

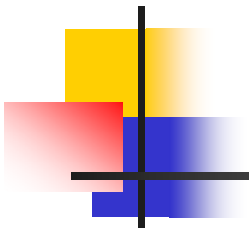
Asphalt Modification via Polyphosphoric Acid and Polymers – Formulations, Binder Properties and Mixture Performance

**WRI/FHA Symposium
“Additives used in Asphalt
Pavements”
Cheyenne, WY
23-25 June 2004**



Acknowledgments

- Andy Menapace – Paragon Technical Services, Inc.
- Mike Hemsley – Paragon Technical Services, Inc.



The thing that hath been is that which shall be; and that which is done is that which shall be done: And there is nothing new under the sun.

Ecclesiastes 1, 9



Background

- Dr. Arnold Hoiberg
- Dr. Stephen Alexander
- TRB – Dr. Gayle King et. al.
- CTAA – Dr. Ludo Zanzotto et. al.
- AAPT – Dr. Gayle King et. al.



Experimental

Saudi - PG 64-22

PPA Modified to PG70-22

Polymer/PPA Modified to PG76-22

Venezuelan - PG 67-22

PPA Modified to PG70-22

Polymer/PPA Modified to PG76-22

California Valley – PG64-10

Polymer/PPA Modified PG76-16



Experimental

- pH Study
- SuperPave Properties – O/RTFO DSR
- Mixture Boiling Strip Test
- Mixture TSR
- Hamburg Rut/Moisture Testing @ 50C
- APA Testing Dry No Anti-Strip
- Chemical Studies

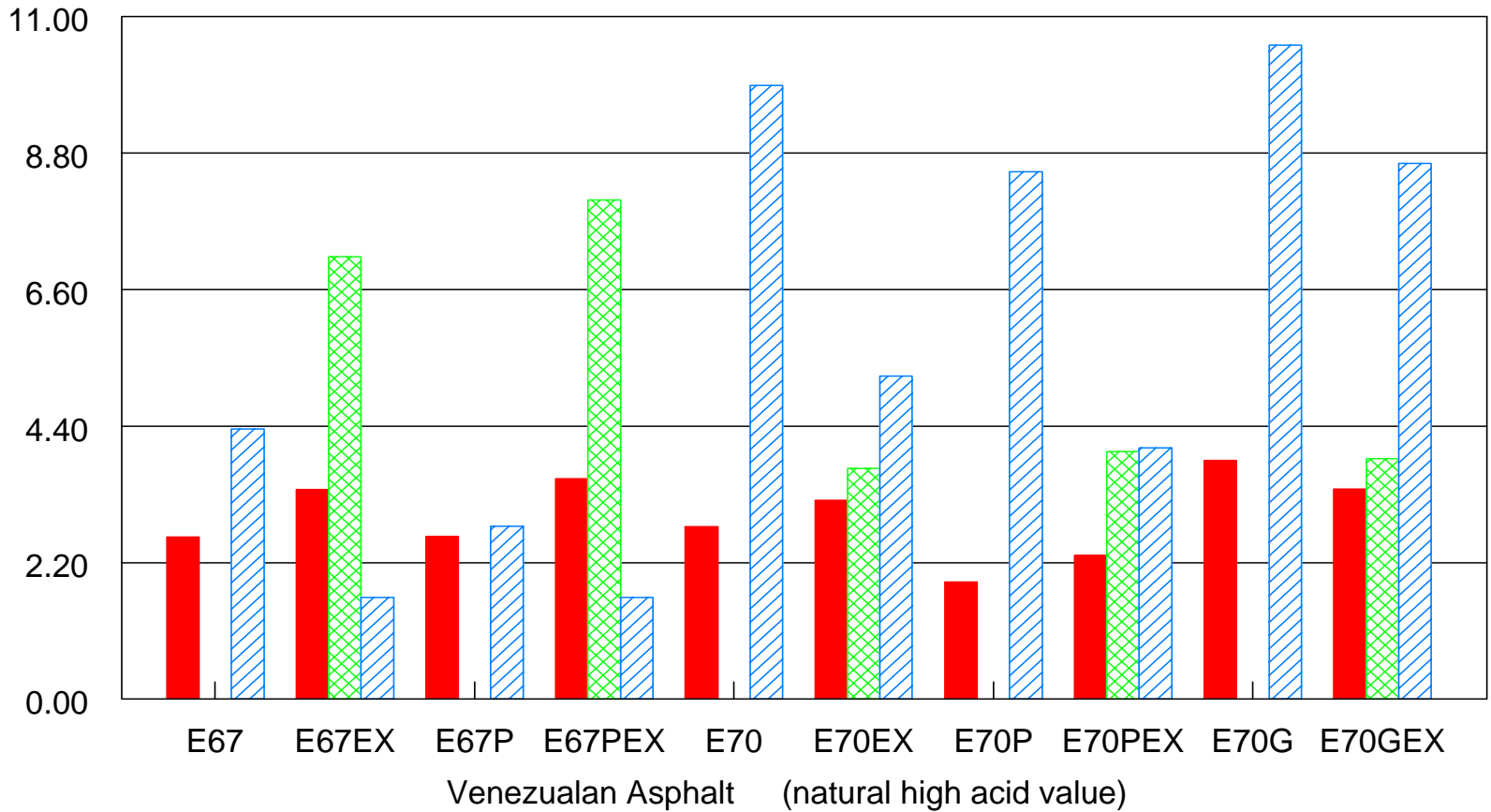


Polyphosphoric Acid Modified Asphalt

Polyphosphoric Acid Modified Asphalt

Asphalt pH, water pH, acid no.

