Alternate Binder Modifiers

Marty Burrow – Vance Brothers

North Central Asphalt User/Producer Group Meeting

Monona Terrace, Madison, WI

February 4-5, 2009

DuPont Innovative Asphalt Modifiers

How to save money with Elvaloy® RET and Entira™ Bond asphalt modifiers

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DuPont Packaging & Industrial Polymers
January 8, 2009

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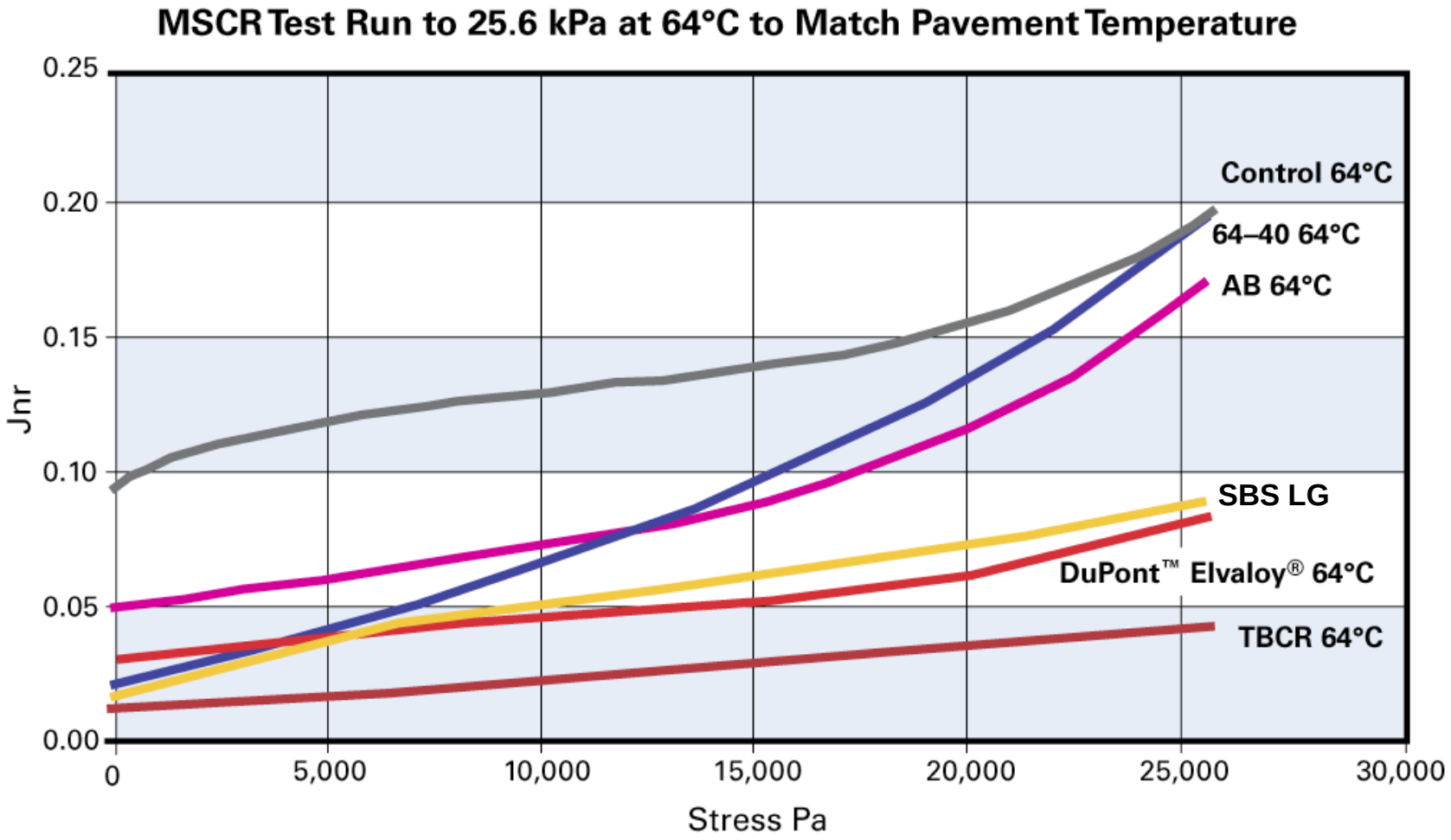
Elvaloy® RET (Reactive Elastomeric Terpolymers)

