict the rutting performance of mixtures
- **Will be coordinated with D'Angelo's work**
 - **AAPT 2007: Recoverable Compliance Jnr**
 - **Expand on Unpublished work by UW**
 - **Need for model at higher stress levels and loading times.**

E1b-1: Rutting Resistance of Asphalt Binders – Experimental Plan



- Literature Review
 - Methods of Binder and Mixture Rutting Evaluation
 - Relationship between binder and mix rutting.
- Selection of Materials Parameters
 - Binder:
 - High Temp PG Grade (PG 58-xx – 76-xx)
 - Modifier: SBS, Elvaloy, SB, EVA, PPA, oxidized
 - Mix
 - Gradation: Fine, Coarse, OGFC
 - Aggregate Shape: Angular and Rounded
 - Asphalt Content: Design and Design + 0.5%

E1b-1: Rutting Resistance of Asphalt Binders – Experimental Plan



- Analysis and Interpretation:
- Model relationship between binder and mixture rutting as a function of:
 - stress level, aggregate properties, and mix volumetric properties
- Include significance variables in prediction of traffic volume effects:
 - Stress level (non linear behavior)
 - Temperature
 - Total Time of Loading
 - Aging (RTFO)
 - Number of Cycles

E1b-1: Rutting Resistance of Asphalt Binders – Deliverables



- Standard Test Procedures and Recommendations for Specifications
 - Evaluate MSCR Protocol and suggest revisions
 - Inclusion of procedure and limits for PG binder specification
- Limits will be based on correlations to mixture response and LTTP data for Rutting Performance.

E1c-1: Warm Mixtures and Relationship to Modeling



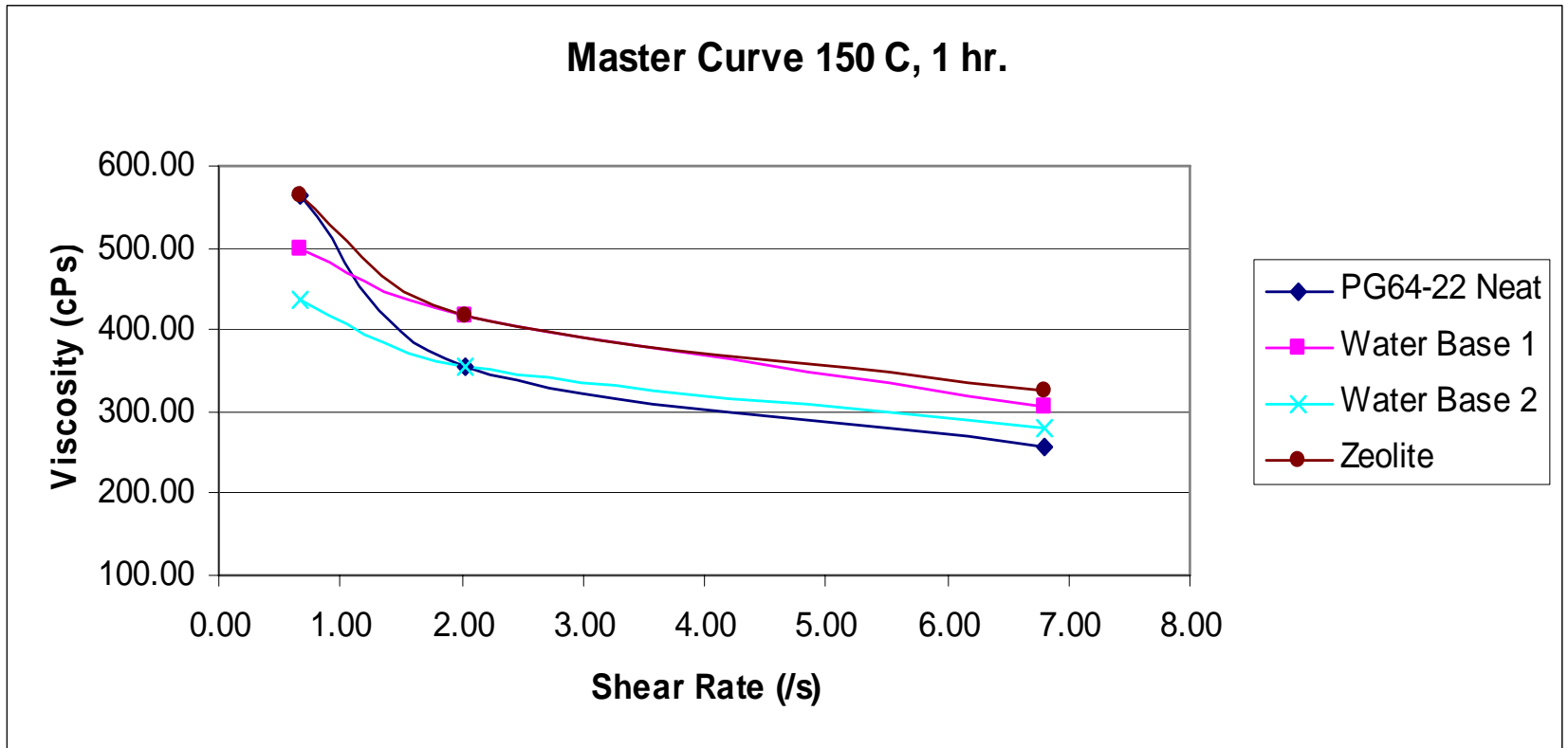
- Focus will be on quantifying effects of various additives on binders, mixtures, and environment.
- Models Needed in the Following Areas
 - Prediction of Reduction in Mixing and Compaction Temperatures
 - Prediction of Reduction in Emissions
 - Effect of Additives on Mixture Durability and Performance
- Will be coordinated with
 - NCHRP 9-43 (Mixture Design Procedure for WMA)
 - NCHRP 9-47 (Field Validation of WMA)

