



MODIFIED
ASPHALT
RESEARCH
CENTER



Optimization of Asphalt Mix Design and Construction with Special Polymers

Professor Hussain Bahia
University of Wisconsin-Madison

Moscow, Russia
March 26-27, 2015



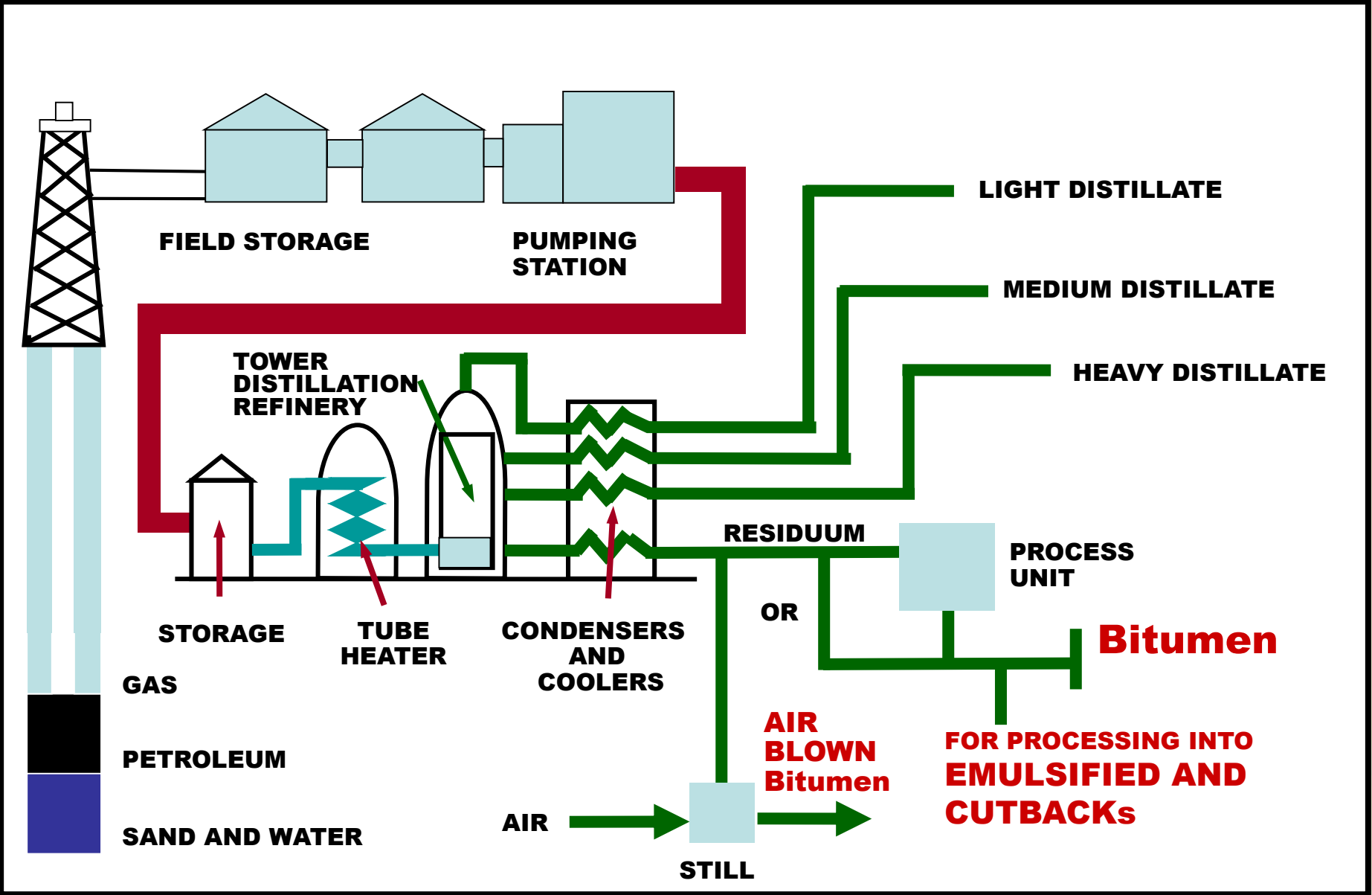
MODIFIED
ASPHALT
RESEARCH
CENTER



Outline

- **The need for Bitumen Modification**
- **Effect of Modification on**
 - Bitumen properties using Superpave and other methods
 - Constructability of asphalt mixtures
 - Rutting and cold temperature cracking testing.
- **Using digital imaging to show how some polymers can cause better packing of aggregates**
- **Potential savings of material, energy, and longer pavement life cycle**