Benefits

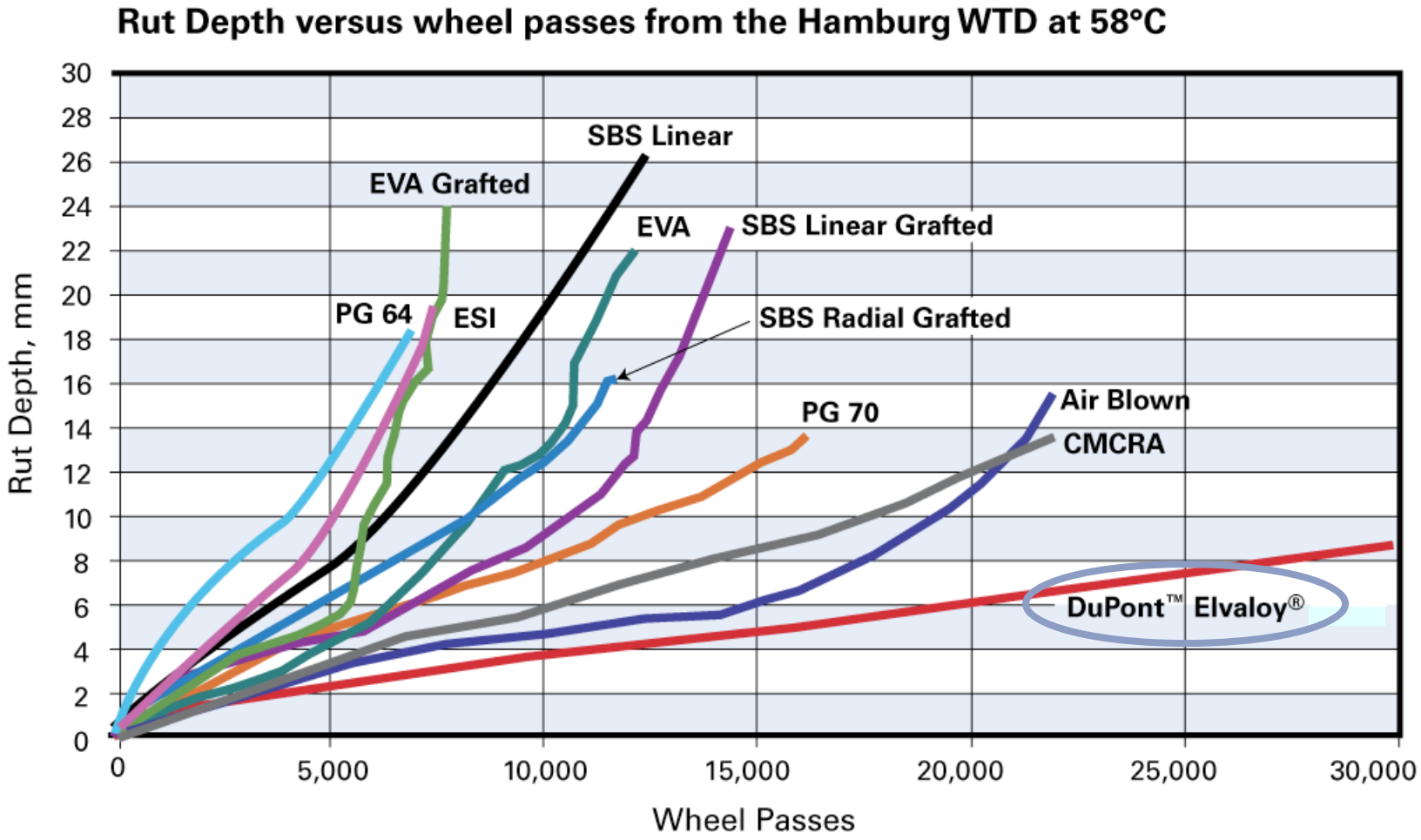
- Easy to use – no high-shear mill required. Melt into asphalt along with low level of PPA to bump several SHRP grades higher
- Phase angle equal to or less than SBS-modified, normally less than 70°
- Elastic recoveries similar to SBS, commonly over 70%
- Also improves other properties that aren't directly measured by the PG system such as fatigue cracking and low-temperature cracking – may lead to lower life-cycle costs
- Competitive cost per ton of asphalt versus other polymer modifiers
- Mix is less sticky than SBS-modified mixes

RET Performance Data: Fatigue



D'Angelo, John. "**Development of A High Development of A High Temperature Performance Based Temperature Performance Based Binder Specification**", FHWA presentation at AMAP Feb 13, 2007, Slide #33

RET Performance Data: Rutting



K.D. Stuart, J. S. Youtcheff, Ph.D., W. S. Mogawer Ph.D. "Understanding the Performance of Modified Asphalt Binders in Mixtures: Evaluation of Moisture Sensitivity", FHWA-RD-02-029, Figure #2

Elvaloy® RET (Reactive Elastomeric Terpolymers)

Pitfalls

- Can't add more than 2.5% Elvaloy® or asphalt may gel
- Can't add more Elvaloy® after PPA added – better to overshoot and add neat asphalt if necessary

