

Polyphosphoric Acid What really is it and best Practices for Use

Review of the PPA workshop April 2009
and recent studies

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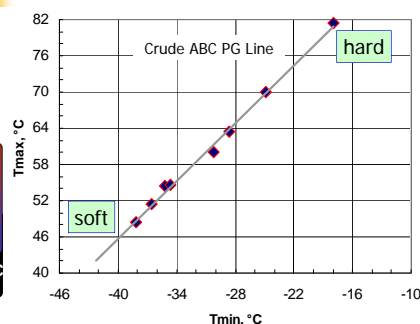
Definition - Asphalt

a high molecular weight, thermoplastic hydrocarbon constituent, found in a large number of petroleum crude oils. Although some asphalts do occur naturally, asphalt as we know it, and as discussed herein, is derived from fractional distillation of petroleum crude oil.

UTI of Performance Grade Asphalts

- A PG 64-22 would have a UTI of 86 C°
- A PG 58-28 also has a UTI of 86 C°
- If we needed a PG 76-22, which has a UTI of 98 C° - how is this accomplished?
- As a "rule of thumb", to achieve a UTI of >92 C°, the asphalt has to be "modified".
- Depending on crude source, some binders with more narrow UTI's of 86 and 89 C° may also require modification

For a given crude, asphalt grade is defined by refinery processing conditions



Puzic 2005

Phosphoric Acid Modification of Asphalt Binder

Definition – Polyphosphoric Acid

- Inorganic Polymer
- Obtained by Condensation of Monophosphoric Acid or by Hydration of P₂O₅
- 0%wt of Free water
- Viscous liquid (25°C) from 840 cP (105%wt) to 60 000 cP (115%wt)
- Crystallisation temperature below 0 to 15°C
- Medium strong acid : Acidity function (Hammett) = 6 (ref H₂SO₄ = 12)
- Highly soluble in organics
- Non oxidant compound

PG76-22 from Saudi Asphalt

PG Grade Achieved	76-22	76-22	76-22	76-22
PPA %	0	0.2	0.4	0.6
Polymer %	4.75%	4.10%	3.75%	3.40%
Brookfield Vis.@ 135	2950	3870	3290	2230
ODSR	1.606	1.532	1.561	1.534
Phase Angle	67.1	64.5	66.2	69.2
Wt. Loss	-0.105	0.21	-0.053	-0.034
RDSR	2.378	2.613	2.569	3.03
PDSR	1198	1126	1422	1276
BBR S Value	125	142	148	143
BBR M Value	0.325	0.335	0.332	0.327
Elastic Recovery	87.50%	86.70%	85.00%	85.00%

PG76-22 from Venezuelan Asp

PG Grade Achieved	76-22	76-22	76-22	76-22
PPA %	0	0.2	0.4	0.6
Polymer %	4.25	3.75	2.9	2.6
Brookfield Vis.@ 135	2350	2030	1510	1360
ODSR	1.557	1.524	1.366	1.42
Phase Angle	68.7	68.6	78.3	79.4
Wt. Loss	0.012	-0.024	0.23	0.008
RDSR	2.472	2.802	2.281	2.58
PDSR	1424	2038	1804	1934
BBR S Value	138	150	163	172
BBR M Value	0.32	0.31	0.311	0.306
Elastic Recovery	80.00%	77.50%	69.00%	64.00%

PG76-16 from CA Valley

PG Grade Achieve	76-16	76-16	76-16	76-10
PPA %	0	0.2	0.4	0.6
Polymer %	5.5	4.4	3.8	3.25
Brookfield Vis.@ 135	2060	1450	1310	1140
ODSR	2.092	1.595	1.414	1.253
Phase Angle	55.8	61.5	67.3	72.2
Wt. Loss	0.11	0.24	0.127	0.049
RDSR	2.327	2.521	2.335	2.296
PDSR	1959	2203	2782	1719
BBR S Value	211	286	291	115
BBR M Value	0.337	0.317	0.312	0.425
Elastic Recovery	85.00%	87.50%	85.00%	82.50%

PPA reaction with binder and Polymers

- PPA reaction with binder is binder specific.
 - Stiffening effect varies for different binders.
- PPA appears to improve SBS elastomeric response.