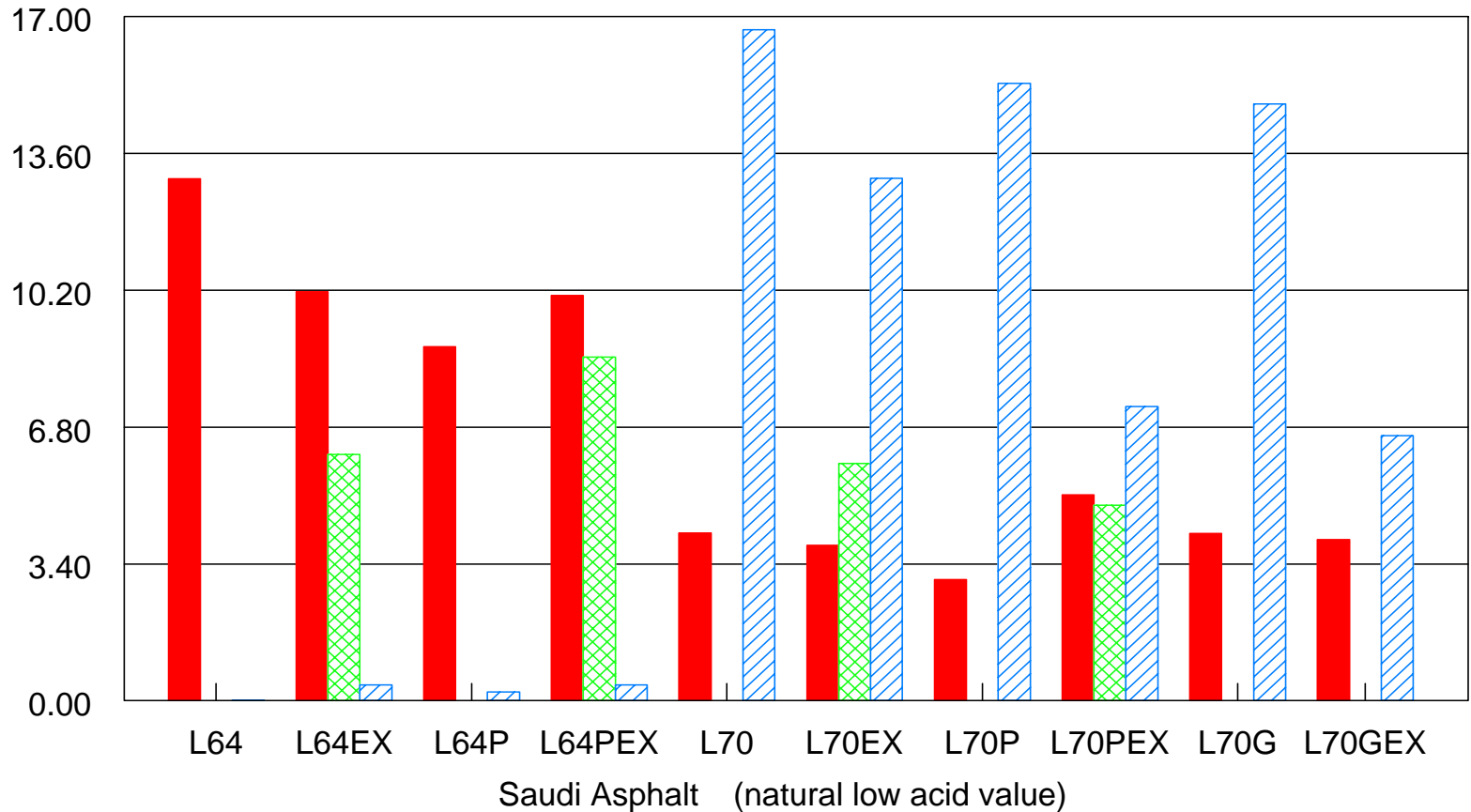
AC pH Water pH Acid No



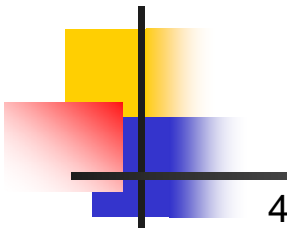
Polyphosphoric Acid Modified Asphalt

Asphalt pH, water pH, acid no.

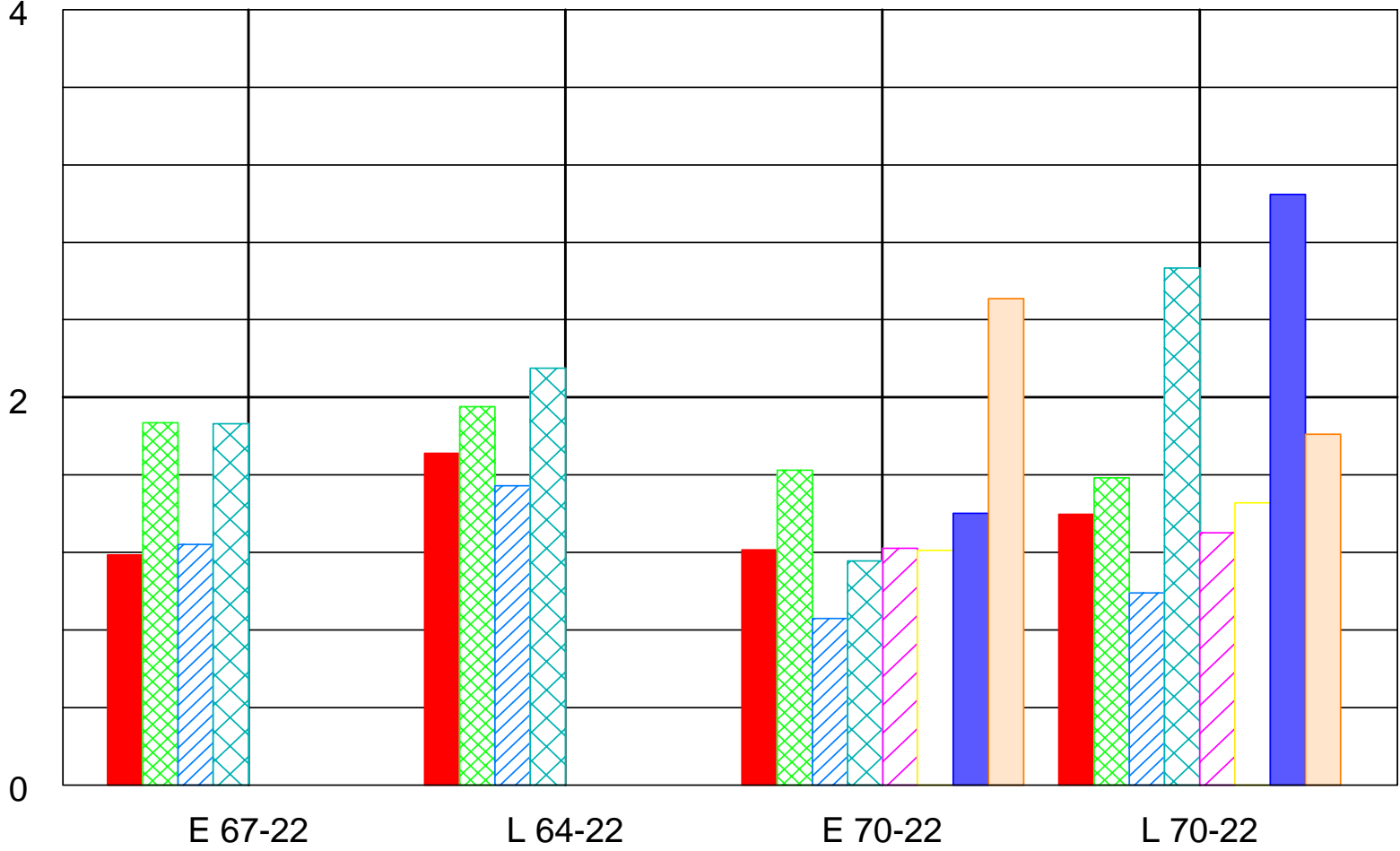
AC pH Water pH Acid No



Polyphosphoric Acid Modified Asphalt Rheological Properties (Unaged)