Easy to use

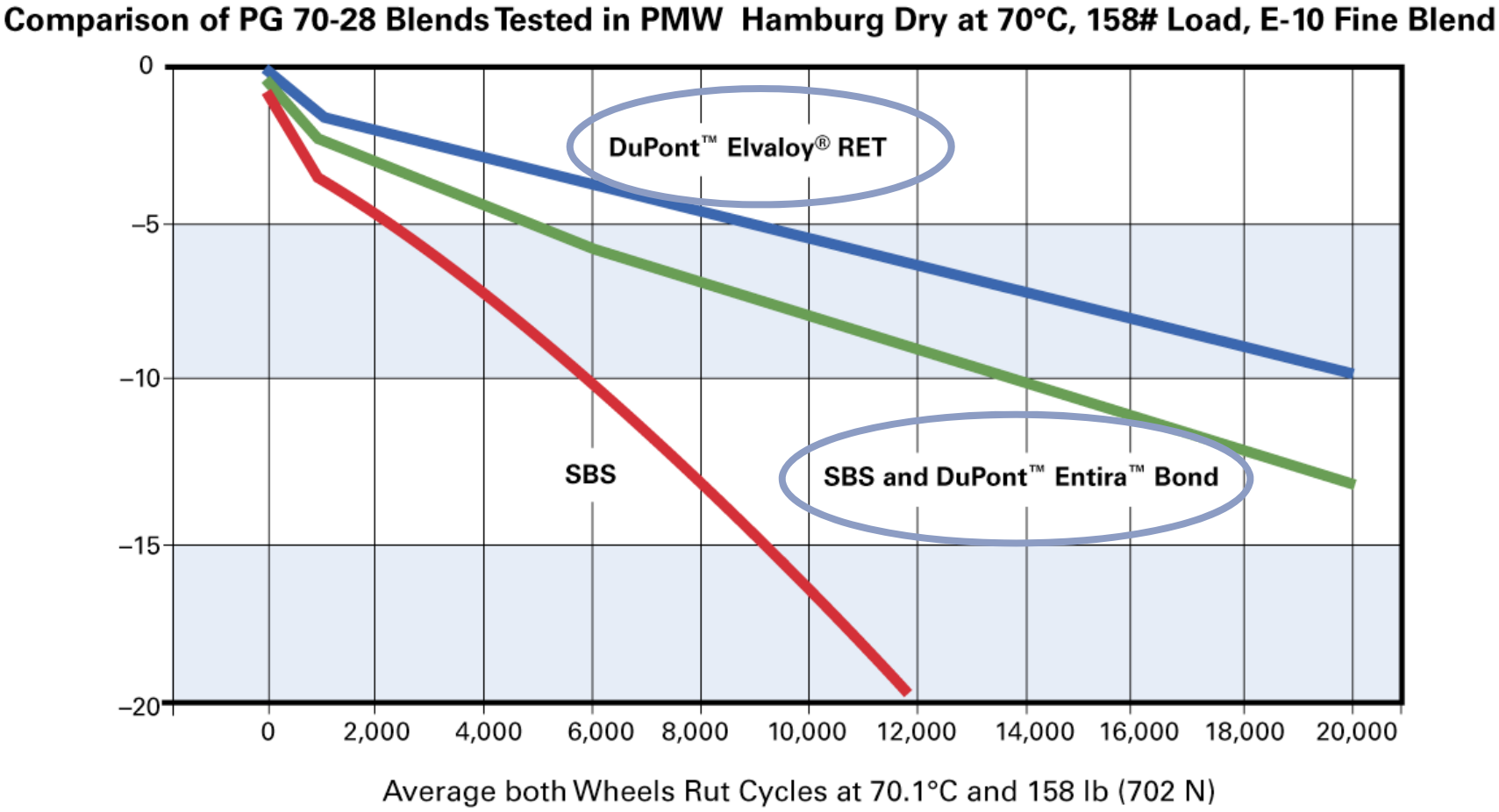
- Use between 0.7% and 2% Elvaloy® depending on asphalt and final grade
- Add to hot asphalt binder and stir – Elvaloy® melts into liquid (no high-shear mill)
- Add small amount of PPA to tank and stir (0.2% - 0.3%)
- Typically four-hours from Elvaloy® addition to ready for aggregate

New Offering: Entira™ Bond 12

Benefits:

- Entira™ Bond asphalt modifier works with SB/SBS modifiers and sulfur – no PPA
- Typically replace half of the SB/SBR/SBS polymer with half as much Entira™ Bond
  - **For example, 4% SBS would be with 2% SBS and 0.8% Entira™ Bond**
- Entira™ Bond has similar performance in binder tests versus SBS alone
- Mix testing indicates improved performance of Entira™ Bond versus SBS alone, although still not as good as Elvaloy® RET
- Designed to help reduce material cost per ton of asphalt

Performance Data: Rutting (includes Entira™ Bond)



DuPont evaluation by independent lab

New Offering: Entira™ Bond 12

Pitfalls

- Lower total polymer concentration is cost savings, but will have lower elastic recovery

Easy to use

- Add to hot SBS-modified or unmodified asphalt – no high-shear mill necessary. Entira™ Bond melts into liquid
- Add cross-linker to tank and stir (no PPA required)
- Ready for aggregate in 4 hours

Product safety information is available upon request. This information corresponds to our current knowledge on the subject. It is offered solely to provide possible suggestions for your own determinations. It is not intended, however, to substitute for any testing you may need to conduct to determine for yourself the suitability of our products for your particular purposes. It is the user's responsibility to determine the level of risk and the proper protective equipment needed for the user's particular purposes. This information may be subject to revision as new knowledge and experience becomes available. Since we cannot anticipate all variations in actual end-use conditions, DUPONT MAKES NO WARRANTIES AND ASSUMES NO LIABILITY IN CONNECTION WITH ANY USE OF THIS INFORMATION. Nothing in this publication is to be considered as a license to operate under or a recommendation to infringe any trademark or patent right.

