Asphalt Binder Chemical Modification

ICL Advanced Additives

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Why Modify Asphalt?

- **Improve Performance**
  - Increase the stiffness of asphalt at high temperatures to improve resistance to rutting
  - Allow the use of softer asphalts to improve the resistance to low temperature cracking
  - More Resistance to Moisture Damage
  - Improve Fatigue Resistance (pavement damage from repetitive loads at intermediate temperatures)

Types of Modification

- Modifiers to increase viscosity/stiffness at high temperatures
  - Polymers
  - Crumb Rubber (recycled tire rubber)
  - Chemical Modification
  - Air Blowing/Oxidation
- Modifiers to improve low temperature properties
  - High flash point oils
- Additives to improve resistance to moisture damage
  - Antistripping Agents

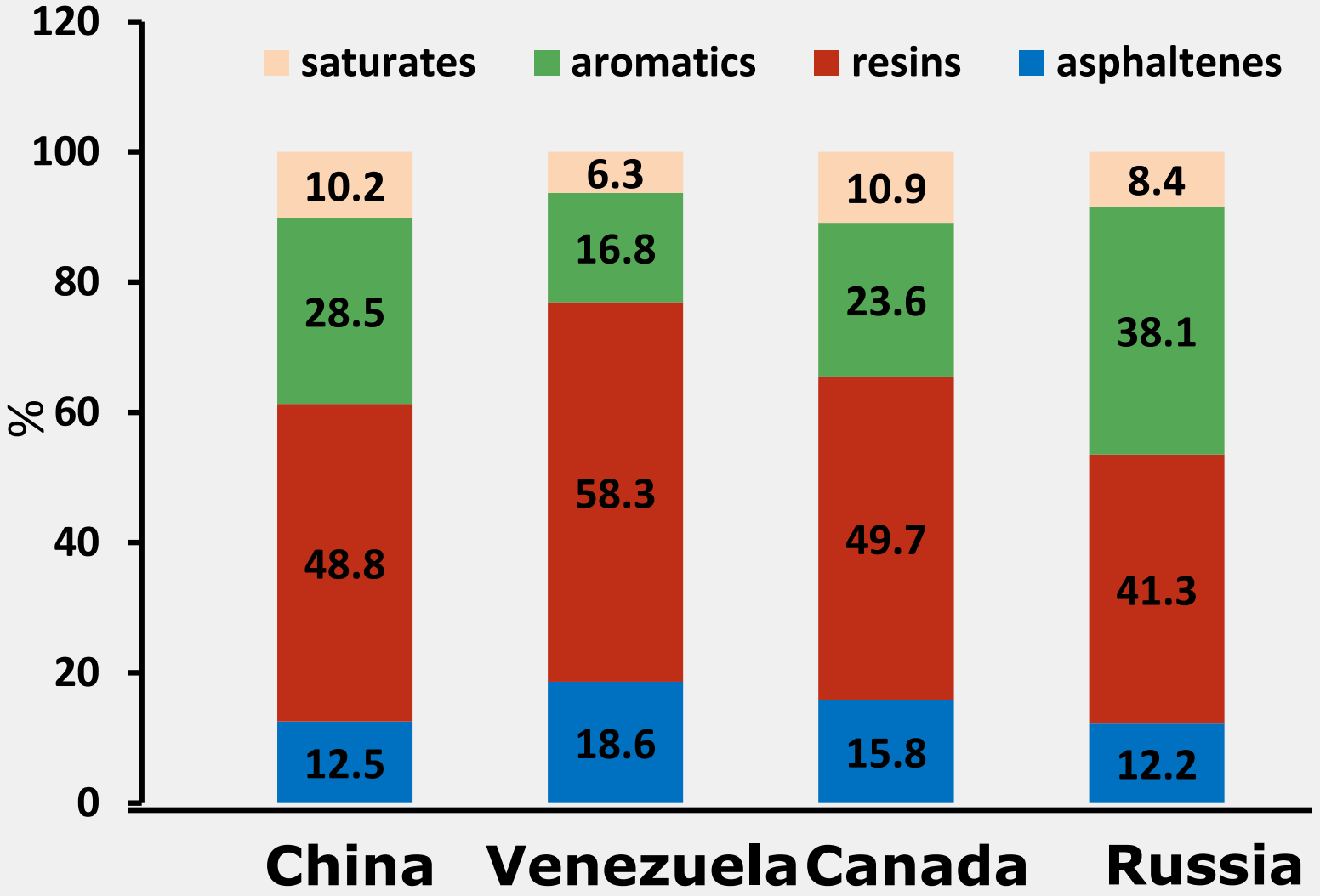
Key Components of Asphalt

- **Asphaltenes (the component which thickens asphalt when fluid)**
  - Very large complex materials
  - Typically 10-25% of asphalt.