Refineries Are not Designed to Improve Bitumen



Bitumen Role in Road Construction - Performance Based Grading

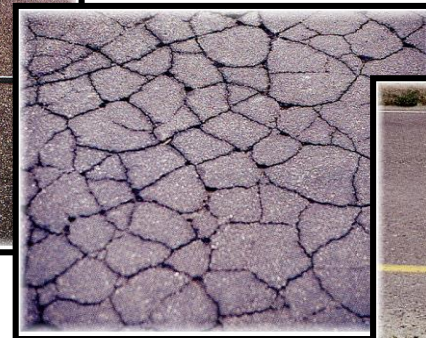
- **Constructability**



- **Performance**



Rutting



Fatigue Cracking



Thermal Cracking

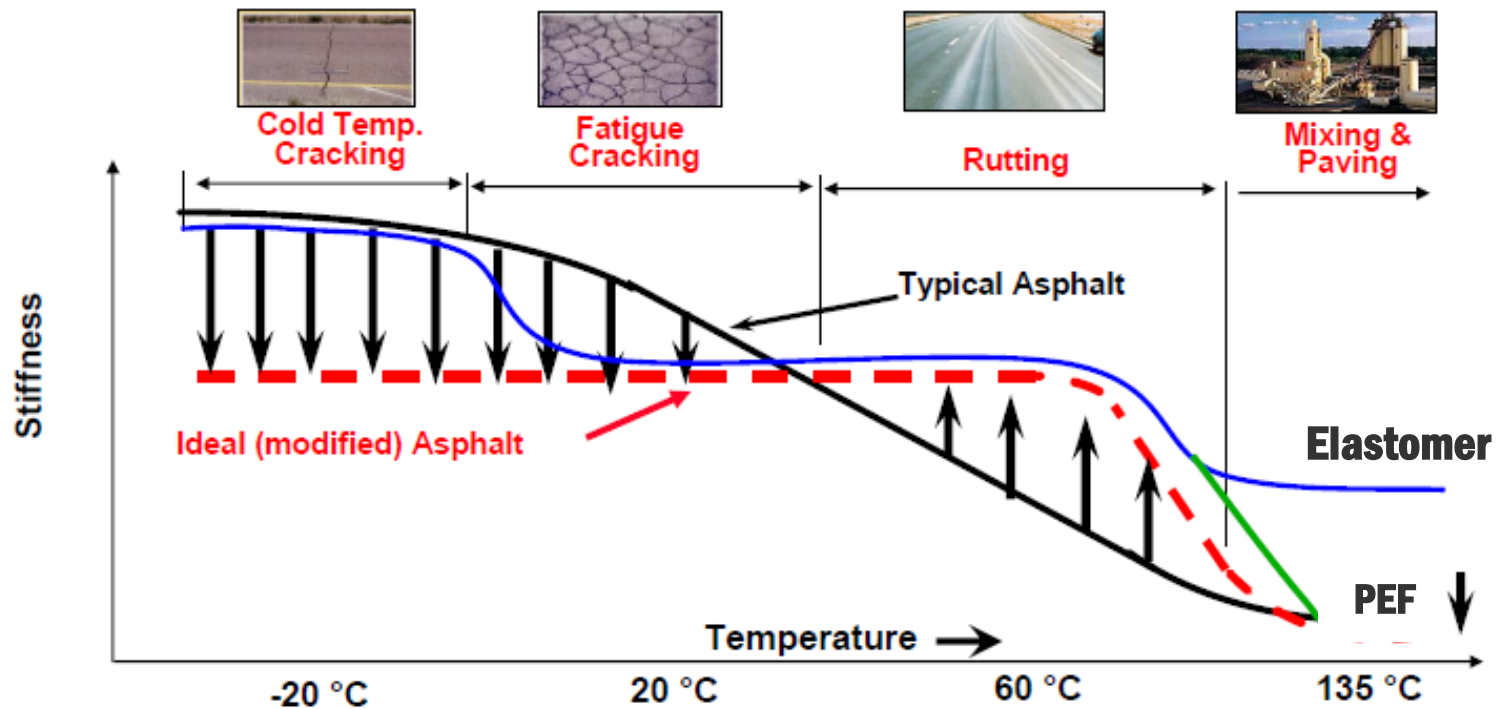
- **Durability**

Polymers for Asphalt

Type	Example
Thermoplastic elastomers	Styrene-butadiene-styrene (SBS) Styrene-isoprene-styrene (SIS) Styrene-butadiene-rubber (SBR)
Thermoplastic plastomers	Ethylene-vinyl-acetate (EVA) Ethylene-methyl-acrylate (EMA) Polypropylene (PP), Polyethylene (PE)
Chemical modifiers	Poly-phosphoric Acid , Sulfur, Lignin and metallic compounds
Thermosetting polymers	Epoxy resin, Acrylic resin
Fibres	Glass fibers, Cellulose, Polyester
Fillers	Lime, Fly ash, Hydrated lime

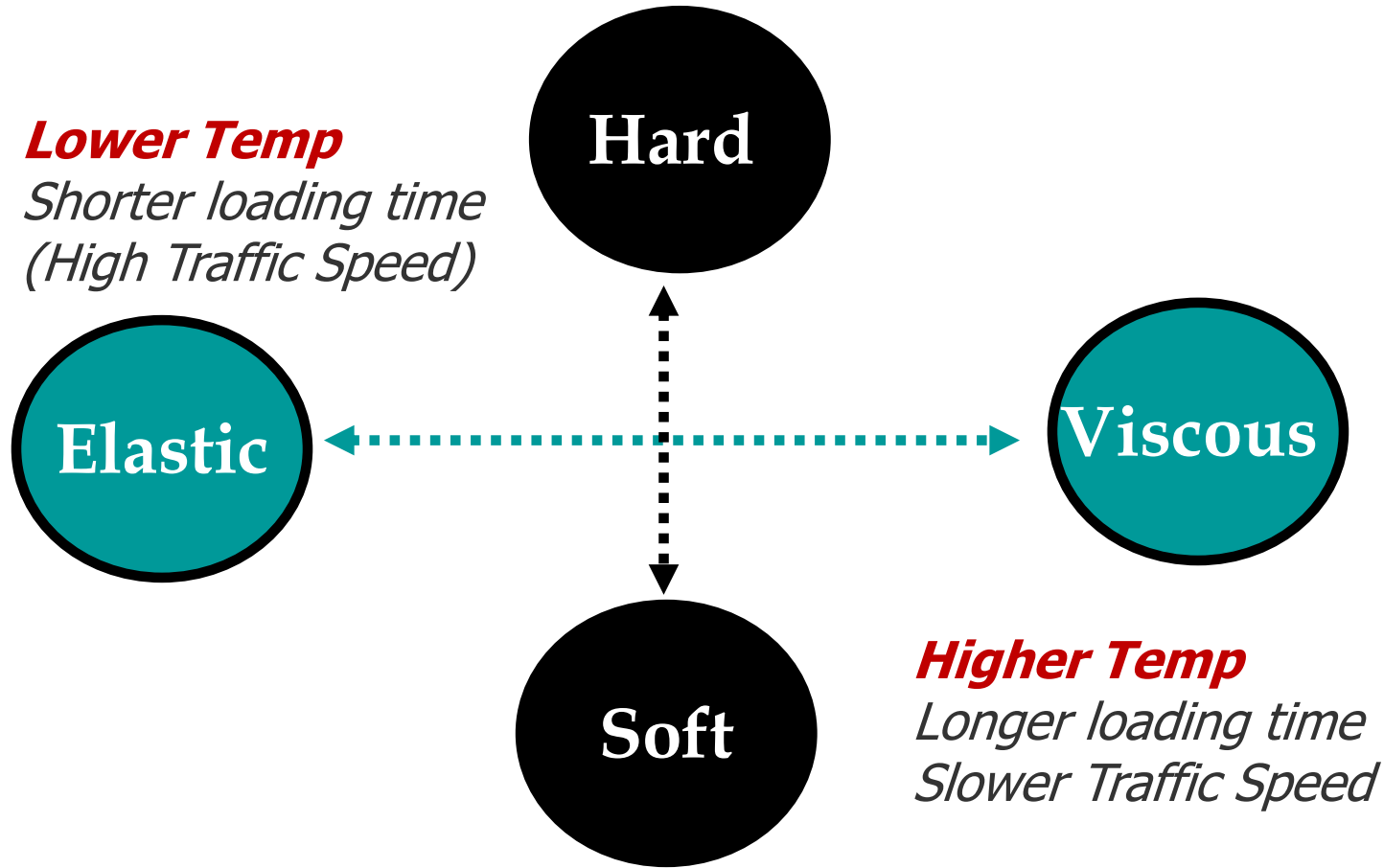
Modification Targets

- Polymer interacts with the asphalt to produce a more durable pavement
 - Elastomers Or Plastomers (FPE)