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SBR Latex Modified Asphalt Cement Current Markets

BASF
The Chemical Company

Current Markets – Plant-Site Injection

- Ohio – PG 70-22
  - Dense-graded wearing course
- Mass. + Vermont – PG 64-22 + 3% SBR latex solids
  - Recipe specification - OGFC wearing course

Mexico, Central America, South America, Europe

- Plant-site injection + pre-blend (small percentage)

SBR Latex Modified Asphalt Cement Suggestions – State of the Practice

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- **Plant-site injection preferred method**
  - Accurate with proper metering controls and technique
  - Mixing occurs in pug mill or at nozzle/in continuous drum
  - Low cost + efficient method for polymer addition
  - No need for storage of multiple PG grades
    - Eliminates storage and thermal stability problems
    - Produce PG grade binder *in-situ* from standard base AC
    - Pre-blend SBR and grade to determine loading to meet required PG grade (usually PG 70-22 or PG 76-22)
    - Submit base AC certification + recorded proof of latex addition rate for state materials QC requirement

Plant-Site Injection – Drum Plant

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SHRP Plus Props – SBR, SBS, Elvaloy®AM Mexican AC-20 Base AC

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Binder Tests	Test Method ASTM/AASHTO	Mexican AC-20 Base Asphalt			
		AC-20	NX 1129	SBS	Elvaloy
		0.0	3.0	3.0	2.0
		SHRP PG Testing			
Brookfield Viscosity (135°C,cps)	ASTM D4402	458	2141	1412	1850
Temp. @ DSR G*/sinδ =1.0 kPa (°C)	AASTHO T 315	66.7	77.7	80.5	77.0
Phase Angle (76°C, °)		-----	77.1	76.0	70.1
Temp. @ RTFO G*/sinδ =2.2 kPa (°C)		69.7	79.9	85.6	80.7
Phase Angle (82°C, °)		-----	71.1	72.7	64.5
Temp. @ PAV G* x sinδ = 5000 kPa (°C)		19.5	13.2	19.5	19.1
Temp. @ S=300 MPa (60s,°C)	AASHTO T 313	-20.8	-23.6	-20.4	-20.8
Temp. @ m=0.30 (60s,°C)		-15.5	-13.1	-9.1	-14.6
Continuous SHRP PG Grading	AASHTO R 29	67-26	78-23	81-19	77-25
SHRP PG Grading	**AASHTO M 320**	**64-22**	**76-22**	**76-16**	**76-22**
		SHRP PG "Plus" Testing			
Compatibility - Δ_{sp}(°F)	ASTM D5892	0.2	5.3	12.8	0.1
Elastic Recovery (10°C,%)	AASHTO T 301	10	50	61	38
Elastic Recovery (25°C,%)		6	61	74	58
RTFO-ER (25°C,10 cm,no wait,%)		31	64	71	70
Ductility (4°C,cm)	ASTM D113	4	13	8	5
Penetration (4°C,dmm)	ASTM D5	25	26	19	25
Penetration (25°C,dmm)		58	48	38	49
Softening Point (°F)	ASTM D36	124	137	143	143

SHRP Plus Props – SBR vs SBS
Chevron PG 64-28 Base AC

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The Chemical Company

Tests on Binder	Test Method ASTM/AASHTO	Control 0.0	NX 1129 2.0	NX 1129 3.0	Rad. SBS 3.0
SHRP PG Testing					
Brookfield Viscosity (135°C,cps)	ASTM D 4402	533	1208	1858	1612
Temp. @ G*/sinδ = 1.0 kPa (°C)	AASTHO T 315	65.9	73.4	77.9	77.6
Phase Angle (76°C, °)	AASHTO T 315	-----	80.9	76.9	79.6
Temp. @ S = 300 MPa (60s,°C)	AASHTO T 313	-24.0	-24.4	-26.6	-24.0
Temp. @ m = 0.30 (60s,°C)	AASHTO T 313	-19.1	-20.2	-17.2	-17.0
Continuous SHRP PG Grading	AASHTO R 29	65.9-29.1	73.4-30.2	77.9-27.2	77.6-27.0
SHRP PG Grading	**AASHTO M 320**	**64-28**	**70-28**	**76-22**	**76-22**
SHRP PG "Plus" Testing					
Compatibility - Δ_{sp}(°F)	ASTM D 5892	0.25	0.42	1.20	0.35
Elastic Recovery (10°C, 5 cm/min to 20 cm, straight-sided molds, 5 min wait, %)	AASHTO T 301	10.5	48.2	56.9	55.0
Elastic Recovery (10°C, 5 cm/min to 20 cm, straight-sided molds, no wait, %)	AASHTO T 301	19.4	56.2	64.4	65.0
RTFO-Elastic Recovery (25°C, 5 cm/min to 10 cm, straight-sided molds, no wait, %)	AASHTO T 301	27.5	62.5	70.0	56.2