- **Maltenes (oily type material- everything but asphaltenes)**
  - Resins: like asphaltenes but much smaller
  - Saturates: basically oils- think of motor oil or light greases
  - Polar Aromatics: oils which contain sulfur, oxygen, and/or nitrogen. These oils have “sticky” characteristics.

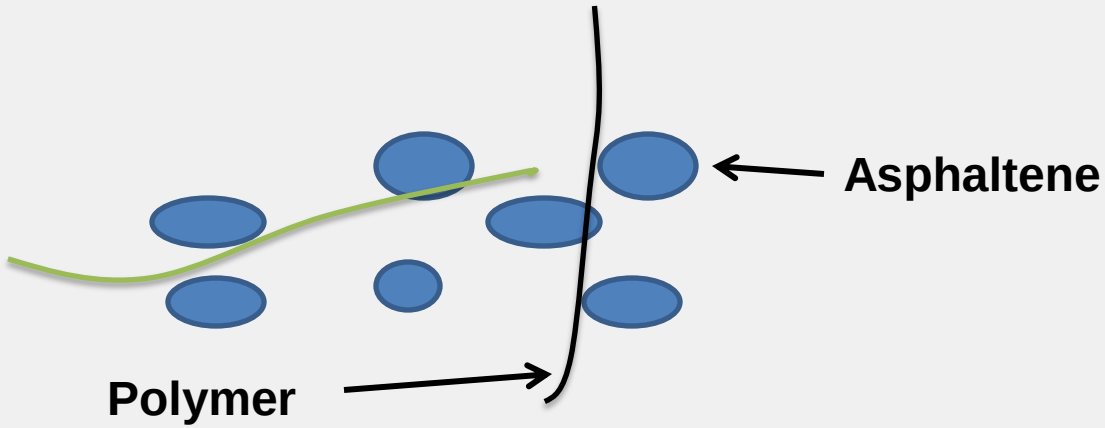
Modifiers Designed to Improve High Temperature Properties Is About Helping the Asphaltenes

Asphalt Composition



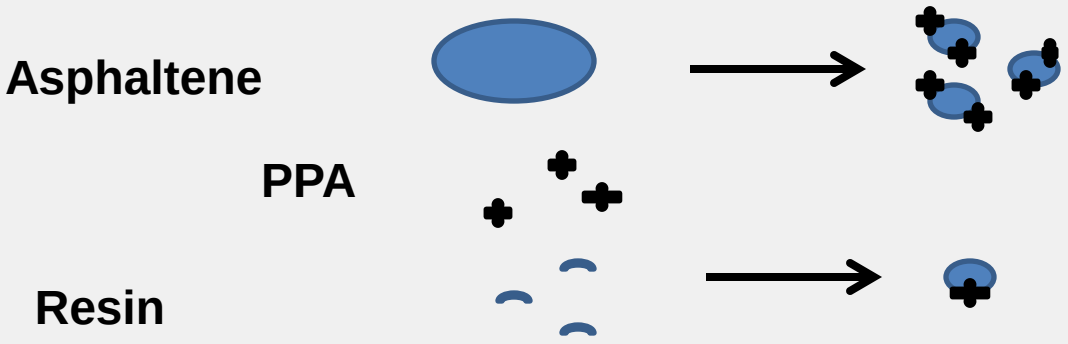
Modifier Effects: Polymers

- Add large molecules that interact with the asphaltenes
- Asphaltene content does not change