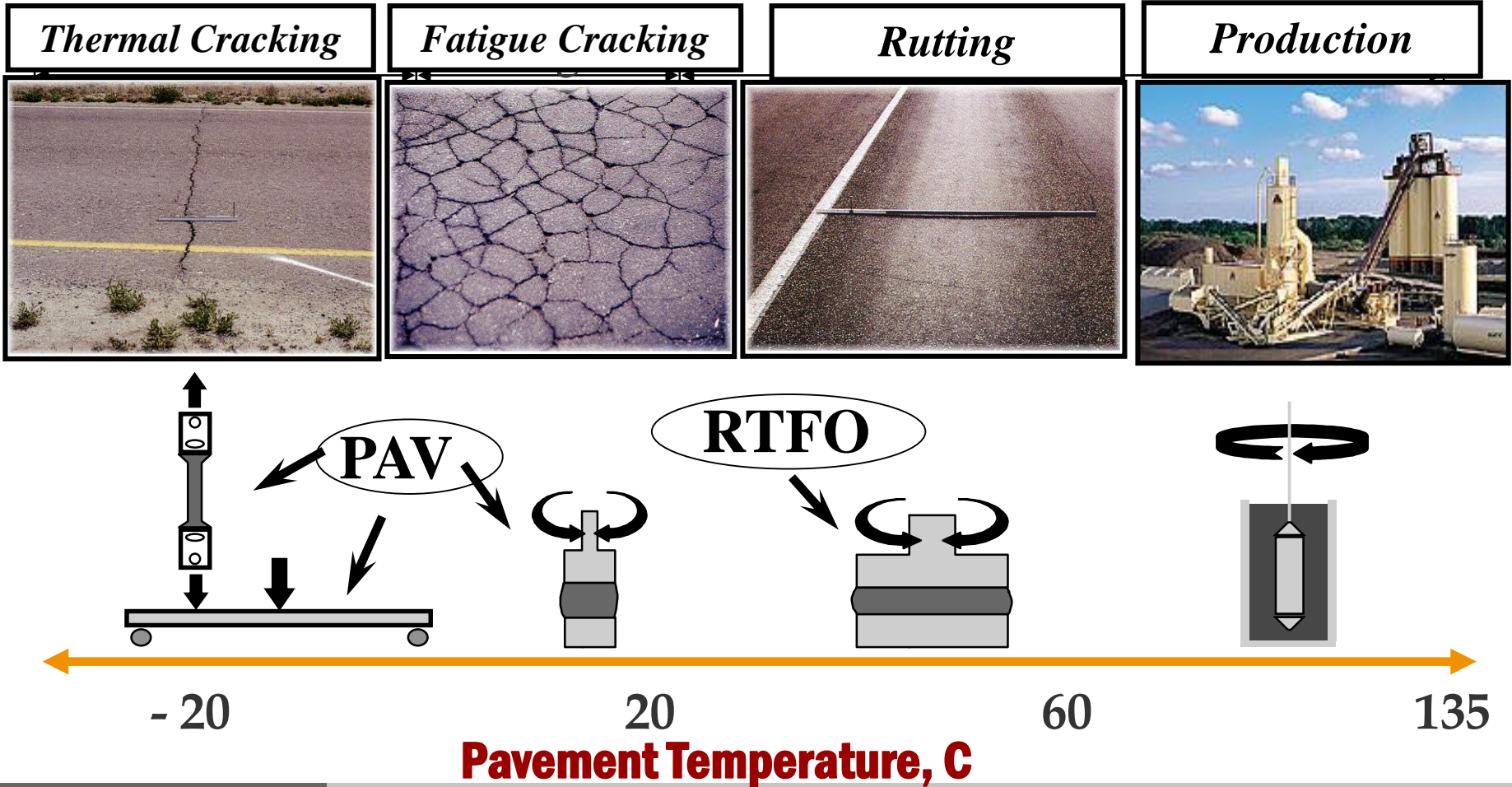


Modification can Improve Bitumen Behavior

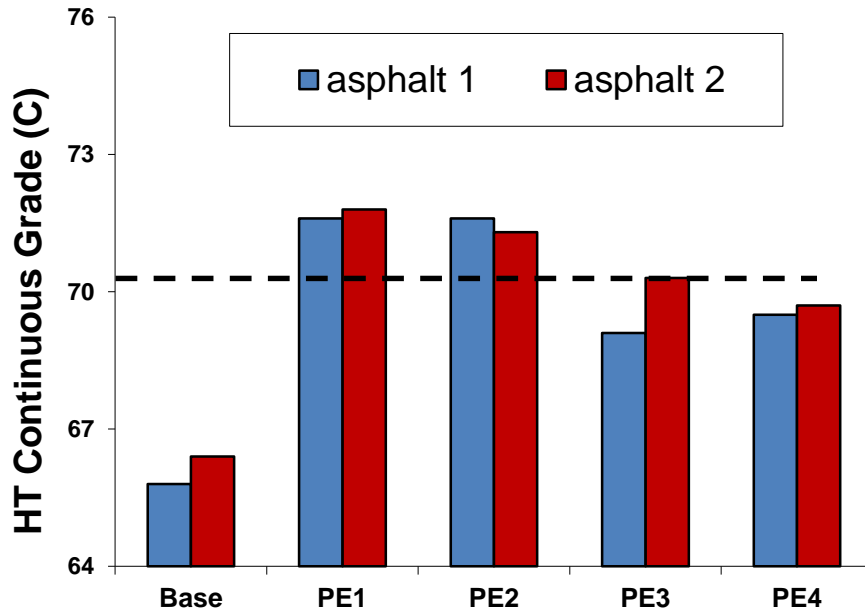
Hardness and Visco-elasticity



Fundamental Rheology Tests – PG System

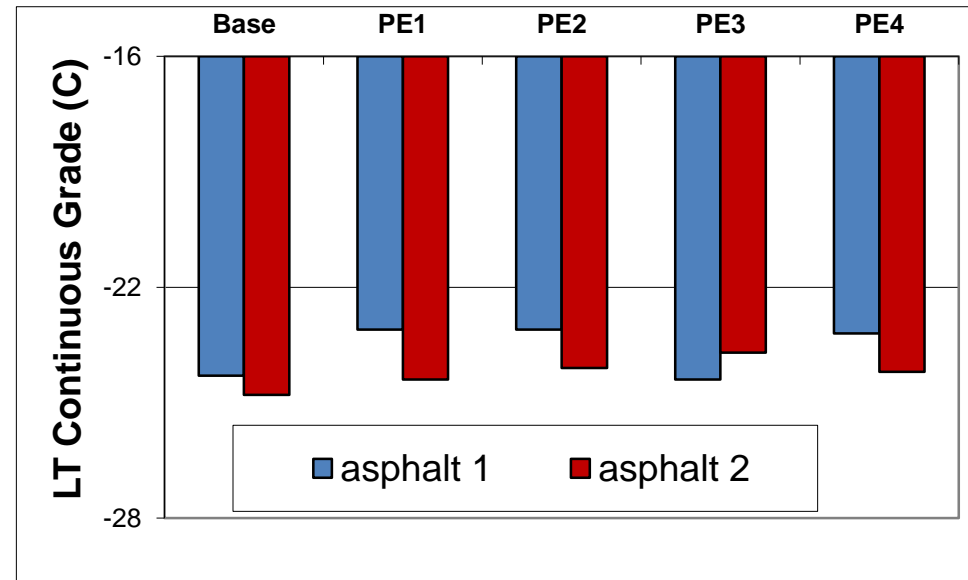
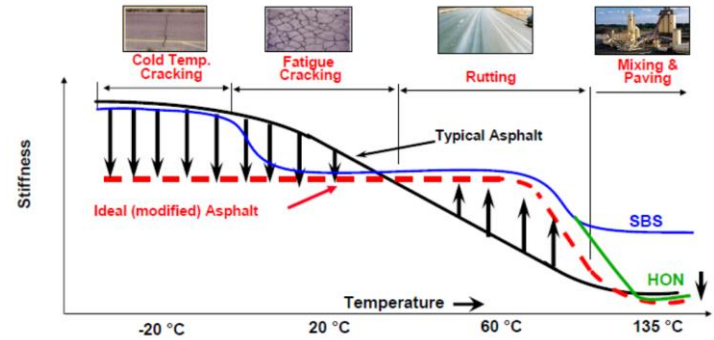