SHRP Plus Props – SBR vs SBS
Marathon PG 58-28 + United PG 58-28

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The Chemical Company

Binder Tests	Test Method ASTM/AASHTO	Marathon-Ashland PG 58-28			United Refining PG 58-28		
		Mar-Ash	1129	SBS	United	1129	SBS
		0.0	3.0	3.0	0.0	3.0	3.0
		SHRP PG Testing					
Brookfield Viscosity (135°C,cps)	ASTM D 4402	292	1812	792	300	1541	825
Temp. @ G*/sinδ = 1.0 kPa (°C)	AASTHO T 315	59.4	66.6	69.6	60.5	67.8	69.1
Phase Angle (64°C, °)		88.7	79.4	79.6	88.2	78.2	80.4
Temp. @ G*/sinδ = 2.2 kPa (°C)		59.6	65.0	67.8	59.8	67.8	68.5
Phase Angle (64°C, °)		86.7	74.6	75.9	85.7	72.9	77.0
Temp. @ S = 300 MPa (60s,°C)	AASHTO T 313	-20.8	-22.4	-21.2	-21.6	-23.3	-22.5
Temp. @ m = 0.30 (60s,°C)		-20.6	-19.9	-19.9	-20.8	-19.2	-20.0
Continuous SHRP PG Grading	AASHTO R 29	59.4-30.6	65.0-29.9	67.8-29.9	59.8-30.8	67.8-29.2	68.5-30.0
SHRP PG Grading	**AASHTO M 320**	**58-28**	**64-28**	**64-28**	**58-28**	**64-28**	**64-28**
		SHRP PG "Plus" Testing					
Compatibility - Δ_{sp}(°F)	ASTM D 5892	-----	1.90	**>36.6**	-----	0.20	**>38.9**
Elastic Recovery (10°C,%)	AASHTO T 301	5.8	65.9	76.3	6.3	65.0	74.4
Elastic Recovery (25°C,%)		0.0	63.8	85.6	1.2	62.6	85.6
RTFO-ER (25°C,10 cm,no wait,%)		17.5	70.0	68.8	18.8	62.5	82.5
Ductility (25°C,cm)	ASTM D 113	137	150	132	115	150	117

Polyphosphoric Acid Binder Modification

IDOT

October 9, 2008

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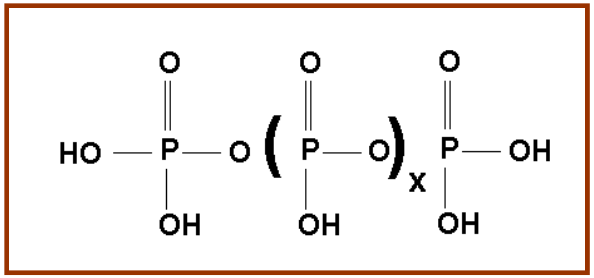
ICL Performance Products LP

St. Louis, MO

Overview

- Polyphosphoric Acid (PPA)
- Modification of neat Asphalt
  - Broaden PG grade
  - Recommended: One PG grade bump, <1.2% PPA
- Co-modifier with SB/SBS polymers
  - Reduced polymer levels
  - Better performance than either modifier used alone
- Catalyst/Stabilizer with Ethylene Terpolymers
- Storage Stability
- Moisture Sensitivity
- Best Practices

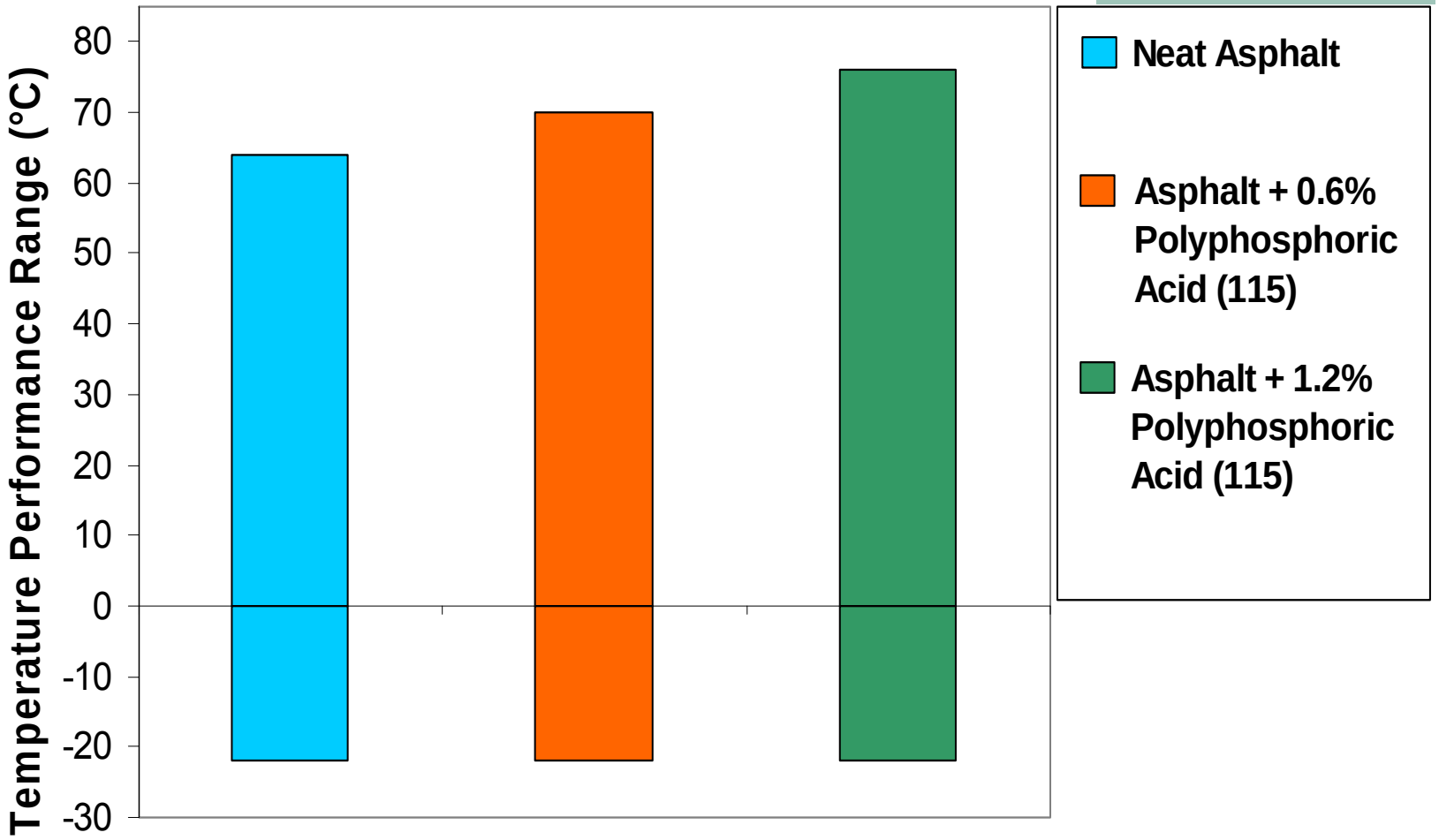
Polyphosphoric Acid (PPA)