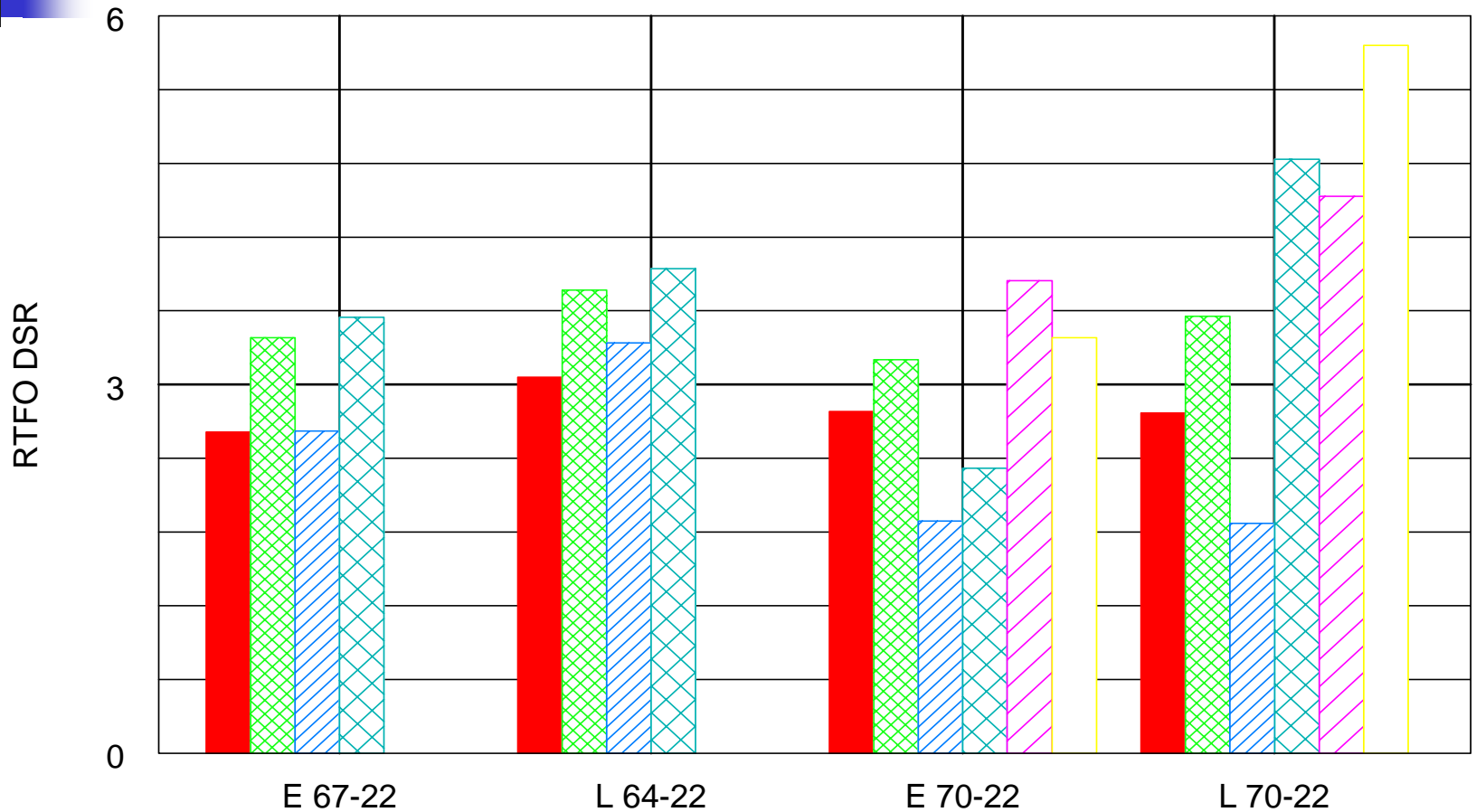
ORIG DSR



Polyphosphoric Acid Modified Asphalt

Rheological Properties (Aged)