Modification by Changing PG Grades



PG 64 - 22 >> PG 70-22

PE1, PE2= NA, PEs PE3, PE4=European PEs



PG Grades and Binder Modification

Modification with Polymers

Modifi-
cation
with
Oils

High Temperature, °C

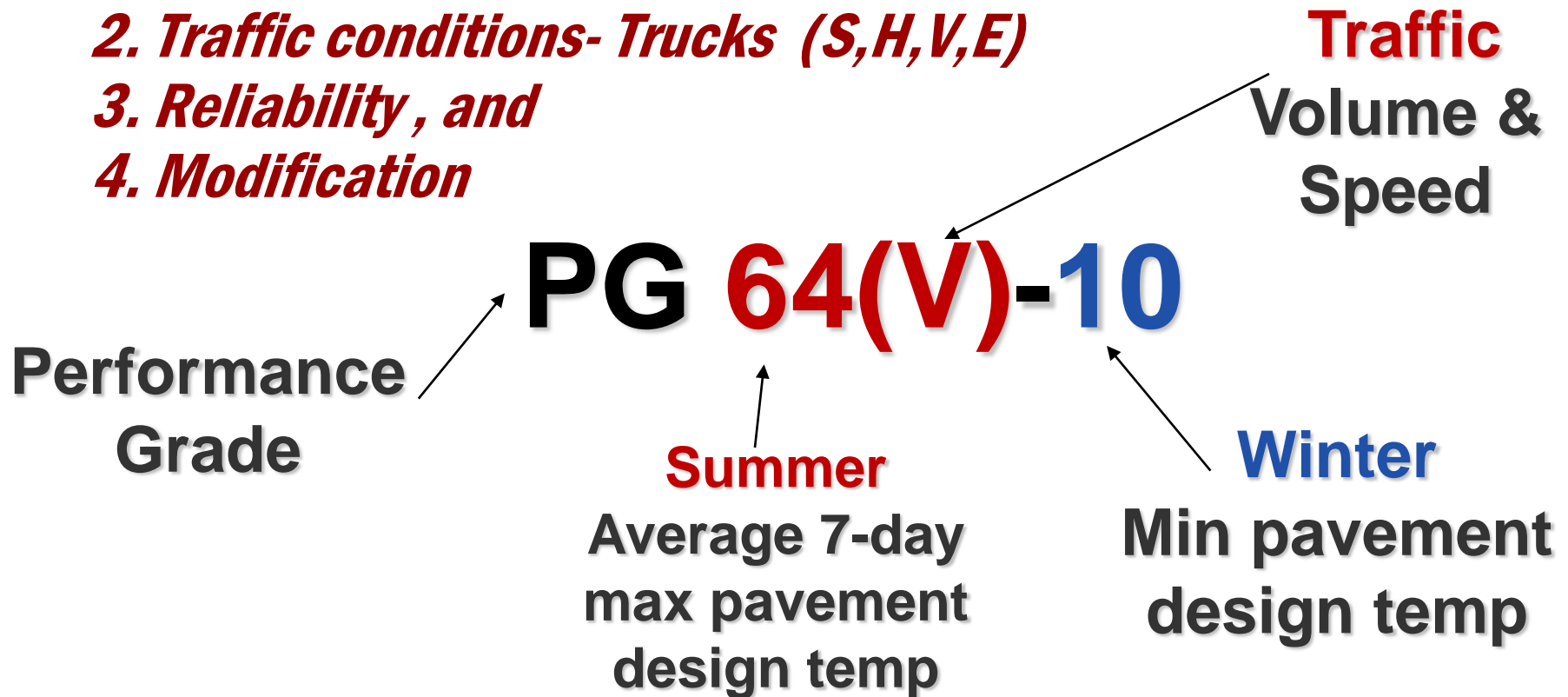
	52	58	64	70	76
Low Temperature, °C					
-16	52-16	58-16	64-16	70-16	76-16
-22	52-22	58-22	64-22	70-22	76-22
-28	52-28	58-28	64-28	70-28	76-28
-34	52-34	58-34	64-34	70-34	76-34
-40	52-40	58-40	64-40	70-40	76-40

Legend:

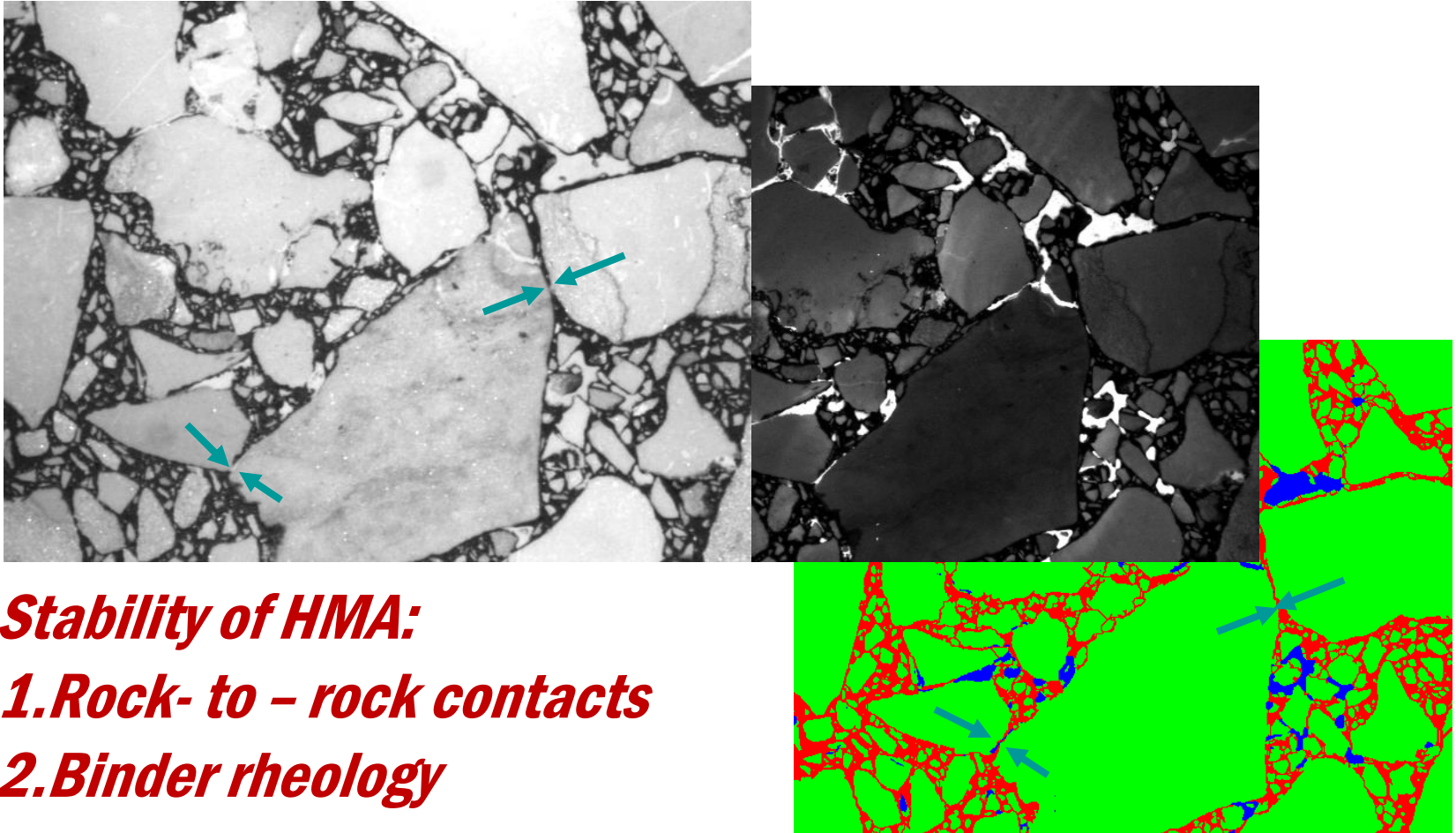
- = Crude Oil
- = High Quality Crude Oil
- = Modifier Required