- PPA Chemical Attributes
  - Different from Orthophosphoric acid
  - No Free Water
- 105% and 115% most common
- Increases asphalt stiffness, expands PG range to meet Superpave specs
- Does not affect low-temperature grading

Use of PPA as a Straight Modifier for Asphalt Cement

Performance Grade Rating



Increased high temperature PG rating, no loss in low temperature properties

Use of PPA as a Co-modifier with Polymers

PPA + SBS - % Polymer Reduction

Property		Results, Trial #			
		-00 Control		-01	
Ingredients (Wt. %)					
PG 58-28		96.5		96.5	
Kraton SBS, 1101		3.5		2.75	
PPA, 105%		--		0.6	
Sulfur		0.1		0.1	
Observations During Blend					
Ease of Mixing		Good		Good	
Appearance		Smooth		Smooth	
Homogeneity		Good		Good	
Texture / Viscosity		Smooth / Good		Smooth / Good	
Properties					
DSR, G*/sinδ, kPa	64°C	2.84		3.96	
	70°C	1.73		2.38	
	76°C	1.11	Fail Temp = 77.84°C	1.47	Fail Temp = 80.93°C
	82°C	0.762		0.921	
Elastic Recovery, %	25°C	94		92.3	

Reduced polymer level with ***superior*** binder properties

PPA + SBS - % Polymer Reduction

- The PG (high temperature) was improved from a PG 58-XX to PG 76-XX, 2 “grades.”
- Achieved an Original DSR 30% higher than Control without PPA.
- Original Elastic Recoveries were equivalent, well above DOT requirements.
- No differences observed in processing the PG with PPA as a co-modifier.
- The “True High PG” of the binder with PPA was 3°C above the Control without PPA, approximately ½ a high temperature PG.
- Use of PPA as a co-modifier resulted in an enhanced PG improvement with less overall modification, 3.35% vs. 3.5%.
- Polymer loading was reduced from 3.5 to 2.75, or by more than 20%. Additional reduction appears feasible

DuPont™ Elvaloy® RET combined with PPA

- Low levels of PPA used, typically 0.2 to 0.3 wt% of binder
  - This low usage level would have minimal impact on final properties if Elvaloy® RET polymer were not present.
- Reduction in reaction time from 18 hours to 1 hour
- Reduction in processing temperature

Typical Results with Elvaloy® RET alone, and with PPA

	Pass/Fail Temp unaged (°C)	Pass/Fail Temp RTFO (°C)	BBR s-value Temp @ 300 MPa	BBR M @ temp = 0.30	SHRP Temperature Spread (°C)
Base Asphalt	**55.3**	**56.3**	**-23.4**	**-22.7**	**88.0**
With Elvaloy®	**64.0**	**65.3**	**-21.6**	**-22.0**	**95.6**
With Elvaloy® + PPA	**71.1**	**74.1**	**-23.4**	**-23.5**	**104.5**