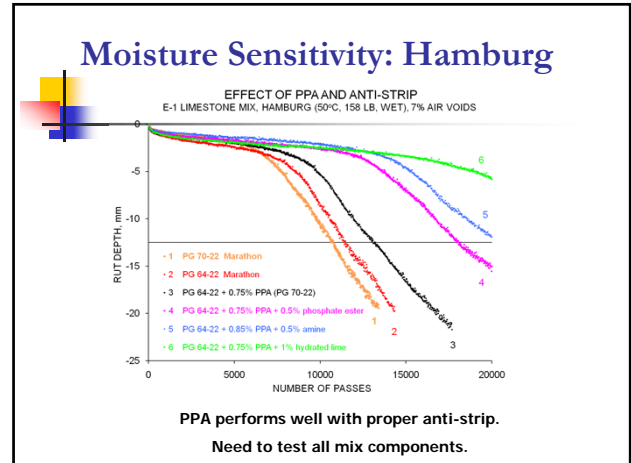
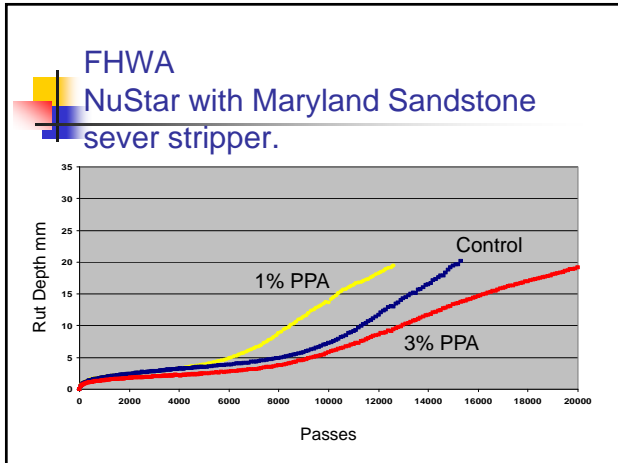
Moisture Sensitivity

- Does adding a hydrophilic material like phosphoric acid impart moisture sensitivity to the binder?

Hamburg Moisture testing

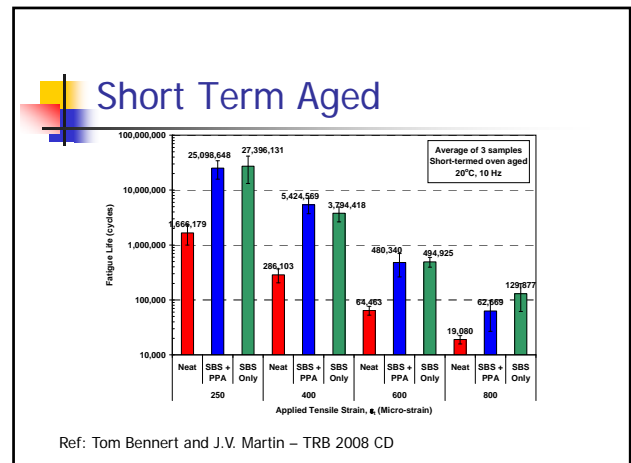
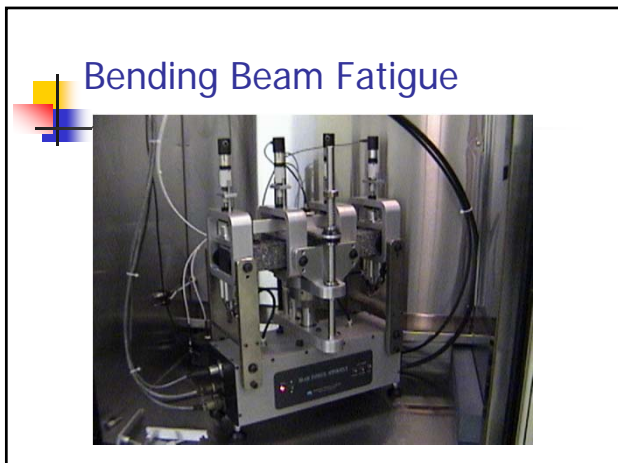
- FHWA Research study
- Mathy study

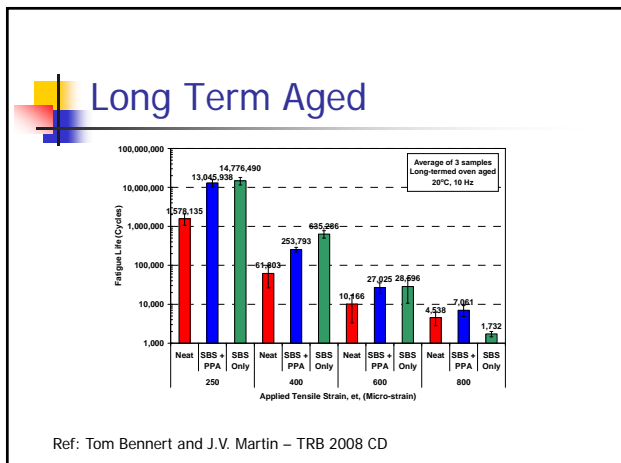




- ### Conclusions – Hamburg Testing
- Test is only an indication and was with limited asphalt
 - PPA increased moisture sensitivity of the neat binders for one AC
 - Action of amine and phosphate ester anti-strips is aggregate specific- PPA may increase moisture sensitivity with certain Amine's
 - With lime treated aggregates the moisture sensitivity is unaffected or improved by PPA modification
 - Users need to test each asphalt/aggregate/anti-strip combination.