The New Grading System- MP19 – PG xx(z)-yy

- 1. Climate: xx-yy*
- 2. Traffic conditions- Trucks (S,H,V,E)*
- 3. Reliability, and*
- 4. Modification*

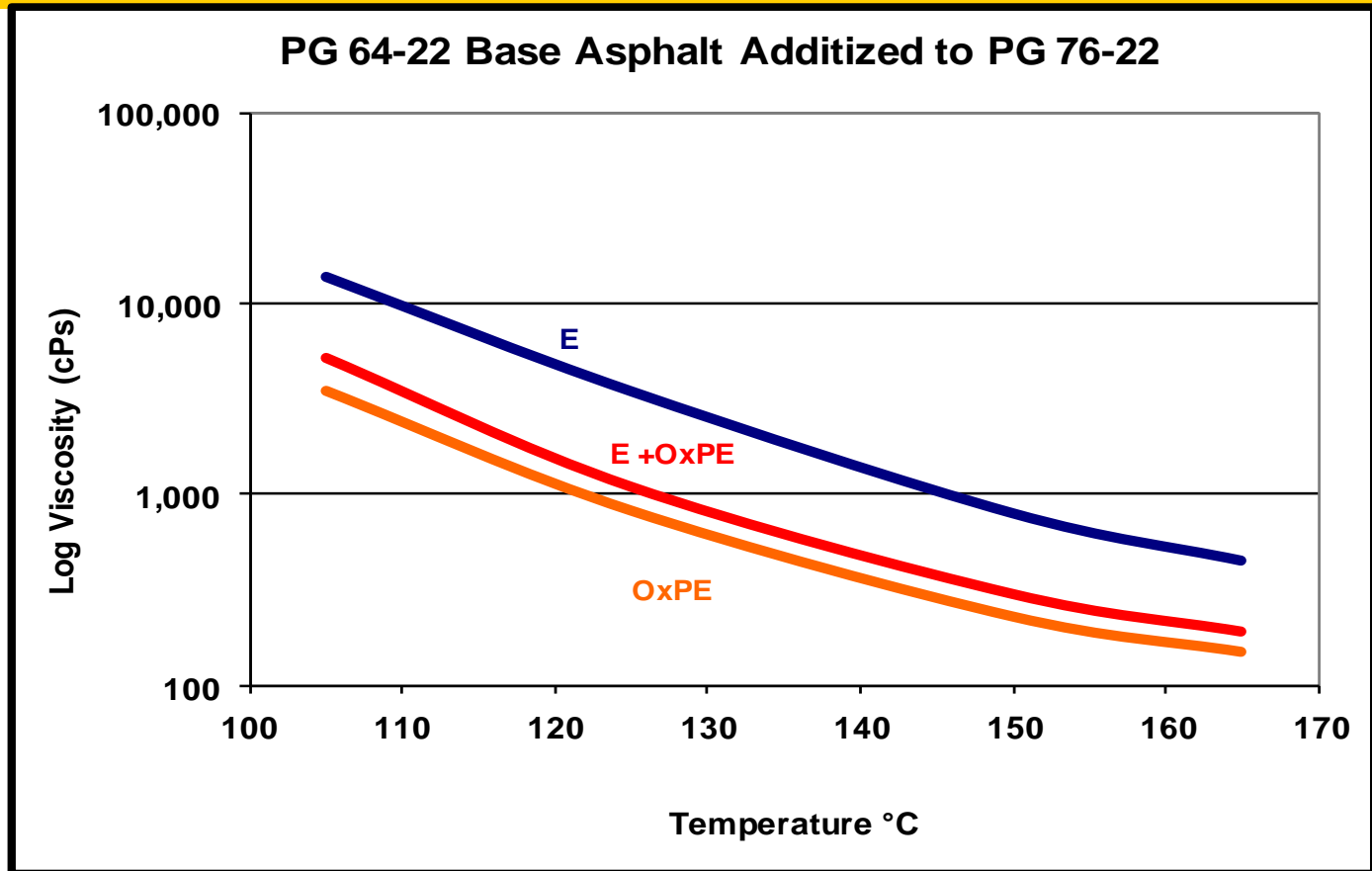


Effect of Modifier on Aggregate Structure : Rocks + Asphalt + Air Voids



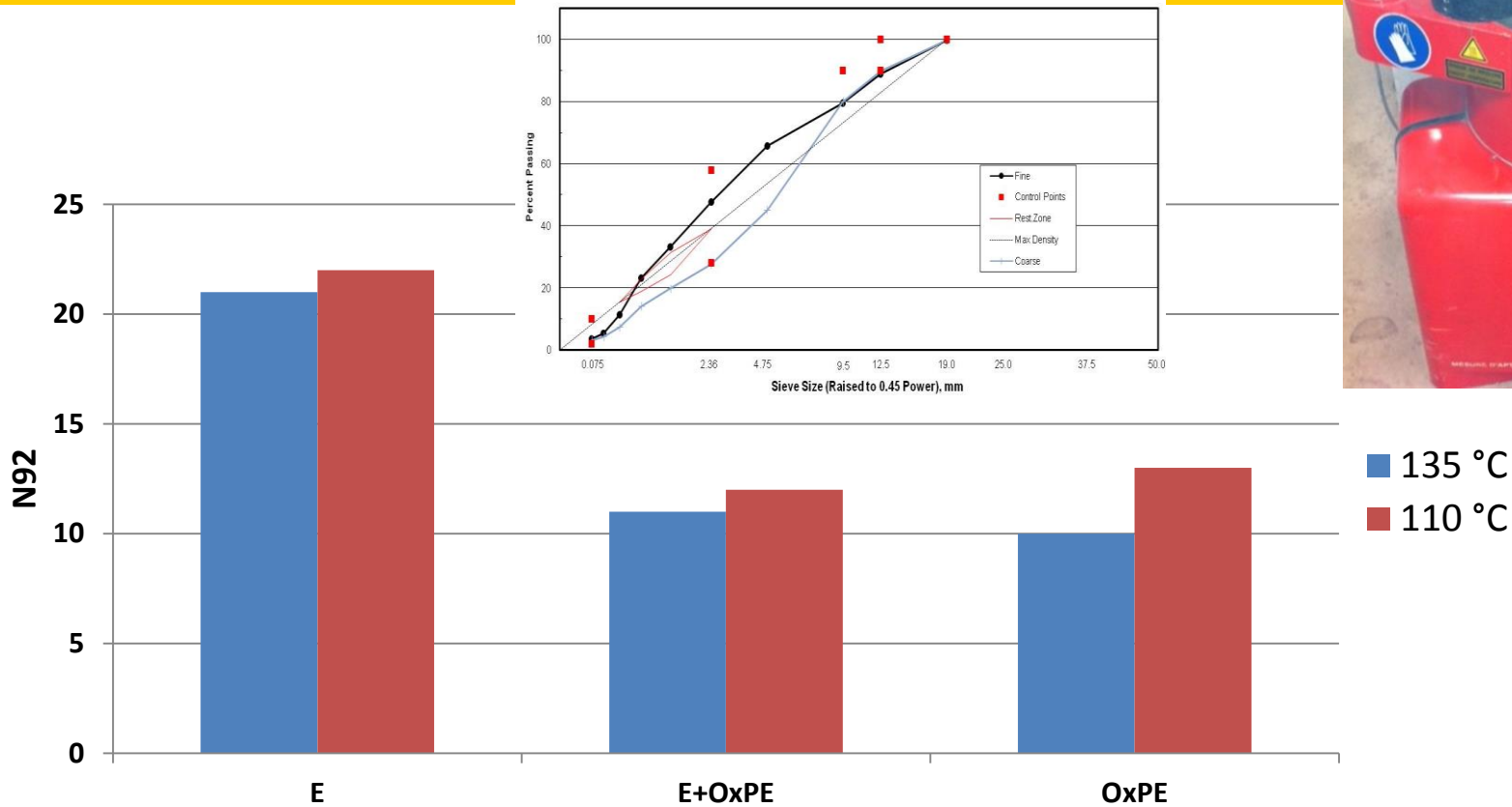
Stability of HMA:
1. Rock- to - rock contacts
2. Binder rheology

Polymers can Change Viscosity vs. Temperature



PE Does not Change Viscosity

Workability Gyrations to 92% Density

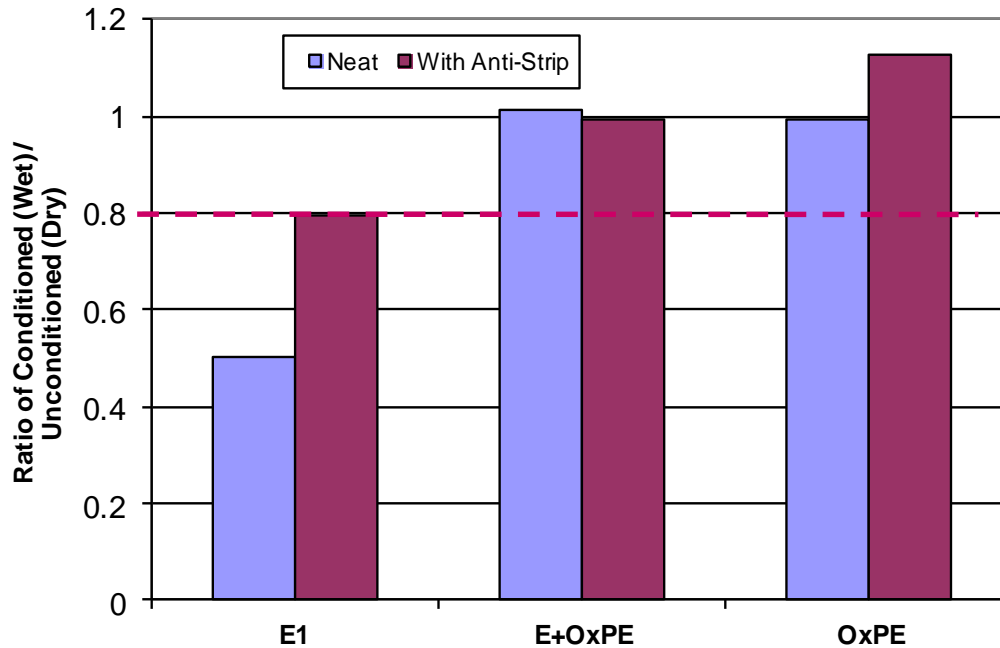