Elvaloy/PPA improves all binder performance properties

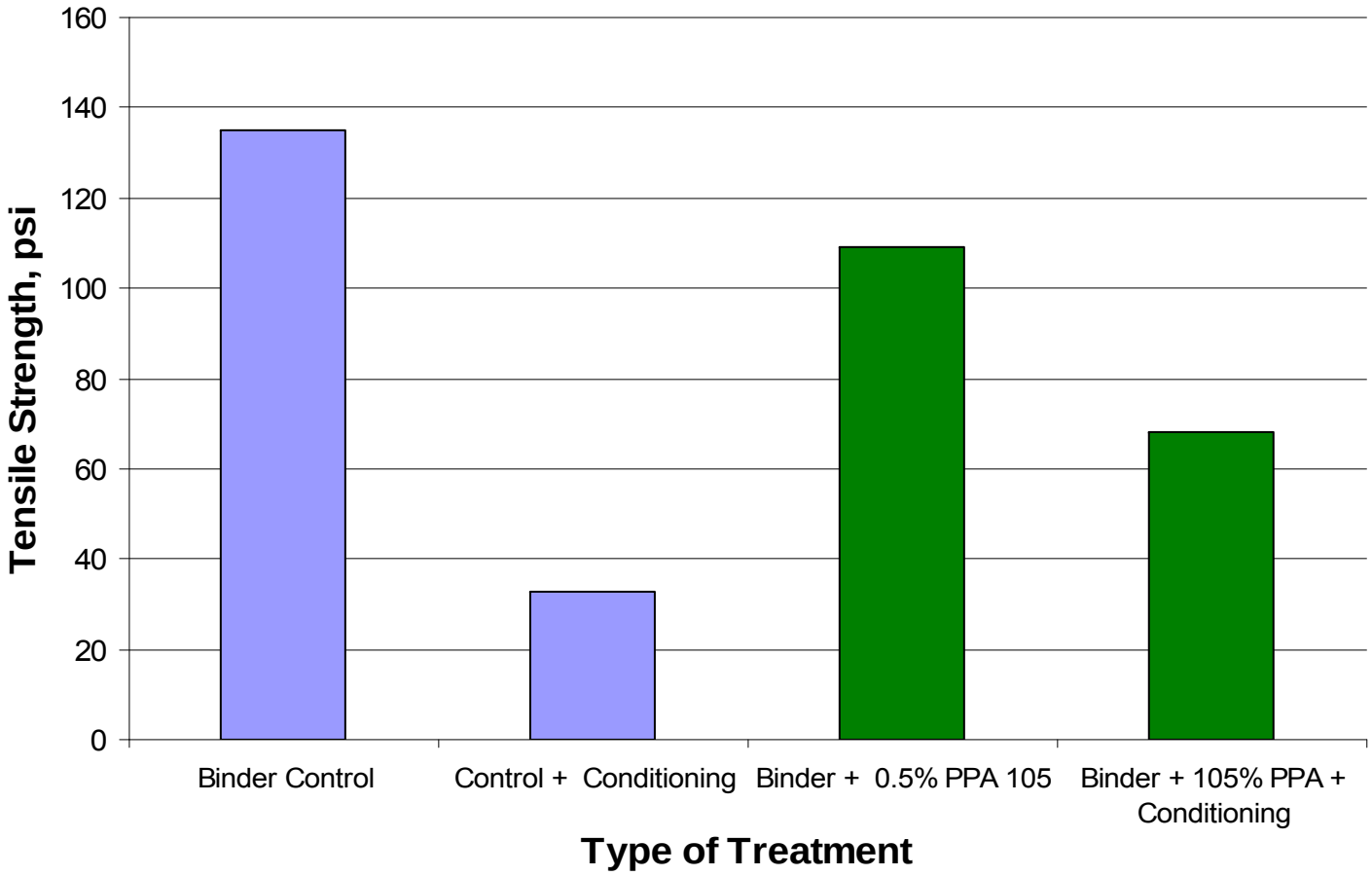
Polymer + PPA Modification

Combinations of PPA and Polymer result in products that can be **both** less expensive and better than those obtainable via either method alone