- ### PPA and Fatigue
- Review of several studies.





NCAT Test Track Description

- 1.7 mile Closed Loop Facility
- Consists of Forty-Six 200 ft. Test Sections
- Each Section Cooperatively Funded
- Operation and Research Managed by NCAT

PPA/SBS Binder for NPTT-2000

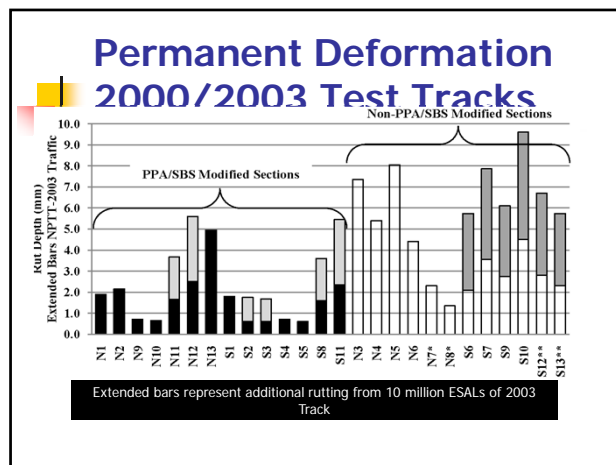
- 2000 Test Track Formulation
 - SuperPave™ PG76-22
 - Venezuelan Crude Source
 - 3.5 Weight Percent SBS Block Co-Polymer
 - 0.25 Weight Percent Polyphosphoric Acid (105)
 - 0.05 Weight Percent Amine Anti-Stripping Agent

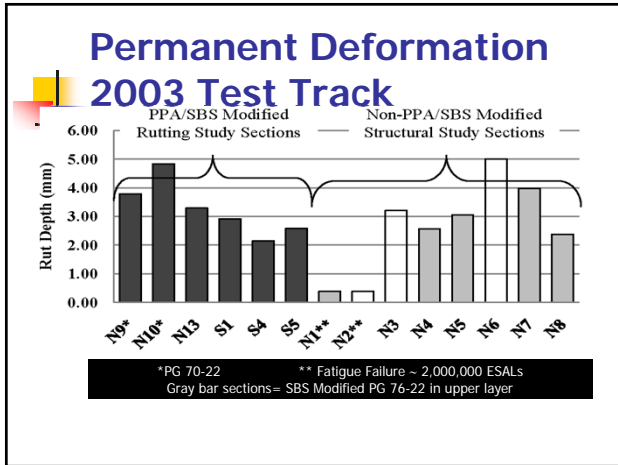
Construction of 2000 Test Track

- Eighteen Sections Contained PPA/SBS Modified PG76-22
- Various Aggregates
 - Limestone
 - Slag
 - Gravel
 - Granite
 - Marble Schist
 - Combinations of the Above

Construction of 2003 Test Track

- Twenty-Three of the Existing Sections were left to Extended Traffic
 - Nine Sections Left to Extended Traffic Utilized PPA/SBS Modified PG76-22
- Twenty-Two New Sections Built
 - Nine Sections Reconstructed or Partially Reconstructed Using PPA/SBS Modified Binder
 - Six PG76-22 and Three PG70-22





- ### Fatigue 2003 Test Track
- Fatigue Cracking Observed in Three Test Sections
 - All Sections Within the Eight Structural Sections
 - None of the Fatigue Cracked Sections Contained PPA/SBS Modified Binder
 - Two Sections Contained SBS Modified Binder

- ### Moisture Damage
- Average Annual Rainfall in Excess of 40 inches
 - Some Aggregates in Construction of Both Research Cycles Susceptible to Moisture Damage
 - Moisture Damage was not a Mode of Failure Identified in Either Research Cycle
 - In Top Down Cracked Sections Moisture Damage was not Apparent