Prediction of Temperature Reduction – Focus on Binder

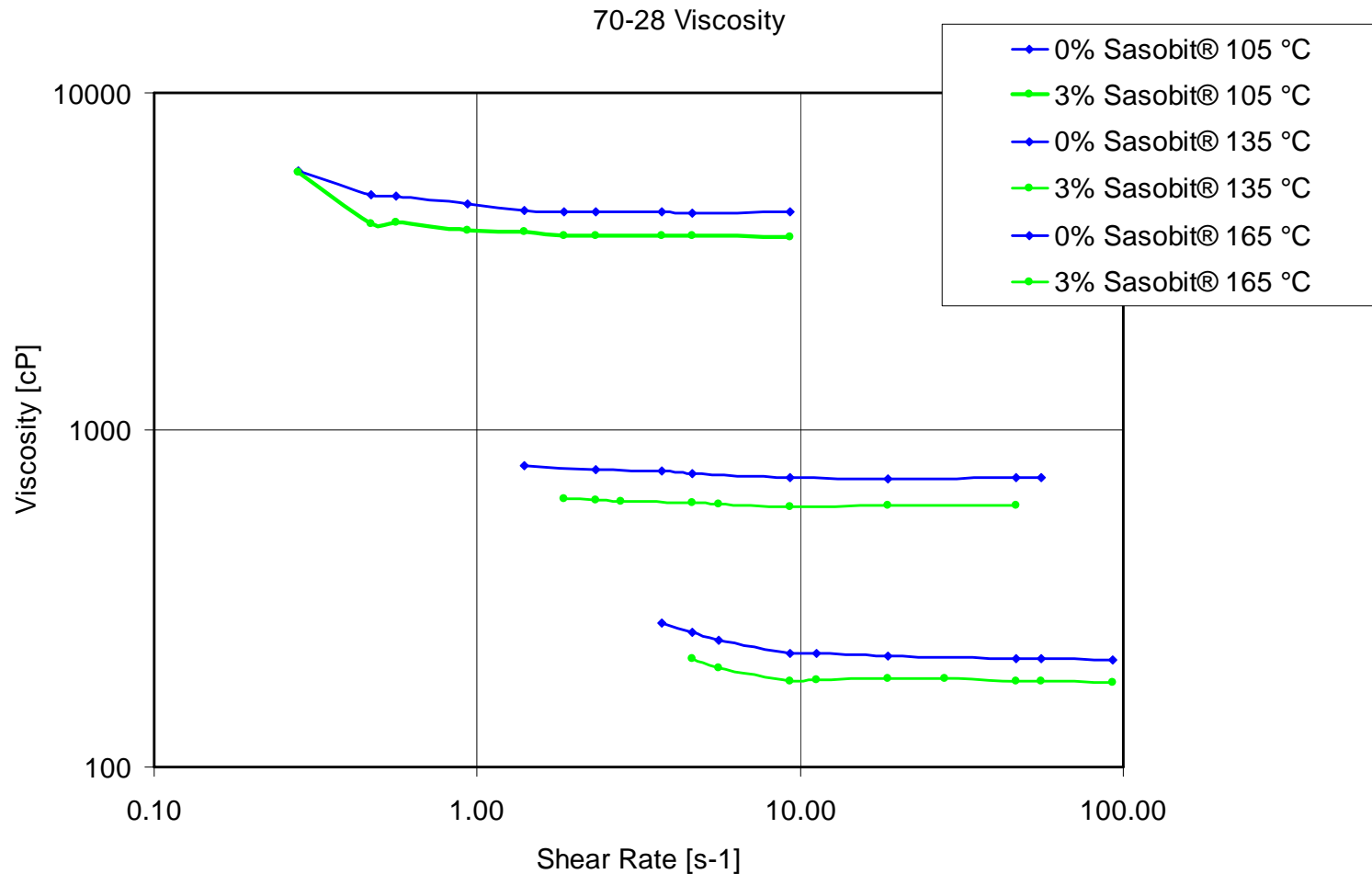


- Asphalt Binder
 - viscosity and temperature sensitivity
 - Content in mix (film thickness)
- Additive
 - Type – Wax Based and Hydrated Mineral
 - Concentration
 - Curing / setting rate