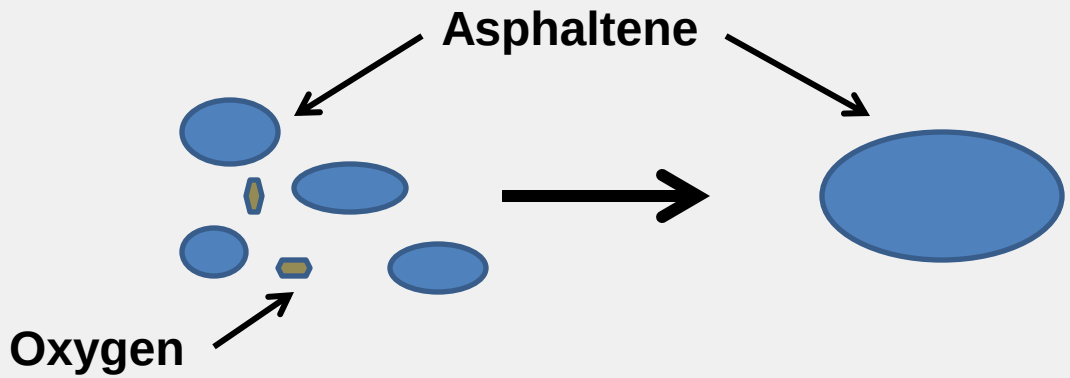
Modifier Effects: Chemical Modification

- Change larger asphaltenes into multiple smaller ones
- Combine larger resins into asphaltenes
- Asphaltene content increases, more smaller asphaltenes



Modifier Effects: Air Blowing

- Combines asphaltenes to make larger asphaltenes
- Asphaltene content goes up, average asphaltene size goes up



Modifier Effects: Combinations

Combining modification technologies can provide optimum performance and formulation costs

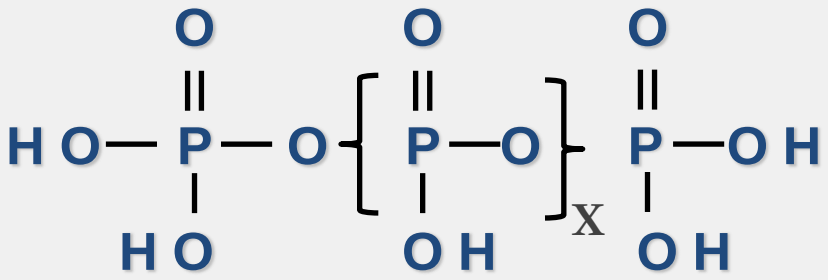
Use of PPA as a Single Modifier for Asphalt Cement

History of PPA in Asphalt Pavement

- 35 years: Tosco-Lion, US Patent 3,751,278 (1973)
- 30+ Patents. Since 2000: 60+ Publications
  - Concerns: Amine, Lime Anti-Strip
- NCAT Test Track 2000/3 18 Test Sections, 10 M ESAL
  - SBS/PPA; Various aggregates; Amine or lime anti-strip
  - Improved rut depth, 1 fatigue crack, no moisture damage
- MnROAD test track 2007 – excellent performance to date
  - Excellent performance to date
  - Successful PPA Symposium April 2009

PPA usage: 3.5 to 14% of the asphalt pavement in USA.
Estimated 150 to 450 million ton of hot mix over last 7 years.

Polyphosphoric Acid (PPA)