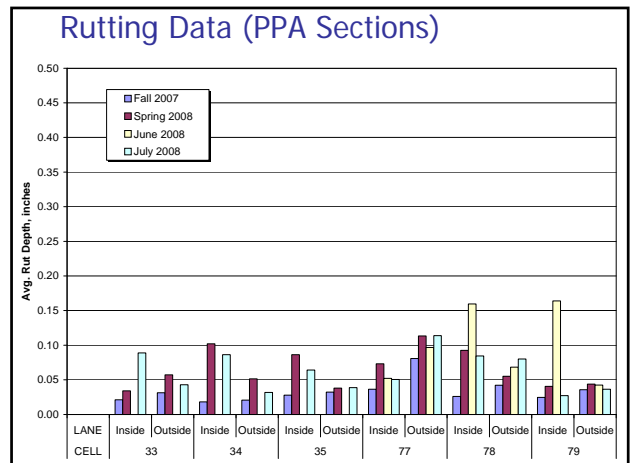


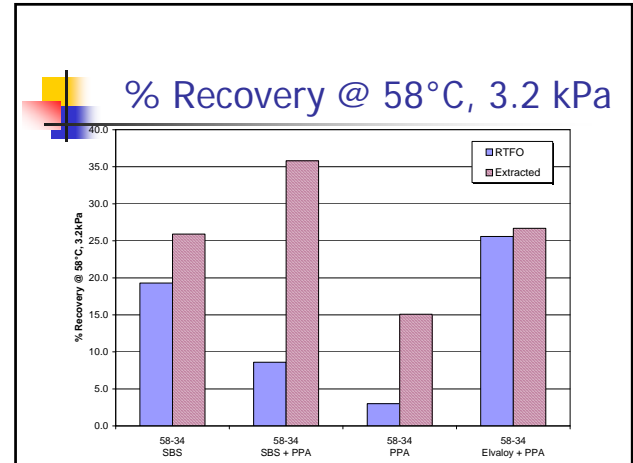
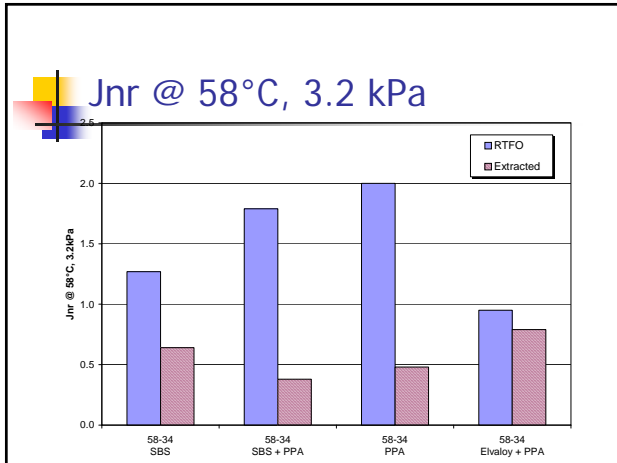
Test Cell Designs

- PPA Only
- PPA + SBS
- SBS Only
- PPA + Elvaloy

- Level 3 Superpave
- PG 58-34 Binder
- No RAP
- Limited Limestone
- Hydrated Lime
- Liquid Antistrip

Cell	77	78	79	33	34	35
Top Layer	4" 58-34 Elvaloy + PPA	4" 58-34 Elvaloy + PPA	4" 58-34 Elvaloy + PPA	4" 58-34 PPA	4" 58-34 SBS + PPA	4" 58-34 SBS
Second Layer	8" Full Depth Reclam.	8" Class 6	8" Full Depth Reclam. + Fly Ash	12" Class 6	12" Class 6	12" Class 6
Third Layer	Clay	Clay	Clay	Clay	Clay	Clay





Summary

- All 4 PPA mixes performing well since 2007
- Field samples showed excellent rutting and stripping performance in lab tests
 - Low Temperature Cracking test results coming soon.
- PPA + Polymer generally performed better than either modifier along
- Test sections will continue to be monitored for 5 years

Conclusions

- The Effects of Asphalt Modification with Polyphosphoric Acid is Asphalt and Crude Source Dependent.
- Polyphosphoric Acid works with SBS polymer to improve cross-linking and improve elastomeric response.
- The Effect of PPA on moisture damage is asphalt and aggregate dependant and is treatable with both lime and liquid anti-strips.

Conclusions

- PPA use should be limited to one grade bump or a max of 1.5%.
- PPA usage above 1.5% should only be used after extensive lab evaluation.
- PPA has been used successfully on actual pavements using a wide variety of aggregate sources even limestone.
- Polyphosphoric Acid is a valuable tool to binder suppliers necessary to provide binders that meet current specifications and provide performance desired.

Thank You!