Polymers can improves workability

Moisture Sensitivity-(AASHTO T283, + EN12697-11)

Tensile Strength Ratio*

All Compositions Additized to PG 76-22



Bolling Water Test**



3% E



3% OxPE

Dorservis Russian lab test shows increased adhesion to granite

*Evaluation completed in collaboration with Modified Asphalt Research Center -

MARC at Univ. of Wisconsin-Madison

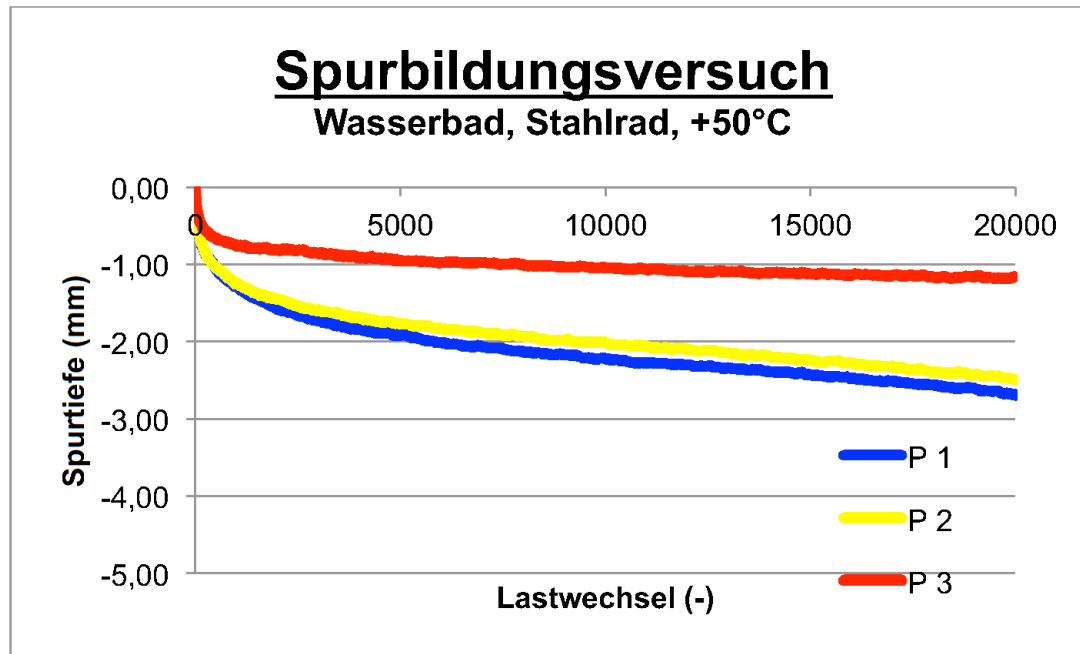
**North West Russian Granite Aggregate



Reduces or eliminates need for Anti-Strip

Wheel Tracking Test-(EN 12697-22)