AC EX P PEX G GE

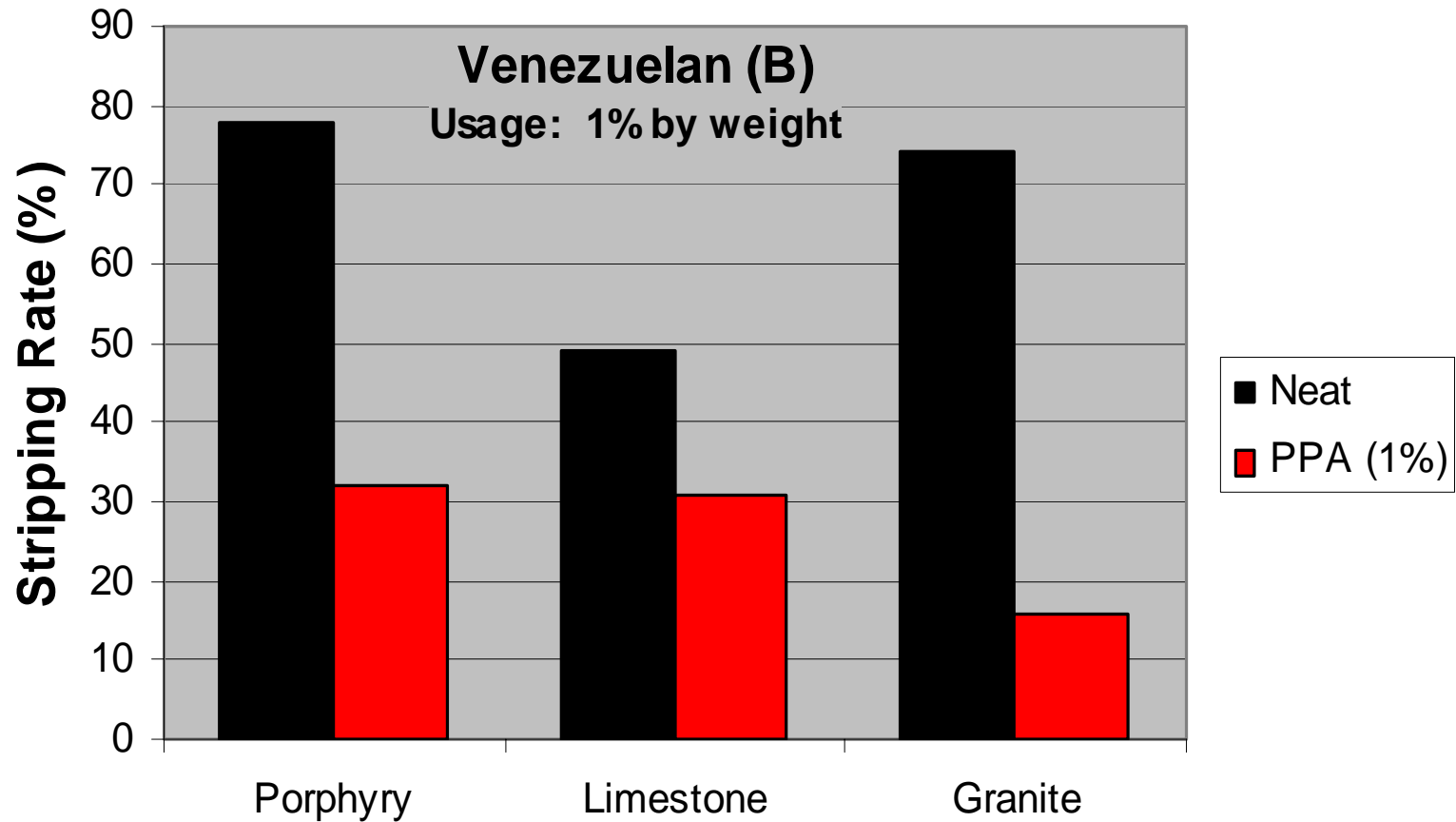




TSR

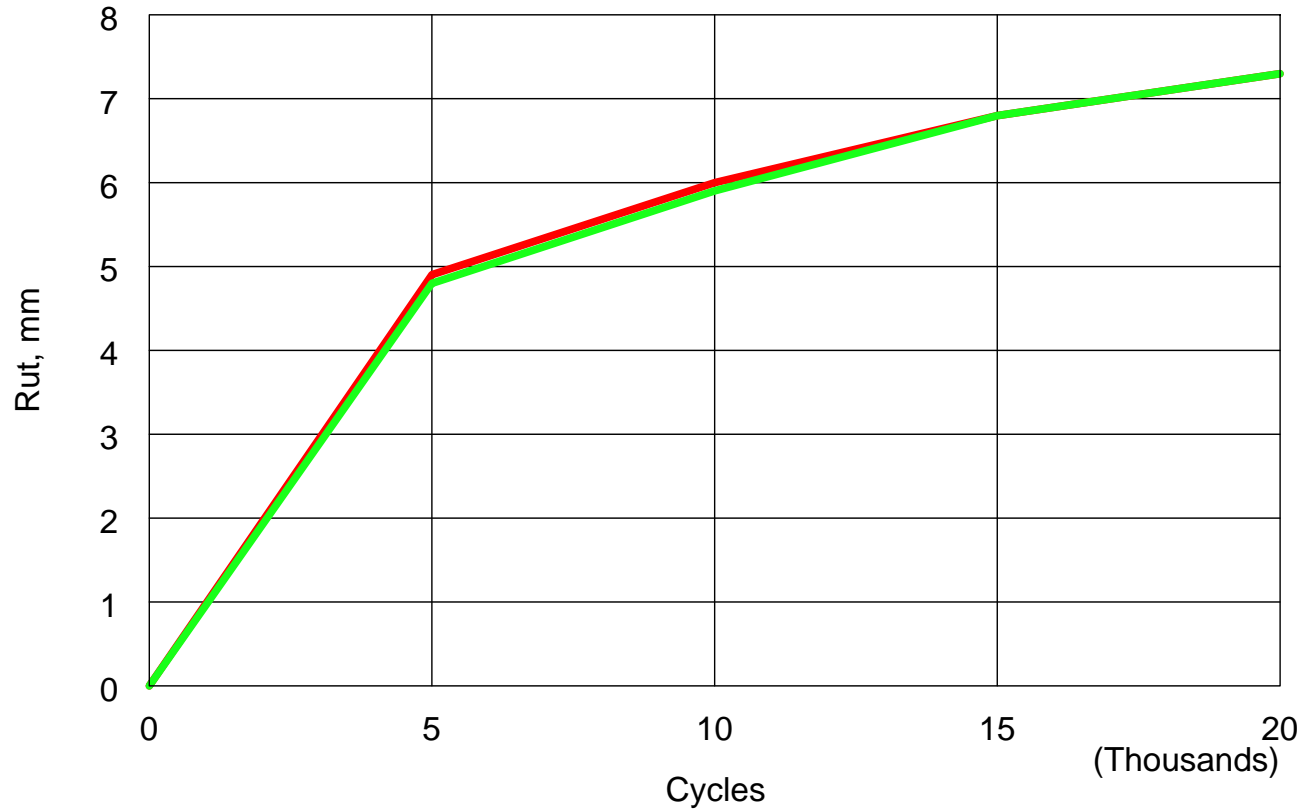
Liquid	Dry Strength	Wet Strength	TSR	% Dry Strip	% Wet Strip
EPG67	8675	7000	80.7	4	6
EPG67+P	8475	6675	78.7	3	6
EPG70	7375	7100	96.3	2	6
EPG70+P	7450	9075	121.8	2	5
EPG70+G	8600	9500	110.5	2	5
LPG64	7575	7650	101	8	8
LPG64+P	7400	6900	93.2	6	6
LPG70	7675	6450	84	4	7
LPG70+P	8025	7550	94.1	4	6
LPG70+G	8300	7250	87.3	4	7