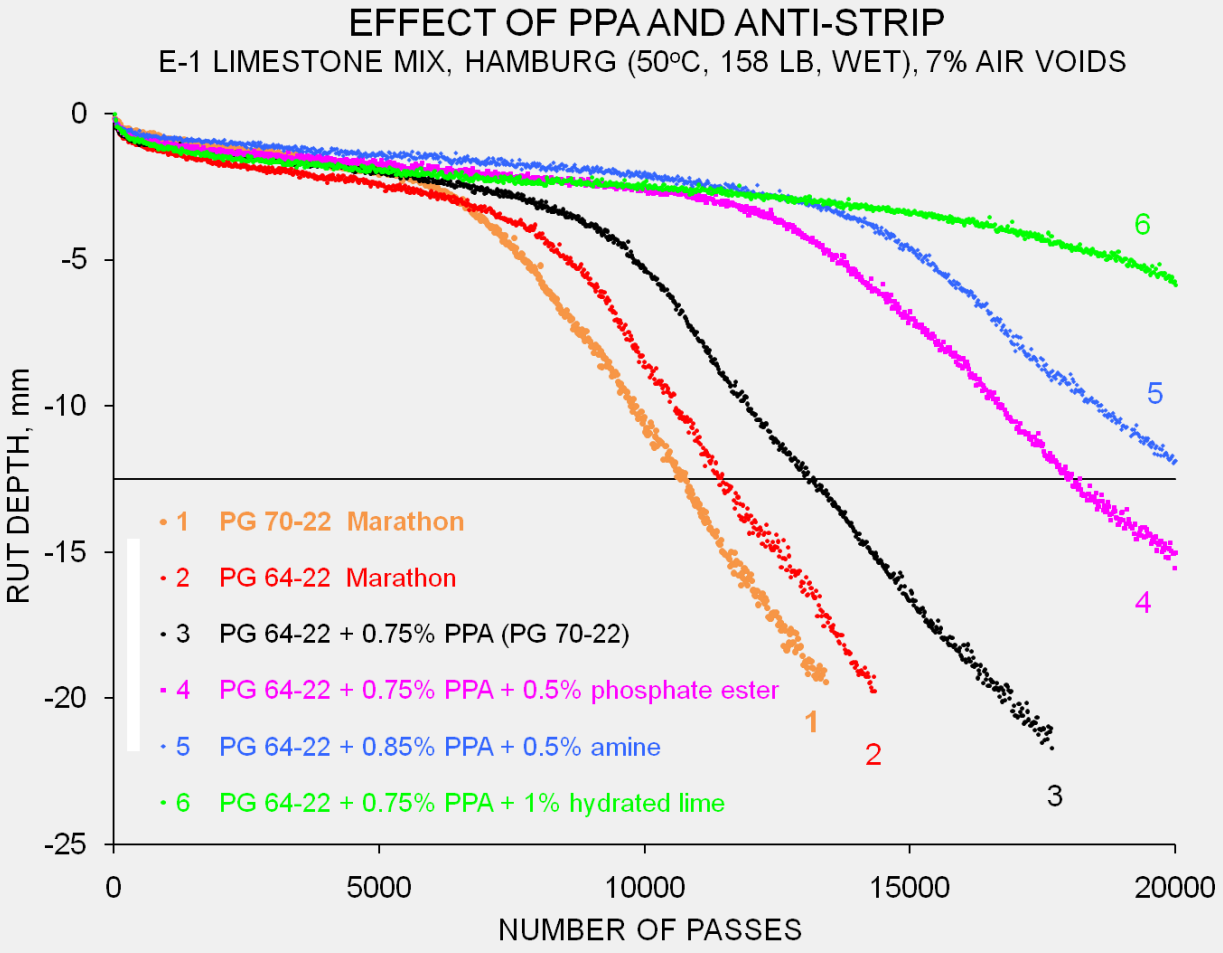


- PPA Chemical Attributes
  - Different from Orthophosphoric acid
  - No Free Water
- 105% and 115% most common
- Increases asphalt stiffness, improves rutting resistance, expands PG range to meet Superpave specs
- Does not affect low-temperature grading
- Modification does NOT involve oxidation and actually slows it down
- Retards binder aging