Test: water 50°C, steel wheel, 20000 cycles



Binders used in SMA 8S:

P1: PmB 45A (E)

**P2: PmB 45A
(E + OxPE)**

P3: PmB 45C (OxPE)

Rutting Resistance - EN 12697-22

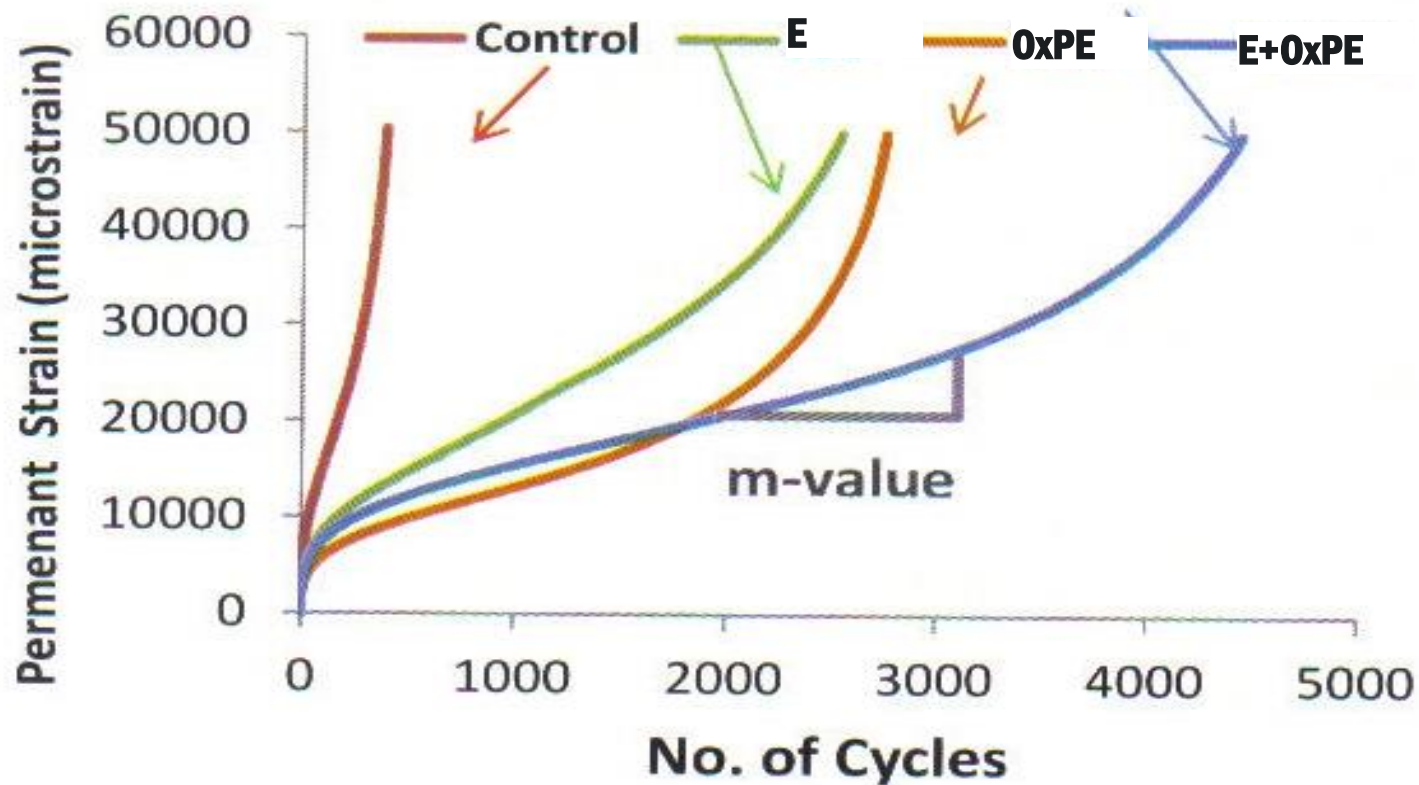
With Hybrid formulation, rutting reduced by ~ 50%.

	Pen 35/50 (E1)	Pen 50/70	Pen 35/50 (E2)	Pen 35/50 (E+OxPE)	Pen 35/50 (OxPE)	Spec BBSG 0/10 Cl 3
30000 cycles @ 60°C air	3.4	5.1	4.2	2.2	3.1	< 5,0