Belgium Road Research Center Stripping Rate



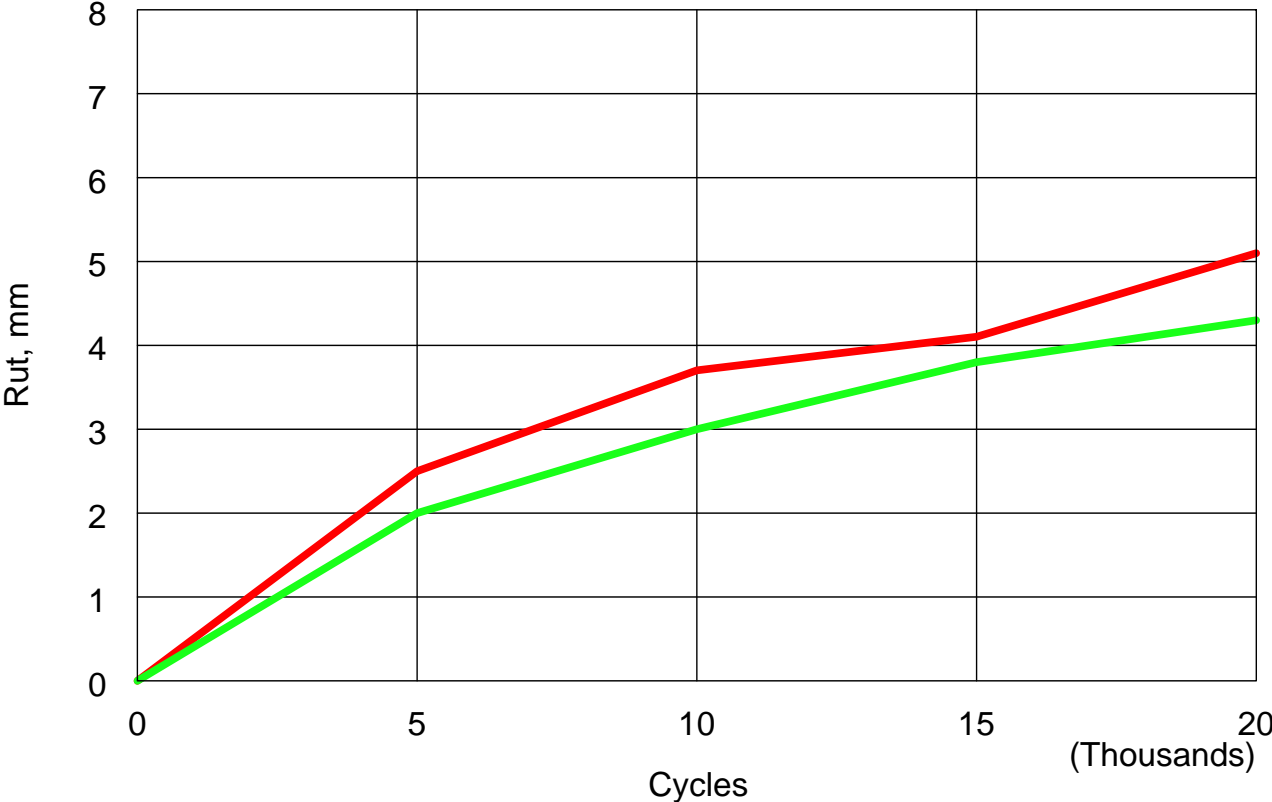
Hamburg @ 50C Wet

— L 70 Rut Depth = 7.3 mm — E 70 Rut Depth = 7.3 mm



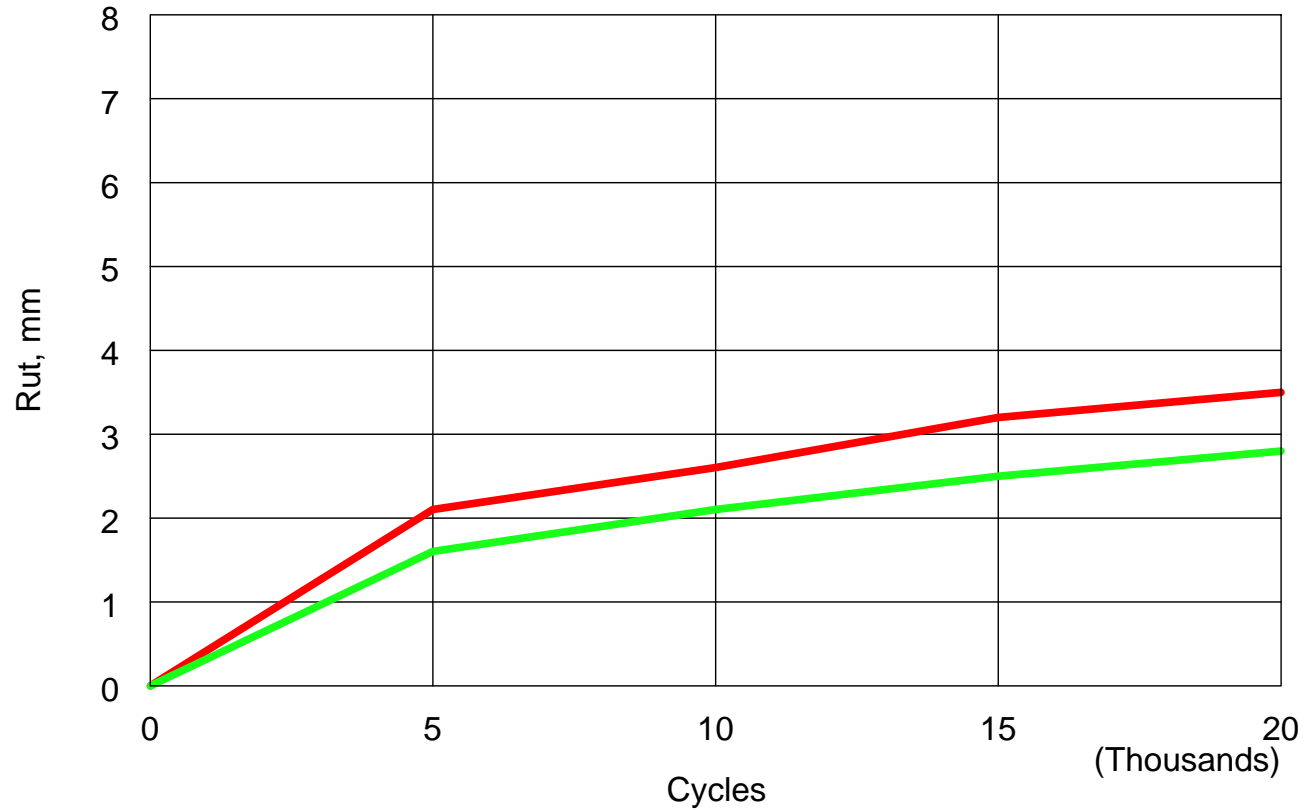
Hamburg @ 50C Wet

L 70P Rut Depth = 5.1 mm E 70P Rut Depth = 4.3 mm



Hamburg @ 50C Wet

— L 70G Rut Depth = 3.5 mm — E 70G Rut Depth = 2.8 mm





Polyphosphoric Acid/Polymer Modified Asphalt