Performance Grade Rating

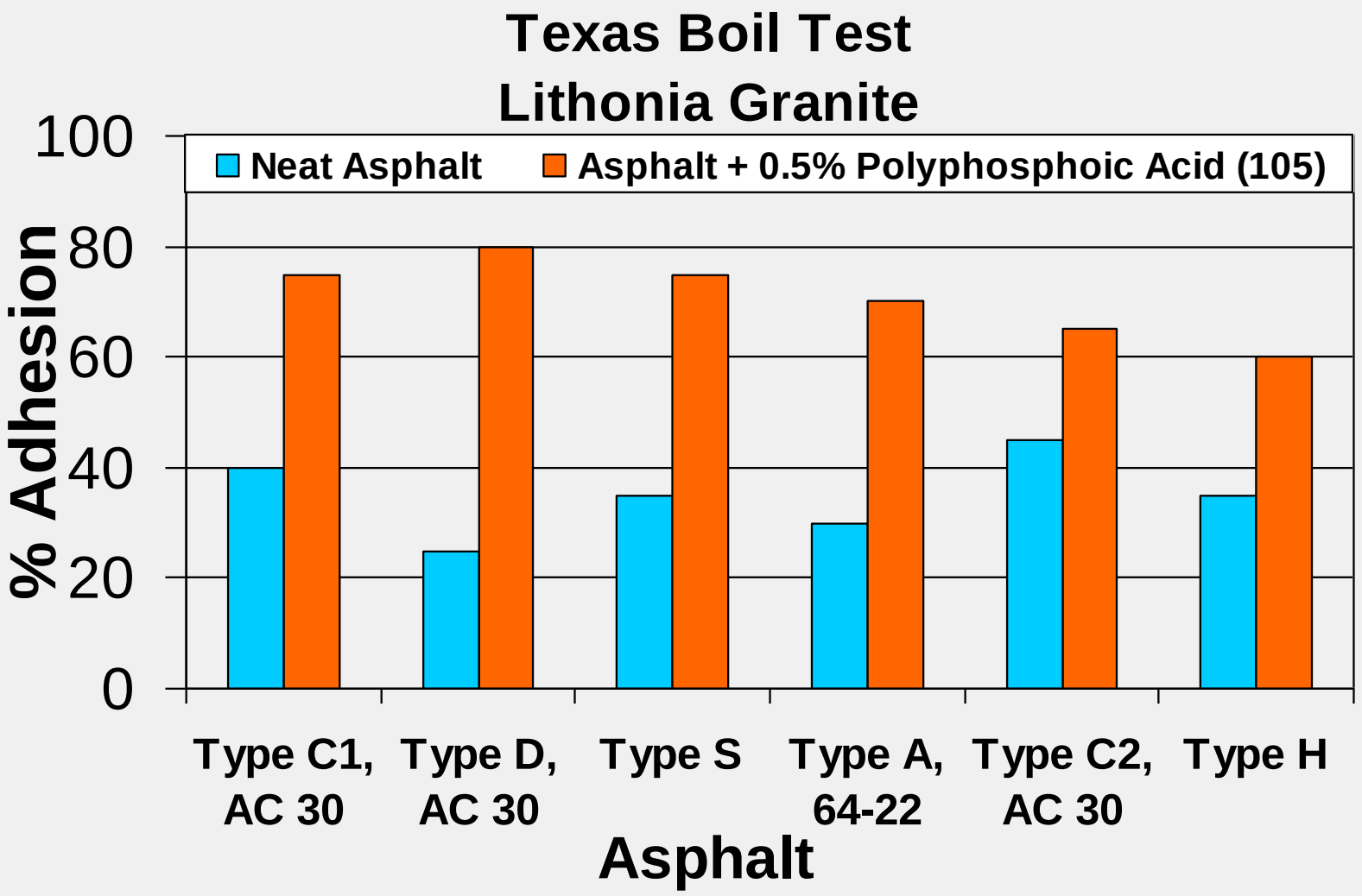
Polyphosphoric Acid increases the high-temperature grading with no loss of the low-temperature properties