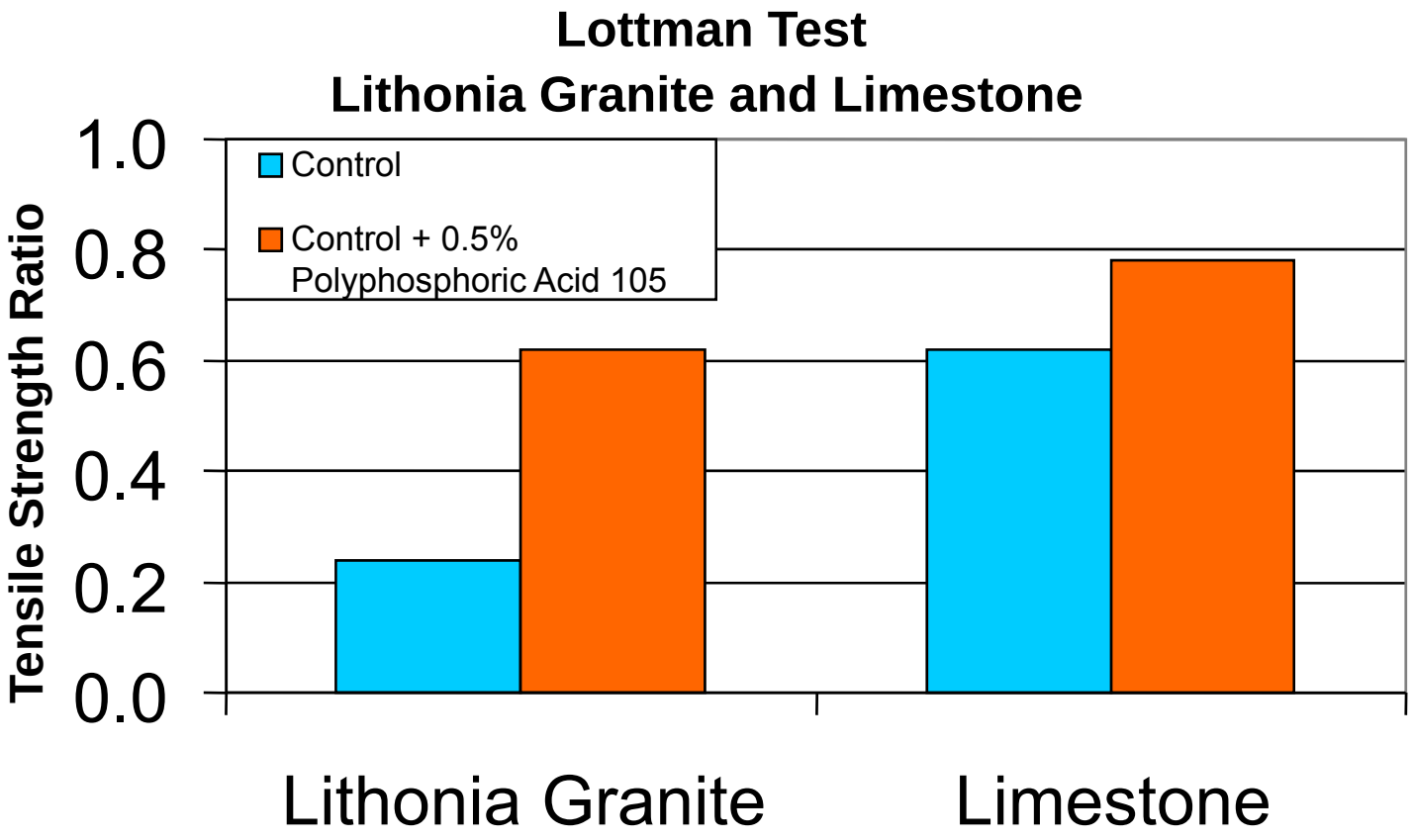
Moisture Sensitivity

Moisture Sensitivity

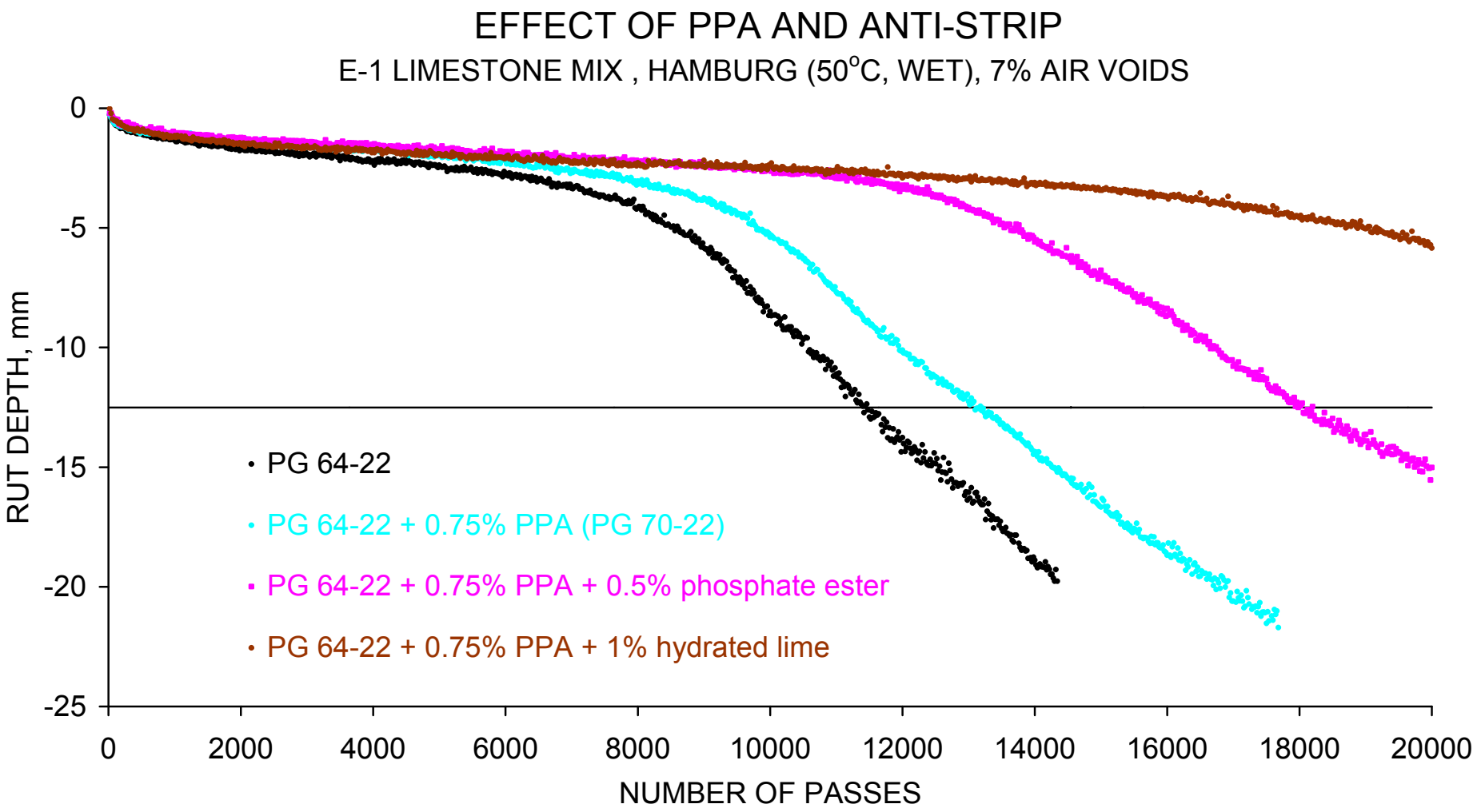
Tensile Strength, Lithonia Granite



Moisture Sensitivity
Tensile Strengths Ratio



Moisture Sensitivity: Hamburg



PPA performs well with proper anti-strip - Need to test all mix components

Conclusions

- Long history of successful use
- Estimated 100 to 400 Million Tons of pavement currently in place where PPA has been used in the last 5 years
- Unique properties obtainable when used as a co-modifier with polymers
- Continuing research on
  - Use in combination with antistrips
  - Use in combination with polymers

or you think you can’t...

QUESTIONS