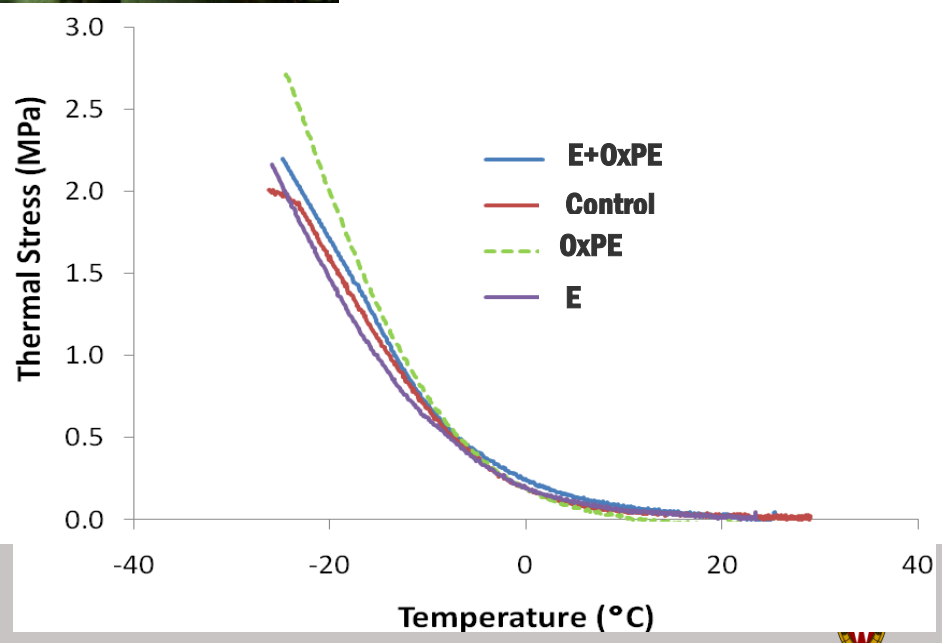
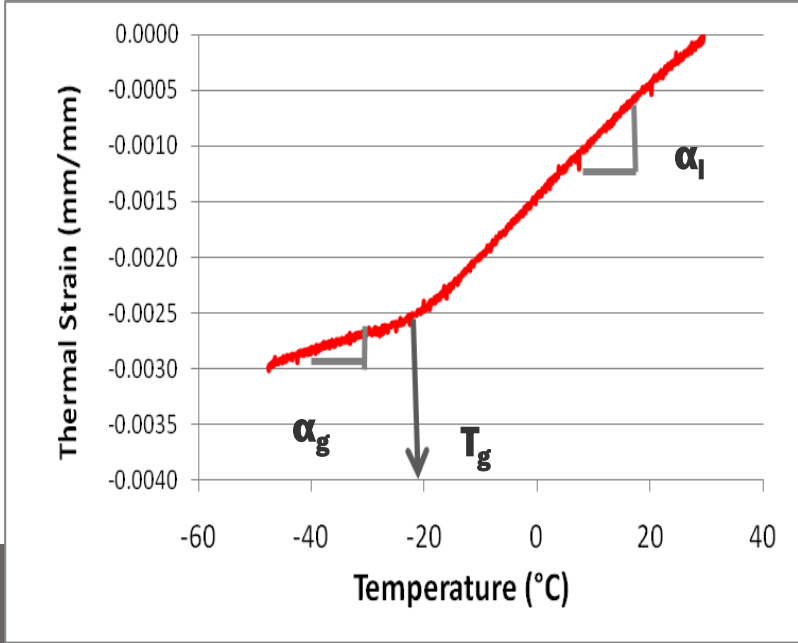
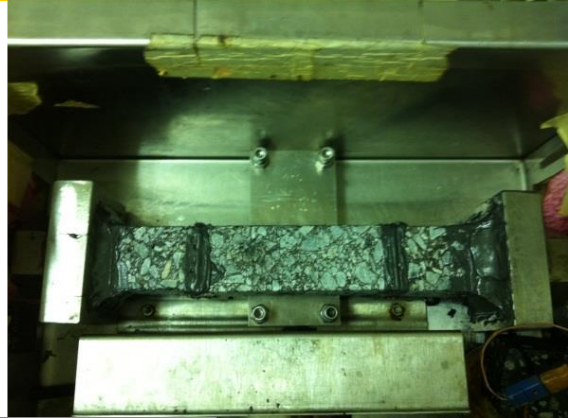
Rutting Resistance - Flow Number (AASHTO TP79)

Typical Flow Number(FN) curves



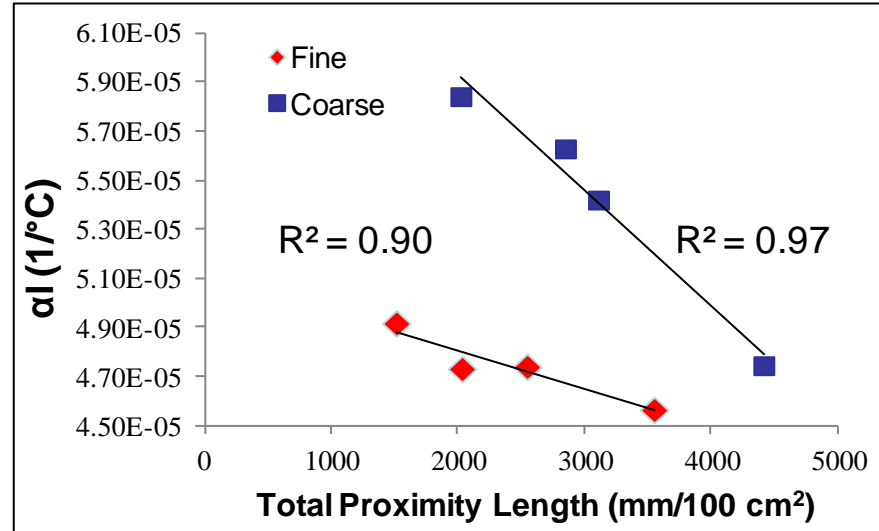
Thermal Stress Restrained Specimen Test (TSRST)

Ashphalt Thermal Cracking Analyzer(ATCA)



Effect of Aggregate Structure on CTC

Aggregate Structure Parameters



Good correlation between Internal Structure Parameters and Coefficient of Thermal Expansion.

Increase in Total Proximity Length



Higher Connectivity of Aggregate Skeleton



Higher Resistance to Thermal Strain

Concluding Results

- **Roads are built with mixtures, not Binders!**
- **Roads' Cracking & rutting are affected by:**
 - aggregate structure and bitumen Properties.
- **There are many modifiers that can improve road performance. The best are those that can improve:**
 - **Workability**
 - **Packing of aggregates at reasonable construction temperatures**
 - **Moisture resistance**
 - **Low and high temperature performance**
- **There could be significant savings of cost, energy and increase in service life of roads**

Thank You!

Questions?

www.uwmarc.org

Hussain Bahia
bahia@engr.wisc.edu

MARC MODIFIED ASPHALT RESEARCH CENTER
Part of the Asphalt Research Consortium

WISCONSIN UNIVERSITY OF WISCONSIN-MADISON

Search...

HOME
ABOUT MARC
NEWS & EVENTS
RESEARCH
PUBLICATIONS
CONTACT US

BBR-SEN
The BBR-SEN system is a modification of the Bending Beam Rheometer, that enables low temperature fracture testing on BBR size beams.
MARC continues to evaluate the potential of the BBR-SEN system for better estimation of the thermal cracking susceptibility of asphalt materials.

Image from Marasteanu (2007)

LATEST NEWS

MARC JOINS NCHRP PROJECT 9-50
Jan 30, 2011 – The Modified Asphalt Research Center at UW Madison has joined North Carolina State University's research team to submit a proposal for the new NCHRP 9-50 project, "Performance-Related Specifications for Asphaltic Binders Used in Preservation Surface Treatments." This project will focus on the development of performance-related specifications (PRS) for asphaltic binders used in preservation surface treatments, usually applied to large pavement surface areas to slow rate of deterioration and maintain or improve its functional condition. The project is expected to start early summer of 2011. More information can be found at the [NCHRP Project webpage](#)?

LATEST EVENTS

MARC TRAINS ETG MEMBERS IN USE OF THE LINEAR AMPLITUDE SWEEP TEST
Feb 22, 2011 – MARC held a webinar on Feb 22 in which Ms. Cassie Hintz and Dr. Raul Velasquez explained the conduction and analysis of the newly introduced Linear Amplitude Sweep (LAS) binder fatigue test. Participants were shown videos of the LAS procedure implementation into commonly used Dynamic Shear Rheometers (DSR). The session also included a demonstrated of the use of the LAS analysis spreadsheet and data interpretation. The meeting was ended with a question and answer session held by Dr. Velasquez on the test theory and procedure.