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 Asphalt

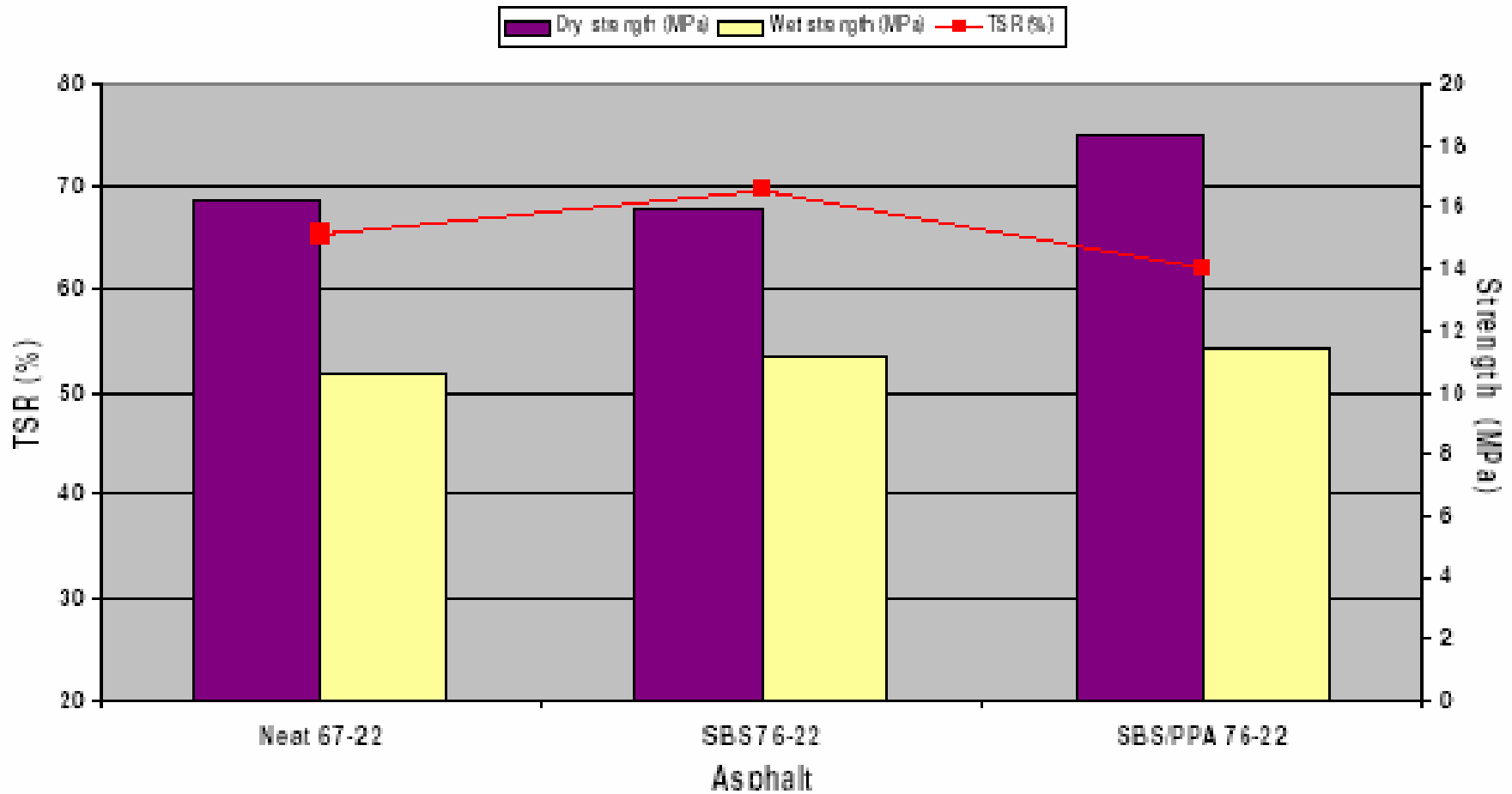
PG Grade Achieved	76-22	76-22	76-22	76-22
PPA %	0	0.2	0.4	0.6
Polymer %	4.25	3.75	2.9	2.6
Brookfield Vis.@ 135	2350	2030	1510	1360
ODSR	1.557	1.524	1.366	1.42
Phase Angle	68.7	68.6	78.3	79.4
Wt. Loss	0.012	-0.024	0.23	0.008
RDSR	2.472	2.802	2.281	2.58
PDSR	1424	2038	1804	1934
BBR S Value	138	150	163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