Reduction in Viscosity for Mineral Additives



Reduction in Viscosity for Wax Additive

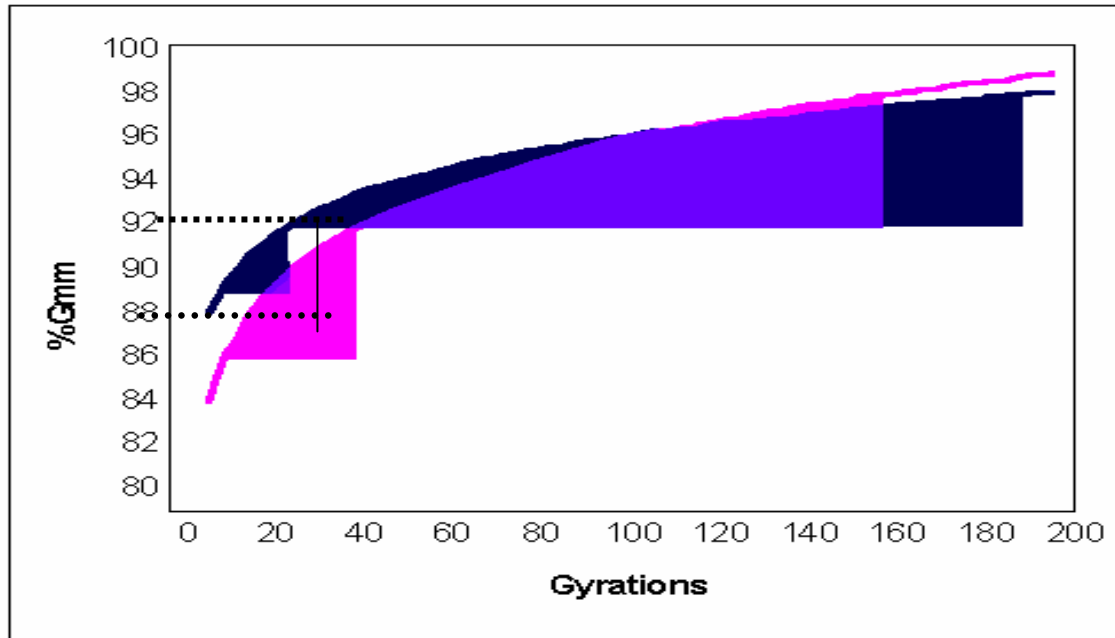


Prediction of Temperature Reduction – Focus on Mixture



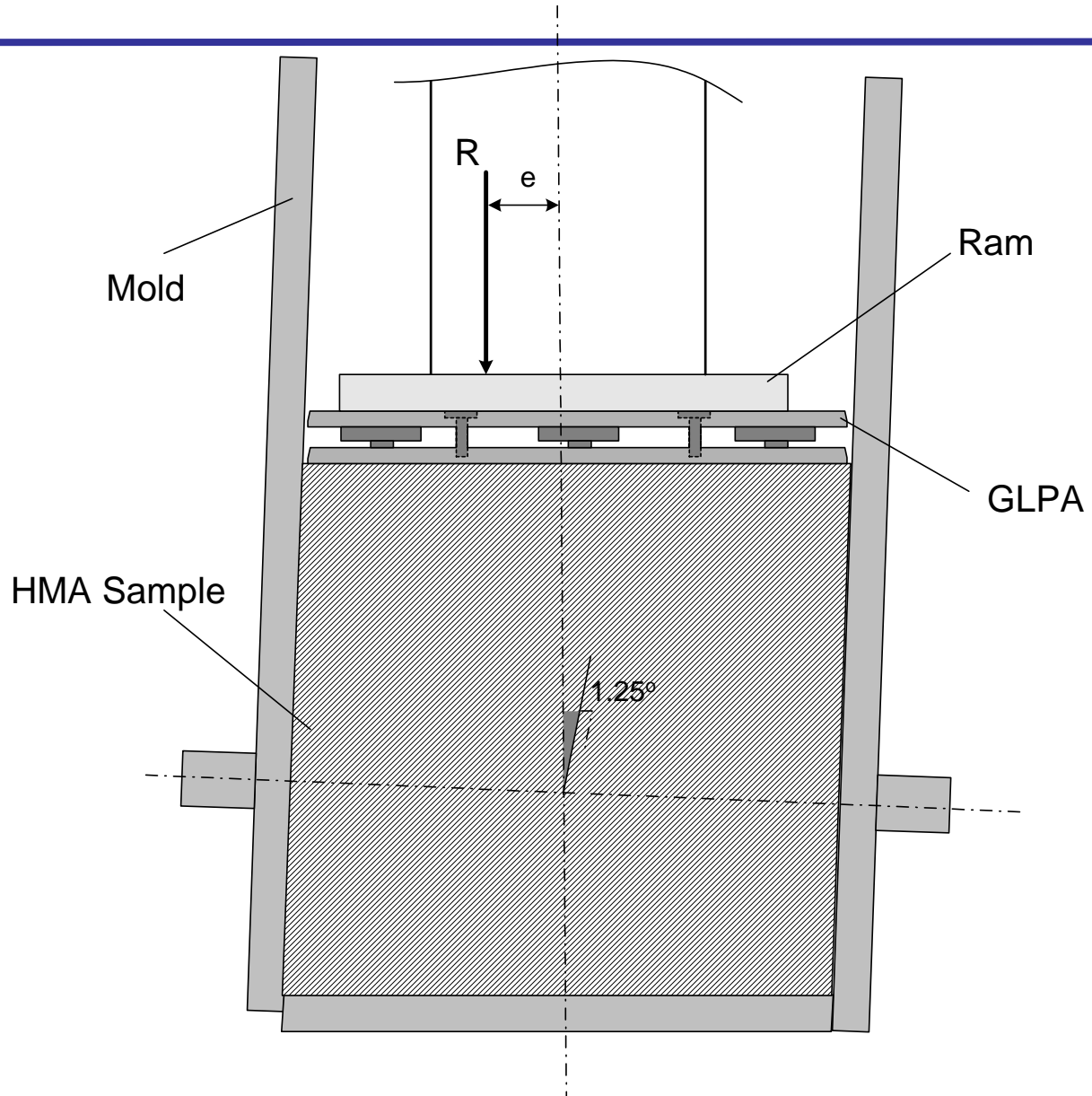
- Mix Design Protocols will be coordinated with NCHRP 9-43
- Mixture
 - How are trends found in binder related to mixture behavior?
 - viscosity and temperature sensitivity
 - Content in mix (film thickness)
 - What aggregate/mix properties are significant?
 - angularity
 - surface texture
 - NMAS
 - VMA
 - Evaluate effect of compactive effort – 600 ksi vs. 250 ksi.
- Evaluation Criteria: Reduction in Compaction Effort
 - Gyrotory Load Plate Developed at UW will be used to measure compactive effort (from 88-92%Gmm)

Quantifying Compactive Effort Using the Gyrotory Load Plate



Lower Compactive Effort is recognized by a smaller area under the compaction curve from 88 – 92% Gmm

PDA



PDA Used in the SGC Compaction Mold



Modeling Environmental Impacts



- Quantify the Effects of Mixing and Compaction Temperatures on:
 - Emissions
 - Less Dust
 - Less Exhaust
 - Energy Savings
 - CO₂, CO, N₂, S₂..
- Literature Review will be conducted to develop methodology
- Efforts will be Coordinated with NCHRP 9-47

Modeling Effects on Mixture Performance and Durability



Models for Prediction of Additives on Binder and Mixture Mechanical Durability and Performance

- Rutting potential
 - Binder repeated creep
 - Mixture repeated creep
- Fatigue Resistance
 - Binder
 - Mixture
- Thermal Cracking
 - Binder
 - Mixture
- Moisture Damage
 - Binder (PATTI- DSR Cohesion)
 - Mixture
- Mixture Testing Protocols will be coordinated with NCHRP

Field Evaluation of Models



- Interpretation and Analysis of Test Results will be used to develop models.
- Models will be evaluated in field trials
 - Reduced mixing and compaction temperatures
 - laboratory density vs. in-place density
 - Reduction in Compactive Effort
 - Number of roller passes to achieve target density
 - Mixture Performance and Durability
 - Performance Surveys will be conducted to evaluate predicted vs. actual distress
- Will be coordinated with NCHRP 9-47

Thank you

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Asphalt Research Consortium

The Consortium will systematically develop and evaluate:

- appropriate tests, procedures, and guidelines for extending the life cycle and improving the overall performance of asphalt pavements;***
- develop new models or advance existing models that capture pavement performance;***
- work cooperatively with other Federal research activities to minimize duplication;***
- to optimize the overall research effort; and disseminate knowledge learned***