Moisture Sensitivity: Hamburg



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

Adhesion to Aggregates



Use of Polyphosphoric Acid results in improved adhesion vs neat asphalt

Lab and Field Tests

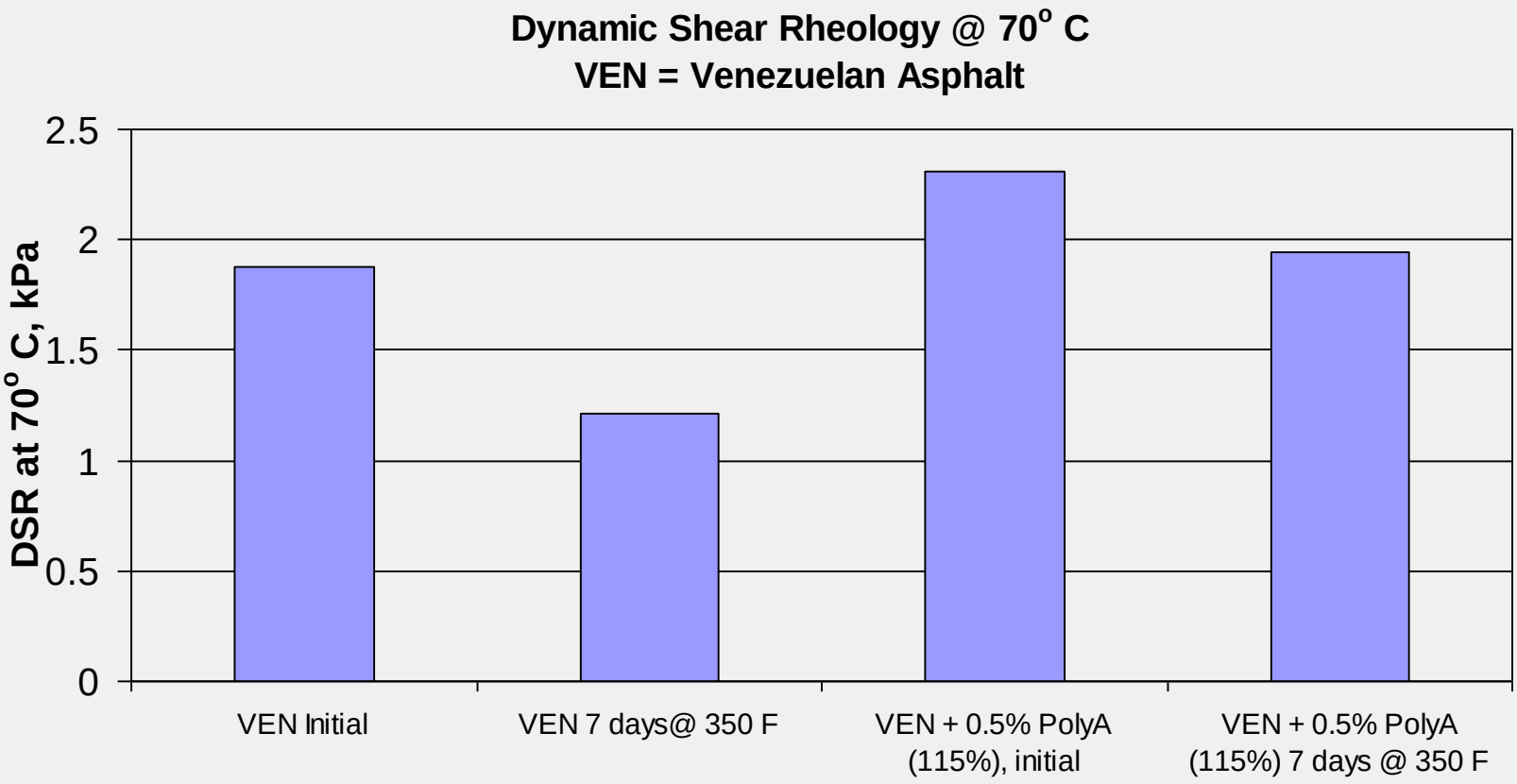
Neat Binder

Binder + 0.5% PPA 115

Hamburg Lab Specimens

MnRoad Test Track:
PPA + Lime anti-strip evaluation.
Perfect performance after 6-plus years

Terminal Storage Stability



Under prolonged high-temperature storage, Polyphosphoric Acid results in an asphalt that maintains its PG rating.

Use of PPA as a Co-modifier with Polymers

Proper Dosage

- Typical Range – 0.25 to 1.5%
- Most Common – 0.25 to 1.2%
- Affected by:
  - Specification Requirements
  - Reactivity of Base Asphalt
  - Interaction with Local Aggregates

Anti-aging Effect of PPA

PAV (100°C, 300 psi)			Thin Film (700 µm)		
Exposure	Carbonyl Index		Exposure	Carbonyl Index	
	PG 64-22	PG 64-22 with 1 % PPA		PG 64-22	PG 64-22 with 1 % PPA
0	0	0	**0**	0	0
1 (RTFOT)	33	25	**1 (RTFOT)**	0	0
20	208	171	**250**	125	125
40	305	263	**500**	167	142
60	433	338	**1,000**	258	217
80	533	483	--	--	--

Polyphosphoric Acid Delivery System (PADS)

Conclusions

- Long history of successful use. Estimated 150 to 500 Million Tons of pavement currently in place where PPA has been used in the last 7 years
- Cost effective- works by making more and smaller asphaltenes
- As stand-alone modifier, high temp. stiffness, no low temp. effect, no negative impact on aging
- Unique properties obtainable when used as a co-modifier with polymers
- Successfully used with hydrated lime and selected amines. Best practice is to test finished products
- PPA modified binders are storage stable
- Continuing research and development

Acknowledgements

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