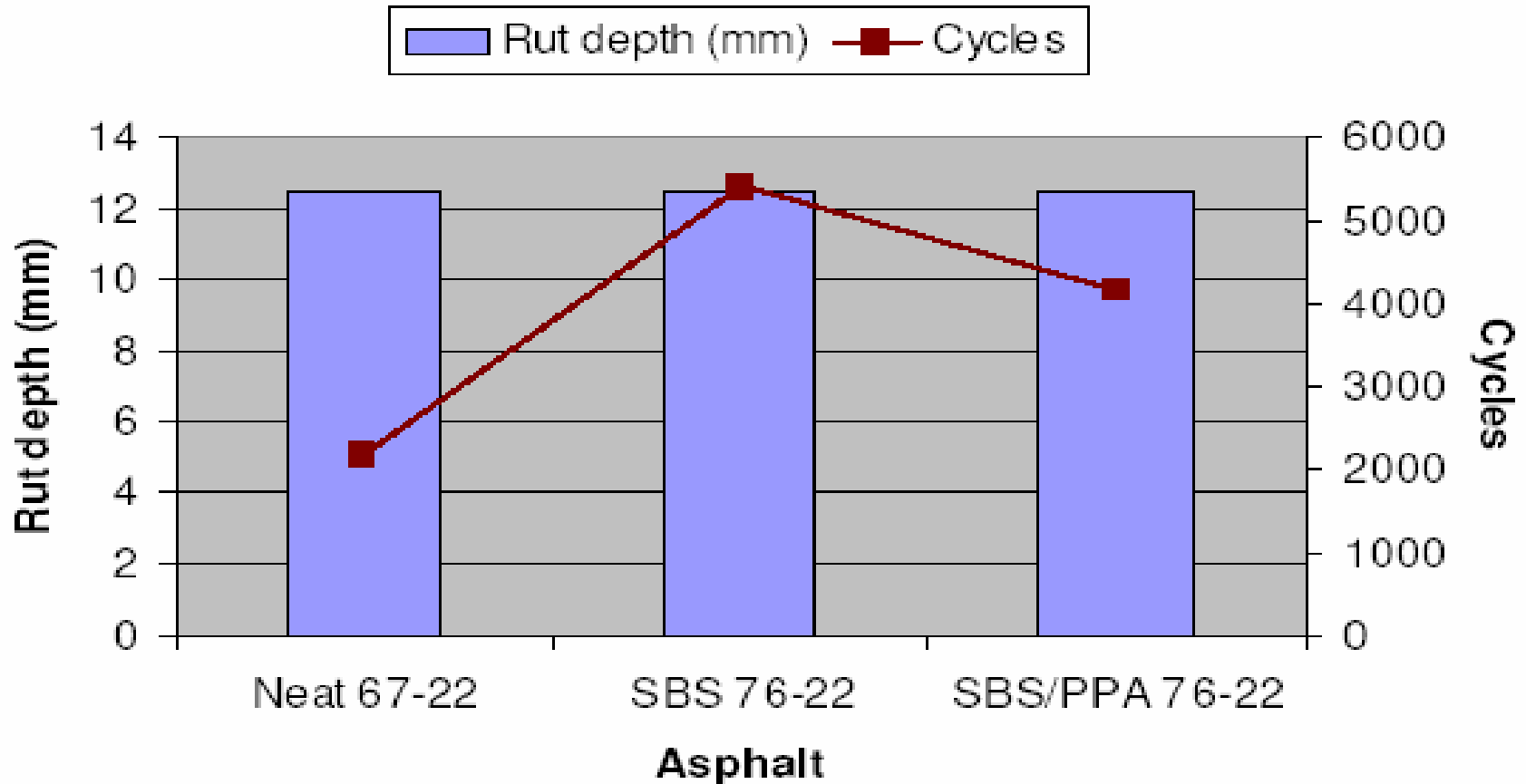
PG76-16 from CA Valley

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%

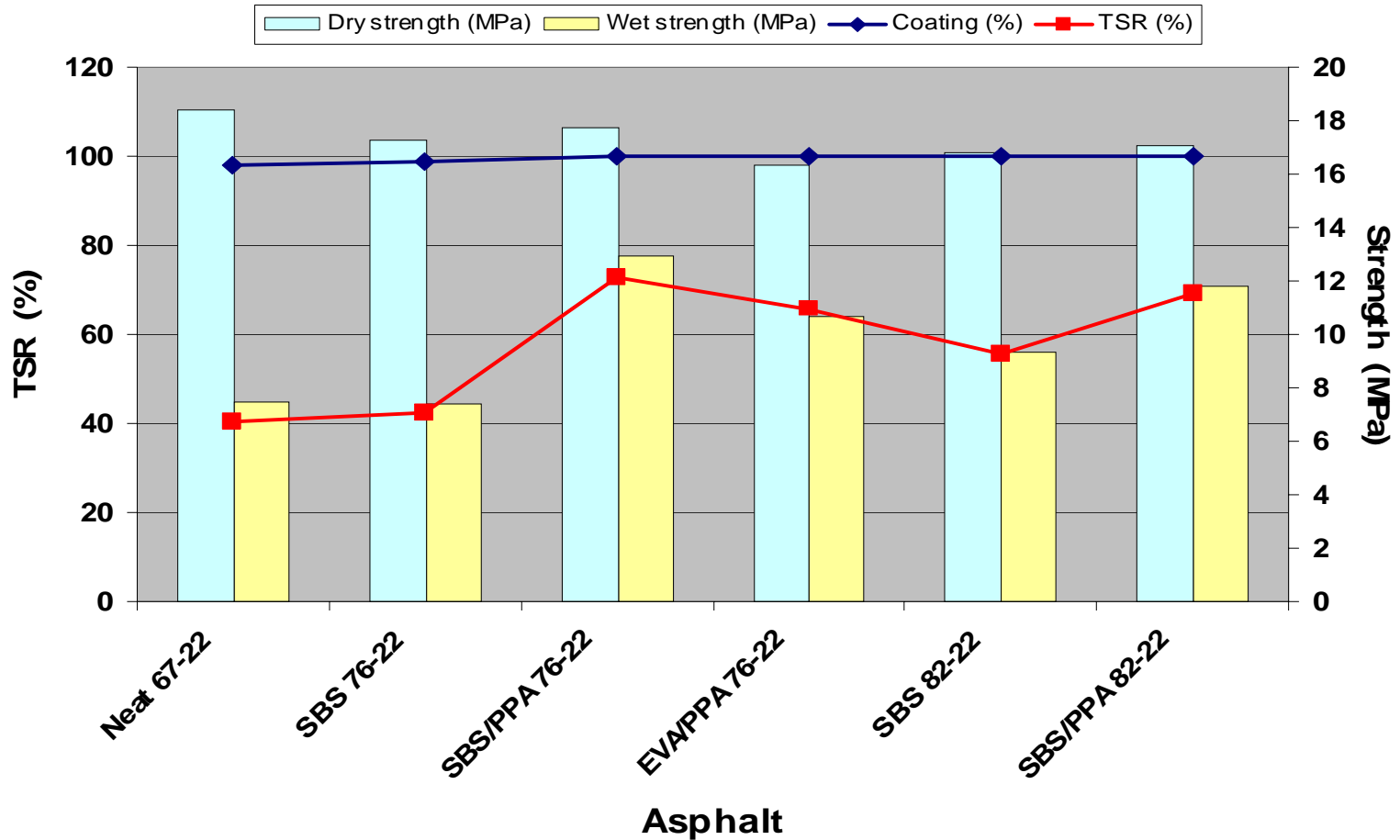
Moisture Resistance (TSR) Saudi Asphalt/Limestone Agg.



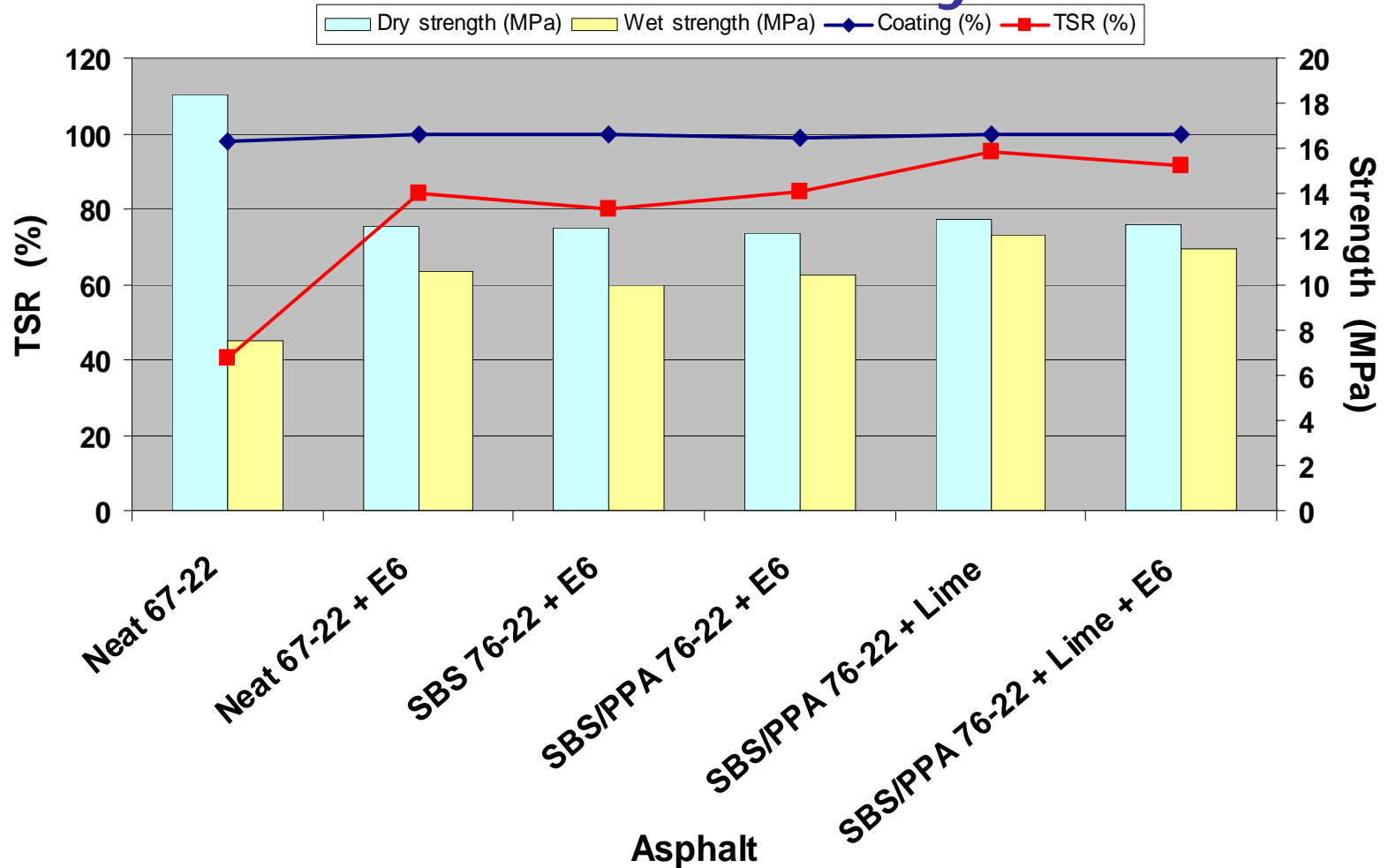
Hamburg Wheel Tracking Saudi Asphalt/Limestone Agg.



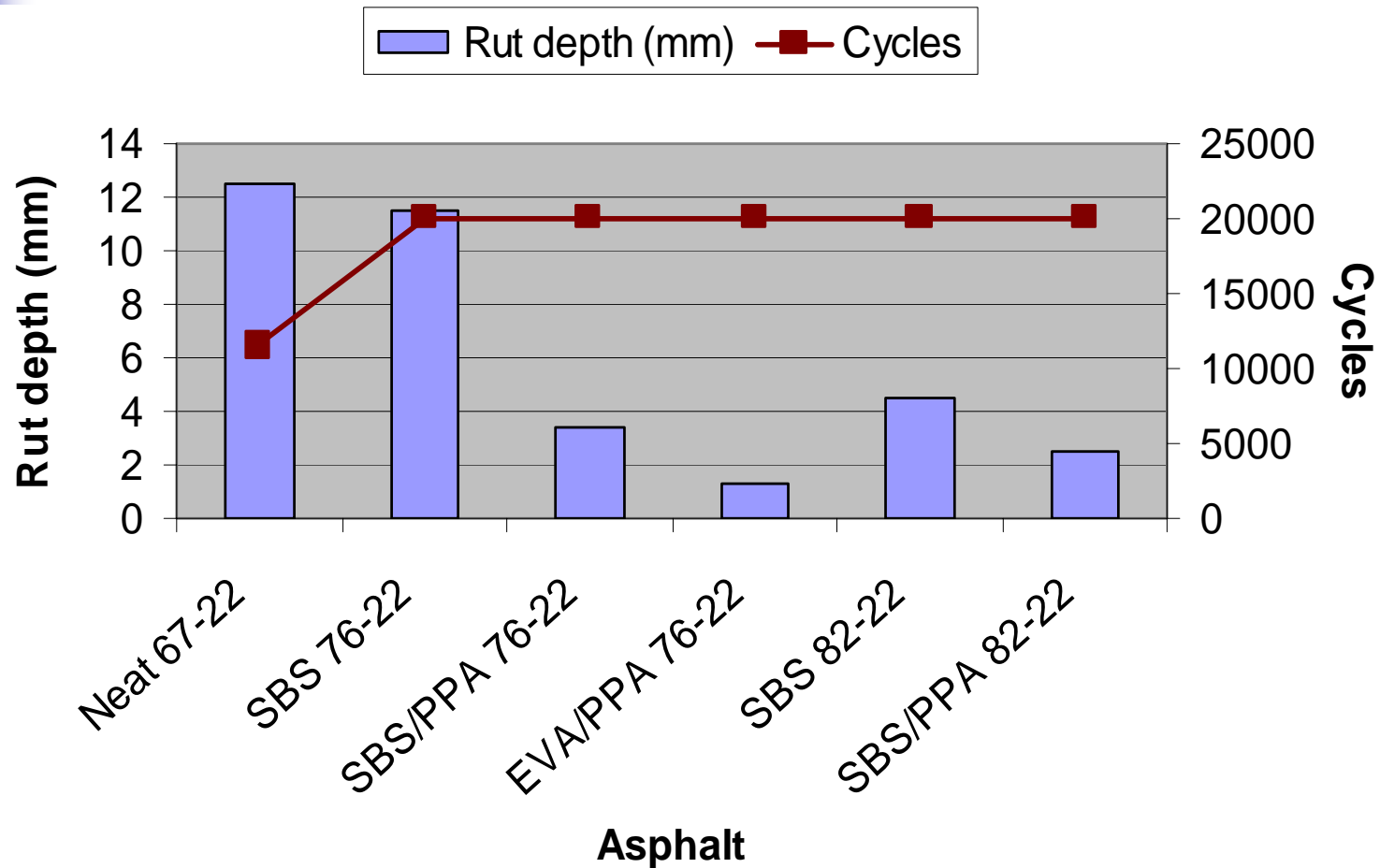
Moisture Resistance (TSR) Venezuelan Asphalt/Granite Agg.



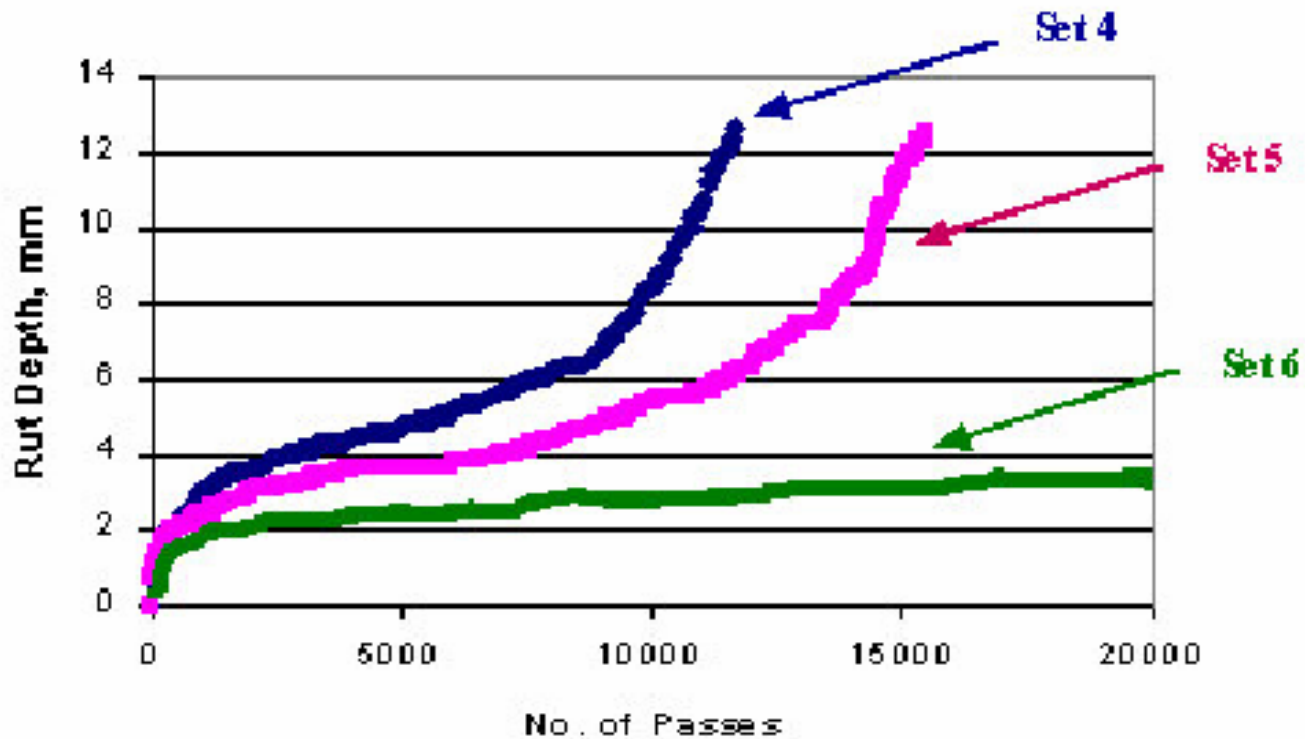
Moisture Resistance (TSR) Venezuelan Asphalt/Granite Agg. W/Lime and Polyamine



Hamburg Wheel Tracking Venezuelan Asphalt/Granite Agg.



Hamburg Wheel Tracking Test



Set 4 : PG67-22

Set 5 : PG76-22 (PG67-22+4, 25% SBS)

Set 6 : PG76-22 (PG67-22+2, 6% SBS+0,6% PPA)



Conclusions

- Polyphosphoric Acid is a Valuable Tool
- Polyphosphoric Acid can be Use to Produce Quality High Performance Binders
- We are Custodians of the Publics Money